Interactions between Agriculture and Industry: Theoretical Analysis of the Consequences of Discriminating Agriculture in Sub-Saharan Africa

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Abstract

Many countries in sub-Saharan Africa discriminated against agriculture to promote industry after independence. The domestic terms of trade were turned against agriculture by the price fixing of monopoly marketing boards. This policy was assumed to reduce labor costs of industry and was combined with overvaluation of the currency, protectionism, and priority rationing of imported inputs to industry. The region got the worst of both worlds—stagnation in both agriculture and industry. What went wrong? In a dual model designed to represent characteristics of the region, discrimination of agriculture is shown to contract industry through trade linkages. Export-oriented agriculture has been held back, and import-dependent industries have suffered because of the foreign exchange constraint. In a dynamic extension assuming learning-by-doing in industry and catching-up in agriculture, it is shown that discrimination against agriculture may reduce the growth rate of the economy and the technological advantage of industry.

1. Introduction

Many countries in sub-Saharan Africa discriminated against agriculture in favor of import-substituting industry after independence. Agriculture was taxed to support industrial expansion. This paper addresses the relationship between agriculture and industry given the structural and political characteristics of the region.

The case for discrimination of agriculture was most starkly spelled out in the economic debate of the first Five-Year Plan in the Soviet Union. The terms of exchange between "town and country" came up as a key decision. Preobrazhensky (1926) was the active proponent of moving the terms of trade, the price scissors, against agriculture. He wanted the peasants to carry more of the burden of industrialization to the advantage of the industrial proletariat. The cheap-food policy was intended to transfer agricultural surplus to finance industrial investment. The labor market aspect included collectivization of agriculture, with increased availability of labor to industry without hurting agricultural output.

The Lewis (1954) model started up the modern literature analyzing interactions between agriculture and industry. The industrial sector is the engine of growth, with the growth process based on new industries using surplus labor from agriculture. We relate to Matsuyama (1992) who develops a full-employment endogenous growth model where productivity growth in industry depends on industrial employment, assuming no productivity growth in agriculture. The less employment in agriculture, the higher is industrial employment and thus the growth rate.

According to the arguments above, sub-Saharan Africa did right by neglecting agriculture and favoring industry: discrimination of agriculture through prices released resources to industry, and protection of industry has prevented resources from being locked into agriculture as a result of comparative advantage. But the models cannot explain why the sub-Saharan economies failed to industrialize when agriculture was discriminated against and industry promoted. When full employment is assumed, squeezing agriculture should yield industrialization almost by definition. In our understanding, the analyses emphasizing competition for labor between agriculture and industry are much too optimistic to understand sub-Saharan Africa. With surplus labor, shortage of unskilled labor has not been an important constraint on growth and choice of policy has more dramatic growth effects than under full employment.

The other regional characteristic we will take into account concerns foreign trade. Ndulu (1991) documents the import compression policy pursued in most countries. Export revenues are concentrated to agriculture (and mining), and industries are dependent on imported inputs. The political handling of the foreign trade has kept industries sheltered from international competition and has managed foreign exchange shortage by rationing. The foreign exchange rationing has created an automatic link between export revenues and domestic availability of imports. Gibson (1985) and van der Willigen (1986) first introduced this type of linkage. Macroeconomic implications are studied in theoretical models by Rattsø (1994) and Torvik (1994, 1997), and in an applied CGE model for Zimbabwe by Davies et al. (1994). The long-run growth consequences of this constraint have not been investigated.

The dynamic analysis of the discrimination of agriculture links sectoral balance to the growth process. Krugman (1981) and van Wijnbergen (1984), and later Matsuyama (1992) and Sachs and Warner (1995) in endogenous growth models, assume that knowledge accumulates as a by-product of experience in industry only. Krugman, van Wijnbergen and Matsuyama hold agricultural productivity constant, while Sachs and Warner assume a perfect spillover from industry to the rest of the economy. We agree that industry is the potentially leading sector in terms of productivity growth and learning-by-doing, but assume that agriculture may take benefit in catching up. Productivity growth in agriculture depends on the technology gap between industrial and agricultural productivity. The endogenization of agricultural productivity growth is an innovation compared to existing studies, and takes advantage of the technology gap concept used in a North–South analysis by Krugman (1979). We model the technology gap between sectors within a country, rather than between countries.

It is well known that agriculture–industry interaction depends on the macro closure of the model. This has been shown in several ways by Taylor (1991), and by Rattsø (1988) in his exploration of the propositions of Sah and Stiglitz (1984). In this paper we extend the closure debate to endogenous growth models. As we shall see, changing the standard closure assumptions of full employment and free trade affects growth predictions dramatically.

In section 2, a dual model of the sectoral balance between agriculture and industry in sub-Saharan Africa is developed and compared to the existing literature. In section 3, the model is used to analyze the short-run effects of agricultural price discrimination and of exogenous changes in productivity. The dynamics of the growth process, driven by endogenous productivity growth, are presented in section 4. Dynamic consequences of agricultural price discrimination are analyzed in section 5. Concluding remarks are offered in section 6.

2. A Dual Model Relevant for Sub-Saharan Africa

The model addresses the interactions between agriculture and industry, basically representing the rest of the economy. The suggested formulation captures the structural characteristics and the policy regime of the region dominating after independence, say from the 1960s through the 1980s. The problems identified may help explain why many countries embarked on structural adjustment during the 1990s.

The model modifies the economic structure proposed by Matsuyama (1992), although the adjustment mechanisms change dramatically. On the production side, we exchange full employment with wage indexation, and introduce intermediate imports as factor input in industry. Instead of the sharp separation between closed- and full open-economy versions in Matsuyama (1992), we assume the typical sub-Saharan situation of agricultural exports and protection of industry. A rationing mechanism links agricultural exports with imported inputs to industry. The agricultural output X_A production function depends on productivity A_A and agricultural labor use L_A:

$$X_A = A_A L_A^\beta. \tag{1}$$

The elasticity of output with respect to labor is β, which determines the size of the supply response; $0 < \beta < 1$. The industrial output X_I production function includes productivity A_I, imported intermediates I, and labor use L_I:

$$X_I = A_I^{1-\lambda} I^\lambda L_I^\theta. \tag{2}$$

The elasticity of output with respect to imported inputs is λ, while the elasticity with respect to labor is θ. Decreasing return to scale in the variable factors is assumed; $\lambda + \theta < 1$. For a given labor use, equal relative increases in productivity and intermediates raise output by the same proportion. The assumption implies that a steady state with a constant growth rate exists.

Agricultural exports are necessary to finance imports of intermediate goods for industry. Foreign exchange rationing assumes that the trade balance is exogenous, and to avoid unnecessary notation we simply set it equal to zero. All international prices are set to 1. Since we abstract from capital goods and consumer imports, the foreign exchange rationing implies that the amount of imported intermediates equals agricultural exports:

$$I = EA_A. \tag{3}$$

E denotes agricultural exports measured in agricultural productivity units, so EA_A is agricultural exports in agricultural goods units.

Labor use is determined from the side of demand under unemployment. The conventional understanding of surplus labor can be interpreted as subsistence agriculture outside the model serving as a labor pool. The supply of labor then is perfectly elastic; a situation often used as the definition of underdevelopment. However, real wage determination in the "modern" sector included in the model is not held back to subsistence level. The formal economy is assumed to have wage-setting institutions whereby the nominal wage is partly indexed to the price level and the real wage follows productivity. Dailami and Walton (1989) offer empirical support for wage indexation for Zimbabwe. Indexation relates the nominal wage W to the consumer price index, dependent on the agricultural price P_A and the industrial price P_I:

$$W = \omega \left(P_A^\alpha P_I^{1-\alpha} \right)^\lambda. \tag{4}$$

The share of agricultural goods in the consumption basket is α, while the degree of indexation is measured by γ; $\gamma = 0$ represents nominal wage rigidity, while $\gamma = 1$ represents real wage rigidity, with values in between representing imperfect indexation. ω is a real wage parameter which is equal to the real wage when $\gamma = 1$. To save notation we assume that the wage is the same in both sectors. The presence of an exogenous wage gap will not affect the results.

The real wage is assumed to follow productivity growth over time, with agricultural productivity A_A and industrial productivity A_I weighted by consumer shares:

$$\omega = A_A^{\alpha} A_I^{1-\alpha}. \tag{5}$$

Profit maximization implies that labor demand in agriculture is given by equation (6). The labor demand can be written in terms of the relative productivity gap $H = A_I/A_A$:

$$L_A = H^{\frac{-(1-\alpha)}{1-\beta}} \beta^{\frac{1}{1-\beta}} P_A^{\frac{1-\alpha\gamma}{1-\beta}} P_I^{\frac{-(1-\alpha)\gamma}{1-\beta}}. \tag{6}$$

The accompanying supply function for agricultural output is:

$$X_A = A_A H^{\frac{-\beta(1-\alpha)}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} P_A^{\frac{\beta(1-\alpha\gamma)}{1-\beta}} P_I^{\frac{-(1-\alpha)\gamma\beta}{1-\beta}}. \tag{7}$$

Increased agricultural productivity increases agricultural labor demand as the real product wage goes down. The production of agricultural goods increases both as a direct consequence of increased productivity and as a consequence of increased labor use. Increased industrial productivity (via H) reduces labor demand and production in agriculture because wage costs are pushed up. The price effects in the agriculture supply function include the positive effect of own price and the negative effect of the industrial price related to nominal wage response.

The labor demand in industries also follows from profit maximization. In addition to prices and productivity, it is affected by the availability of imported intermediates. Inserting from equation (3), agricultural exports E enter the labor demand function for industry:

$$L_I = H^{\frac{\alpha-\lambda}{1-\theta}} P_A^{\frac{-\alpha\gamma}{1-\theta}} P_I^{\frac{1-(1-\alpha)\gamma}{1-\theta}} E^{\frac{\lambda}{1-\theta}} \theta^{\frac{1}{1-\theta}}. \tag{8}$$

The output supply in industry is

$$X_I = A_I H^{\frac{\alpha\theta-\lambda}{1-\theta}} P_A^{\frac{-\alpha\gamma\theta}{1-\theta}} P_I^{\frac{\theta-(1-\alpha)\gamma\theta}{1-\theta}} E^{\frac{\lambda}{1-\theta}} \theta^{\frac{\theta}{1-\theta}}. \tag{9}$$

Higher agricultural exports mean increased availability of the rationed imported intermediates. The resulting higher marginal productivity of labor increases industrial labor demand. Industrial supply increases both as a result of increased labor use and more imported intermediates.

Accumulation of financial assets is zero since trade is balanced under foreign exchange rationing. There is no real capital in the model, and consequently no real investments. When both financial and real investments are ruled out, it follows that the savings rate equals zero, and all income is consumed. The consumption functions have fixed consumption shares:

$$P_A C_A = \alpha(1-t)Y, \tag{10}$$

$$P_I C_I = (1-\alpha)(1-t)Y. \tag{11}$$

Some consumption leakage must be assumed to have a stable equilibrium in a model of unemployment. A proportional tax rate t is introduced in (10) and (11), and is matched by government purchase of the agricultural good below. Since no private and foreign savings are allowed, the model implies government budget balance. Our analysis emphasizes supply linkages, and the demand side is made simple. Constant budget shares imply unitary income elasticity for both goods, as well as unitary elasticity of substitution between the goods. Matsuyama (1992) has investigated the more standard case of Engel's law. Echevarria (1997) and Torvik (2001) study multisector models with CES utility functions. de Groot (1998) has shown more generally how growth in multisector models is affected by income and substitution elasticities.

Total income consists of wage and profit income. Rents are created because of the difference between domestic and foreign prices on agricultural goods. Below these rents are allocated to agricultural income. None of the results in the model depend on the allocation of these rents, as all income groups have the same consumption function. Profit in agriculture, Π_A, is given by $P_A(X_A - EA_A) + eEA_A - WL_A$, where e is the nominal exchange rate. The domestic and foreign prices of agricultural goods may differ because of the policy-controlled domestic price (which is the price each agricultural producer receives at the margin). Profit in industry, Π_I, is given by $P_I X_I - WL_I - eI$. We then get

$$Y = \Pi_A + \Pi_I + W(L_A + L_I)$$
$$= P_A X_A + P_I X_I - eI + (e - P_A)EA_A = P_A(X_A - EA_A) + P_I X_I. \tag{12}$$

When balanced trade is assumed as in (3), the nominal exchange rate has no effect on the income level. The formulation of the production side implies that sectoral supplies are independent of the nominal exchange rate. It follows from policy-controlled agricultural price and protected industry with rationed access to imported intermediates.

The static model is closed with the market-balancing equations for the two sectors:

$$X_A = C_A + EA_A + GA_A, \tag{13}$$

$$X_I = C_I. \tag{14}$$

Agricultural output is allocated to consumption, exports, and government use, while industrial output only is consumed domestically. G is government consumption measured in agricultural productivity units, and is multiplied by the productivity A_A to match agricultural output supply. Given domestic demand and the policy-fixed agricultural price level, agricultural exports adjust to clear the market. The residual output is exported. The manufacturing market is assumed to be cleared by price, since the sector is protected from foreign competition. In the short run, agricultural exports and the industrial price are the key adjusting variables. The closure is similar to models in the dependent economy tradition. In post-independence sub-Saharan Africa, agriculture is the traded sector and industry the nontraded sector by protection.

The economic structure highlights three static linkages between the sectors—via demand, costs, and foreign exchange. The demand linkage contributes to sectoral balance, since higher production in one sector means higher income and thereby higher demand for the other sector. The cost linkage with some nominal wage flexibility transmits a higher price in one sector to higher wage costs in the other sector. When a price increase is driven by demand, the cost linkage contributes to sectoral imbalance, since the demand expansion of one sector implies a cost-led contraction in the other sector. When the price increase is the result of lower output supply, the two sectors contract

in balance. The foreign exchange linkage is the key extension compared to the litera-ture and contributes to sectoral balance. Higher agricultural output and exports release imported intermediates to industry.

Our model does not exhaust all possible linkages between agriculture and industry, but captures the interactions we think are the most important in sub-Saharan Africa. The overviews of Taylor (1989) and Dutt (1990) offer an extended menu.

3. Short-Run Effects of Discriminating Agriculture

The policy of discriminating agriculture can be studied in the model as a downward shift in the agricultural price. Agricultural price policy influences, but does not deter-mine, domestic terms of trade. The formulation differs from the Sah and Stiglitz (1984) modeling of the Soviet debate, as they assume the domestic terms of trade to be a control variable. In sub-Saharan Africa, part of the policy of discriminating agriculture has been protection of industry. The sheltered industrial market has made prices of industrial goods vary with domestic market conditions. Only the numerator of the agri-culture/industry price ratio is policy determined. The effect on the domestic terms of trade by changing the agricultural price is shown to depend on the degree of real-wage rigidity. A low domestic price of agricultural goods can be to the advantage of indus-tries because of the link between the agricultural price level and the wage costs of industries, and can be to the advantage of labor because they get cheap food (except in the case of perfect real-wage rigidity).

The static equilibrium is described in Figure 1, and the two market balances produce the two excess demand functions shown (an appendix with analytical details is avail-able on request). Both market balances imply a negative relationship between agricultural exports and the industrial price. At the agricultural market, a rise in the industrial price creates more demand and less supply (via the cost linkage). A reduc-tion of the agricultural exports clears the market. At the industrial market, higher agri-cultural exports generate more supply (via imported inputs) and less demand (since more of a given income is used to buy intermediates). The industrial price falls to clear the market. A stable equilibrium requires the agricultural balance curve to be steeper than the industrial one.

Discrimination of agriculture in the form of a negative shift in the agricultural price changes the static equilibrium as described in the figure. The agricultural balance curve shifts inwards. The reduced domestic price creates excess demand at the agricultural market, reducing agricultural exports. A strong supply response in agriculture, a high β, requires a large reduction of agricultural exports. A strong cost linkage to industry, high degree of wage indexation γ, and high industrial elasticity of labor θ, means a large rise in industrial output and thereby domestic demand for agriculture, also implying a large reduction of agricultural exports.

The excess supply effect of reduced agricultural price at the industrial market requires a negative shift in the industrial market balance curve. The reduced agricul-tural price induces a rise of industrial supply (via reduced costs) and lower industrial demand (via reduced agricultural incomes). The industrial price must shift down to clear the market. As above, a high β, γ, and θ contribute to a large shift, as they imply strong output responses.

The shifts shown by the market balances in Figure 1 imply that reduced domestic price of agricultural goods generates a fall in agricultural exports. With some degree of real wage flexibility, $\gamma < 1$, a lower agricultural price produces a shift in the domes-tic terms of trade in favor of industry. The consequences for employment and produc-
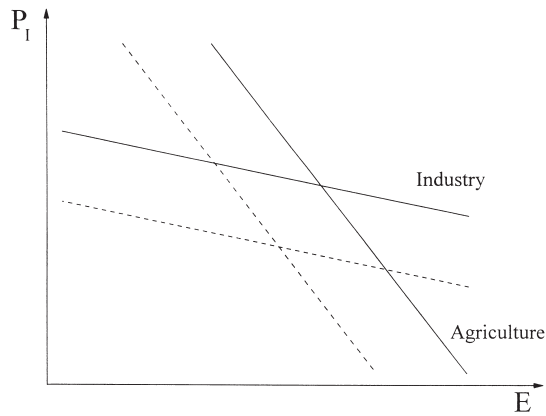
Figure 1. Market Balance Curves for Agriculture and Industry

tion are derived by inserting the adjustments of E and P_I into the labor demand and output supply functions. As expected, the policy results in lower agricultural employment and production. In contrast to standard full-employment models, decreased employment in agriculture does not automatically mean higher employment in industry. In fact, the opposite happens. Industrial employment and production are also reduced when agriculture is discriminated against. In the short run, discrimination against agriculture reduces production and employment in both sectors.

According to our model, discriminating against agriculture cannot raise short-run industrial output in the structural context of sub-Saharan Africa. The main expansionary channel, the cost linkage from agriculture to industry, cannot dominate. In contrast to Sah and Stiglitz (1984), the contraction in industrial production and employment does not follow from decreased demand for industrial goods when agricultural output contracts. In the present model the contraction of industry is due to a supply linkage. When industry is dependent of imported intermediates and foreign exchange is rationed, squeezing agriculture means less availability of imported intermediates to industry and thus an inward shift in the industrial supply curve. The policy of the region could not work given the handling of the foreign exchange constraint.

The model can throw light on the role of sectoral productivities, as discussed by Matsuyama (1992). The market balances show that only the relative level of productivity between sectors, $H = A_I/A_A$, matters. Again we use Figure 1 to sort out the mechanisms involved. The increased productivity gap between industry and agriculture, H, shifts the agricultural market equilibrium curve to the left. When agriculture becomes less productive relative to industry, agricultural supply decreases because the wage relative to agricultural productivity goes up. At the same time demand for agricultural goods increases, based on increased income in the industrial sector with a lower wage/productivity ratio. Both effects contribute to excess demand at the agricultural market, implying reduced agricultural exports and thus an inward shift in the agricultural market balance curve.

At the same time, excess supply at the market for industrial goods is created. Demand for industrial goods decreases as a result of lower agricultural production and income. In addition, supply of industrial goods goes up because the industrial sector takes advantage of a lower wage/productivity ratio. To balance the market, the price of industrial goods has to fall, shifting the industrial market balance in Figure 1 down.

The short-run effects imply that agricultural exports E fall when industry becomes more productive relative to agriculture. As regards the industrial price, one would expect the standard (Balassa–Samuelson) result that when the relative productivity between the sectors shifts one way, the relative price shifts the other way. Interestingly, although this is a possible and likely result also in our model, it is not the unambiguous result. The sub-Saharan African style of rationing system introduces an additional channel affecting the industrial price compared to the standard model. Lower agricultural exports reduce the availability of imported intermediates, contract industrial supply, and thus push the industrial price up. The possibility of a higher industrial price when the industrial sector becomes more productive relative to the agricultural sector increases in λ; i.e., the more dependent the industrial sector is on imported intermediates.

When relative productivity H increases, the labor demand in agriculture goes down, as the real product wage in agriculture increases. When the industrial sector becomes more productive relative to the agricultural sector, employment in industry falls. The effect of a reduced real product wage in industry pulls in the direction of increased employment, but is dominated by less availability of imported intermediates. Less import of intermediates pushes the marginal productivity of labor down, and in this way labor demand is contracted. In the static model an increased productivity gap between industry and agriculture reduces employment in both sectors. Employment benefits from increased relative productivity of agriculture.

The result differs from both the closed- and open-economy versions of Matsuyama (1992). In his open-economy version reduced agricultural productivity shifts the comparative advantage in favor of industry, reducing agricultural employment while increasing industrial employment. In his closed-economy model reduced agricultural productivity pushes agricultural employment up and industrial employment down. In the sub-Saharan African situation, however, it is to the advantage of industry when agriculture uses more resources, because in effect the agricultural sector creates scarce resources to industry by creating foreign exchange. When foreign exchange, and not labor, is scarce, employment in both sectors is pushed down when agricultural productivity drops.

4. Productivity Dynamics in the Dual Growth Model

The modeling of agriculture–industry interaction has appeared in many forms and contexts since Lewis (1954). Issues related to productivity growth are addressed by several authors in the Kaldorian tradition emphasizing return to scale, as shown by the overview of Skott (1999). Agriculture is a growth constraint because of decreasing returns to scale. In the models of Canning (1988) and Skott (1999), increasing returns to scale in industry relax the long-run constraint agriculture places on growth. Assuming constant returns to scale in industry, Thirlwall (1986) finds that only productivity growth in agriculture matters for economic growth. In our model, the productivity, and thereby the dynamic scale effect, is endogenous in both sectors.

Since Arrow (1962), many have modeled technological progress as the result of accumulated experience. Learning-by-doing is external to the firms, and thus is not taken into account in labor and production decisions. There are two key assumptions that drive the productivity results in the models of Krugman (1981) and van Wijnbergen (1984), as well as in later dual endogenous growth models such as Matsuyama (1992) and Sachs and Warner (1995). The first is the assumption of full employment. The more employment is squeezed in one sector, the more employment automatically increases

in the other sector. The second is the assumption regarding productivity growth. The models postulate that only employment in the industrial sector contributes to learning-by-doing. By combining the two assumptions, a simple, but powerful growth prediction results: the more one succeeds in squeezing employment outside industry, the higher is the growth rate. A policy discriminating agriculture is the mirror image of a policy increasing growth. Compared to this literature, it is of interest to investigate the growth dynamics with labor surplus, foreign exchange constraint, and endogenous productivity growth in agriculture.

Although we model productivity growth differently from those above, we share the view that industrial employment is the principal source of learning-by-doing. Our modeling of productivity growth in the industrial sector is thus equivalent to the earlier literature, but we add endogenous productivity growth in agriculture. The assumption of a technology gap whereby agriculture is catching up on industrial productivity is motivated by the empirical literature on sectoral patterns of productivity growth. The most comprehensive study available by Pieper (1998, p. 38) finds "a leading role for industry in determining the level and trend of aggregate productivity growth." Evidence for sub-Saharan Africa is supplied in Blunch and Verner (1999, p. 17), who study Côte d'Ivoire, Ghana, and Zimbabwe: "For all three countries, there exists a positive impact on agricultural growth from an increase in the industrial sector." The empirical results are consistent with the concluding remarks of Matsuyama (1992, p. 330) where he acknowledges that "learning experiences in manufacturing should be useful in agriculture."

The equations for productivity growth are given below in (15) and (16). As in Krugman (1987) and Matsuyama (1992), we choose the simplest possible learning-by-doing mechanism in industry. Productivity growth in industry increases by v units per unit rise in the labor use, while productivity growth in agriculture increases by u units per unit rise in the technology gap $H = A_I/A_A$:

$$\frac{\dot{A}_I}{A_I} = v L_I, \tag{15}$$

$$\frac{\dot{A}_A}{A_A} = u H. \tag{16}$$

The specification of productivity growth in Matsuyama (1992) is thus a special case of our formulation. By setting $u = 0$ in our model, the productivity mechanism is similar to his.

In the dynamic part of the model, the labor surplus assumption and wage formation again need consideration. When unemployment increases in the short run, mechanisms to bring unemployment back down to a long-run equilibrium must be addressed. We consider two cases. First, we assume that the short-run increase in the consumer wage because of the discrimination of agriculture is maintained over time. The consumer real wages are not brought back down to their original level (given the productivity level). In this case, the discrimination policy towards agriculture is permanent. Second, we discuss the case when the increased unemployment and the higher consumer real wage in the short run puts downward pressure on wages in the long run. This second case can be interpreted either as long-run real wage rigidity (for given productivity), or as returning to some natural rate of unemployment in the long run. The two interpretations have the same steady-state implications in the model. In this case long-run relative prices adjust perfectly to overcome the nominal price regulation.

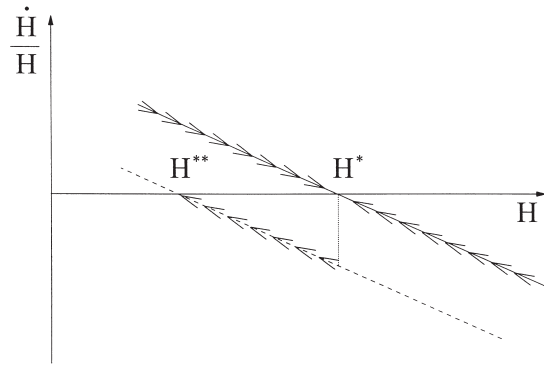The dynamics of the model are now best investigated by analyzing the development of the productivity gap H:

Figure 2. Dynamics of Relative Productivity

$$\frac{\dot{H}}{H} = \frac{\dot{A_I}}{A_I} - \frac{\dot{A_A}}{A_A} = vL_I - uH. \tag{17}$$

To check for stability, we derive

$$\frac{d(\dot{H}/H)}{dH} = v\frac{dL_I}{dH} - u < 0. \tag{18}$$

Since the productivity gap has a negative feedback on its own growth rate, the model has a stable steady state with a constant productivity gap between the sectors. The stability is illustrated in Figure 2, where the (initial) steady-state solution is denoted H^*. If $H > H^*$, H falls over time as indicated by the arrows until H is back at its steady-state value. Two factors contribute to this development. Assume that H lies above its steady-state value. First, the catch-up potential in agriculture is strong, and productivity in agriculture grows fast. Second, the industrial employment is below its steady-state value. Consequently, productivity growth in the industrial sector is weak. It follows that the productivity gap is reduced back to the steady-state value. By the same reasoning, if $H < H^*$, industrial productivity grows faster than agricultural productivity, and the productivity gap grows over time until $H = H^*$.

The endogenous balanced productivity growth mechanism differs from earlier two-sector models. van Wijnbergen (1984), Krugman (1987), and Matsuyama (1992) have unbalanced productivity growth by definition, since they have positive productivity growth in one sector and exogenous productivity in the other. Sachs and Warner (1995) have balanced productivity growth by assumption. Rauch (1997) and Torvik (2001) have balanced productivity growth when the elasticity of substitution in consumption is less than one. Higher productivity growth in one sector relative to another increases labor use and learning by doing in the sector with the lowest productivity growth, and in this way contributes to balanced growth. This mechanism is not present in our model, as the elasticity of substitution equals one. The two channels of balanced productivity growth in the present model have not been investigated in earlier dual models with endogenous productivity growth.

5. The Growth Consequences of Discriminating Agriculture

Since the domestic price level of agricultural goods is the policy instrument used to discriminate agriculture, the long-run consequences are essentially linked to the

response of another nominal variable, the wage level. When no mechanism brings the economy back to an equilibrium real wage, discrimination against agriculture through a lower nominal price has permanent effects. The economy reaches a steady state with endogenous growth characteristics, and policy affects the steady-state growth rate. In the case with long-run real wage rigidity or a natural level of unemployment, the economy reaches a steady state with neoclassical growth characteristics. The policy affects only the level of production, and the steady-state growth rate is undisturbed. In contrast to standard growth theory, the difference between the two cases is not a result of different assumptions regarding production functions, but different assumptions regarding wage formation.

When the domestic price of agricultural goods is reduced, the curve in the phase diagram in Figure 2 shifts downward under short-run real wage flexibility, since

$$-\frac{d(\dot{H}/H)}{dP_A} = -v\frac{dL_I}{dP_A} < 0. \tag{19}$$

When the agricultural price level is shifted down and the consumer real wage goes up, employment in the industrial sector decreases. The initial steady-state productivity gap is decreasing over time until the new steady-state value H^{**} is reached. Discrimination against agriculture reduces the steady-state productivity gap between agriculture and industry, since employment in the industrial sector is pushed down.

The development of the technology gap can be translated into growth paths of productivity in the two sectors, shown in Figure 3. Initially the economy has settled on a steady state with a constant productivity gap H^*. Since the productivity gap is constant, productivity grows by the same rate in the two sectors. In Figure 3, g denotes the overall growth rate of the economy, while g_A and g_I denote productivity growth in agriculture and industry, respectively. When P_A is reduced at time t_0, we know that H falls over time until $H = H^{**}$. Since the growth rate of productivity in agriculture equals uH, agricultural productivity growth starts declining when agriculture is discriminated. As H falls over time, so does the productivity growth rate in agriculture. When H reaches its new steady state, the agricultural productivity growth rate is also at a steady state. Since $H^{**} < H^*$, the growth rate of agricultural productivity in the new steady state, g_A^{**}, is lower than productivity growth in the old steady state, g_A^*.
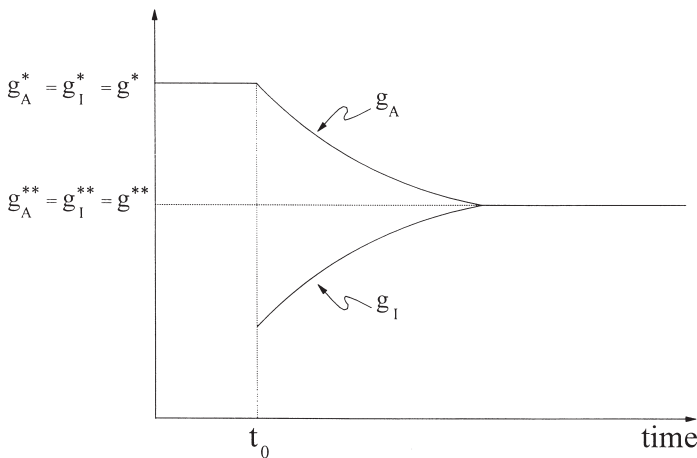

Figure 3. Growth Consequences of Discriminating Agriculture

The growth rate of industrial productivity, g_I, is given by vL_I. Since industrial employment is reduced with a lower P_A, the growth rate of productivity in industry shifts down when the agricultural price is lowered. After this initial shift, we know from the static model that since H falls over time, L_I must grow over time. Consequently, the growth rate increases over time following the initial drop in the industrial productivity. This process continues until g_I reaches its steady-state value g_I^{**}. The increase in g_I towards the new steady state cannot dominate the initial drop in g_I. The reason is simply that productivity growth in the two sectors must be the same in a steady state, and we have already found that $g_A^{**} < g_A^{*}$. It follows that $g_I^{**} < g_I^{*}$ and that industrial employment must be lower in the new steady state compared to the old.

As noted above, the static equilibrium variables P_I and E depend only on the productivity gap H, and not on the levels of productivity. Since the productivity gap is constant in the new steady state, the equilibrium values of P_I and E are constant. The relative price between industrial and agricultural goods is constant in the steady state, and the agricultural exports and intermediate imports grow by the rate g^{**}. The labor demand functions imply constant employment in both sectors. It follows from the production functions that g^{**} is the growth rate of production in both sectors, and thus the overall growth rate of the economy. The wages will grow at the same rate g^{**}. Since the growth rate of the overall income is g^{**}, this is also the growth rate of profits. No forces pull in the direction of full employment in the long run when agriculture is permanently discriminated against by a lower price of agricultural goods. Permanent discrimination reduces the growth rate of the economy with learning-by-doing.

In the case when $\gamma = 1$ in the long run, possibly interpreted as a fall in the real wage when unemployment is above the natural rate, one additional mechanism comes into play. Discrimination of agriculture immediately increases the consumer real wage (increases unemployment), and wages will be falling and employment increasing in both sectors. In terms of Figure 2, the curve for the dynamics of relative productivity is gradually shifting to the right since industrial employment increases compared to the case above (where employment only increases along the curve with lower H). The industrial growth rate increases faster and more than indicated by Figure 3. When $\gamma = 1$ in the long run, the real wage relative to productivity is not changed in the new steady state, and all relative prices return to old equilibrium values. Employment and the growth rate of production in both sectors are unaffected. The economy has returned to the natural rate of unemployment. But the level of production is lower. The temporary employment effect of agricultural discrimination produces less learning-by-doing in the transition to the new steady state. The steady-state growth rate is the same as before, but the growth path of the economy will be lower. As in the neoclassical model of growth, policy affects the level of production, but not the steady-state growth rate.

6. Concluding Remarks

We have shown that discrimination against agriculture combined with protectionism and import rationing can reduce economic growth permanently or temporary in a model designed to represent structural characteristics of sub-Saharan Africa. The policy of turning terms of trade against agriculture was meant to stimulate industry by reducing wage costs. But the agricultural policy was not compatible with the chosen foreign exchange regime. Governments took control of the foreign trade, and export revenues mainly generated in agriculture (and mining) financed priority inputs to industry. In this situation, the price squeeze on agriculture worsened the

foreign-revenue generating capacity and industry was compressed from the supply side.

As in earlier dual models, the dynamics of the development has been analyzed assuming learning-by-doing in industry, making that sector the potentially leading one in productivity growth. In contrast to the earlier literature, productivity in agriculture responds to the technology gap between the two sectors. Taking the structural characteristics of foreign trade restrictions and (at least short-term) unemployment into account, we turn around the standard open-economy dual model result that discrimination of agriculture increases growth. Discrimination against agriculture contracts industrial employment in the short run via the foreign exchange linkage, and in the long run industrial productivity growth and the technology gap are reduced. With real wage rigidity or a long-run natural level of unemployment, the policy affects the level of production, but not the steady-state growth rate. Irrespective of whether the growth rate or the steady-state level of production is reduced, the model explains how agricultural policy together with protectionism and foreign exchange rationing has contributed to stagnating employment and income level.

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