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Externalities in the agricultural export sector and economic growth: a developing country perspective

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Abstract

For years economists have ignored the diversity in agriculture and its potential to increase long run growth rates by enhancing a country's knowledge base. Non-traditional agriculture requires significant investments in the infrastructure and knowledge; and therefore, has the potential to increase long run growth rates. Policy makers in developing countries have tended to enact macroeconomic policies designed to enhance the manufacturing sector at the expense of the agricultural sector. A theoretical model is developed to explain the dynamics between two non-traditional export sectors and the long run economic growth of the country. The model illustrates that growth in highly perishable agricultural exports, not domestic production of manufactured goods, can potentially lead to higher long run growth rates. The model is applied to the fruit and flower industries in Colombia to bring forth an example with real world relevance. ©1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

Many prominent agricultural economists such as Adelman (1995); Adelman et al. (1995) have recognized the value and important role of agriculture in development. Adelman (1995), however, focuses on agricultural-demand-led industrialization (ADLI). ADLI focuses on shifting a greater share of domestic resources and investment into the agricultural sector than a purely export led strategy. The emphasis is on the small and medium scale farmer and increased agricultural productivity and the linkages provided by higher rural incomes. ADLI supports an open economy that leads to a more efficient allocation of resources since prices are no longer distorted. The ideas proposed in this paper differ from ADLI in that they emphasize the important and dynamic role of agricultural exports for economic growth. The model, in this paper, was developed to extend the commonly held belief that the agricultural sector could only affect long run growth rates through increased demand for manufactured goods or that the only road to development is through industrialization and manufacturing.

The externalities of agricultural led growth are many. Adelman and Robinson (1995) point out that others such as Frank and Webb (1977), Stewart and Streeten (1971), and Chenery et al. (1974) "suggest that certain changes in emphasis–for example, a shift to more labor-intensive technologies, to export promotion in trade policy, to rural rather than industrial development, or a broad based, skill-intensive growth strategy-might favor more equality and need not hinder rapid growth." Adelman (1995) suggests that an agricultural development program is more labor inten-

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sive than even labor intensive manufacturing. While traditional agricultural has its place in development, this paper addresses the value of non-traditional agriculture in development and its potential role as an engine of growth. Non-traditional agriculture in many cases requires a complex infrastructure and significant human capital investment before it can succeed; and, therefore should not be ignored in the policy agenda of developing countries. In the case of Colombia, the agricultural sector in its own right increased Colombia's GNP with fresh cut flower exports being Colombia's fourth largest export and fresh horticulture exports growing rapidly (UNCTAD, 1998).

To date endogenous growth models have identified human capital (knowledge) in a general sense as a source of growth (Lucas, 1988; Romer, 1990). In the model developed here it is only the human capital in the export sector that has the potential to increase growth rates. Given that in many developing countries human capital is limited, it should be utilized in sectors that have the most potential to add to the knowledge base, and consequently increase long run growth rates.

Research expended in the import competing sector will be considered redundant, while research in the export sector will be considered original research. Research is defined as the search to improve production efficiency, infrastructure, and/or knowledge. Research in the import competing sector is redundant because the goods could just be imported avoiding costly research, and human capital expenditures, in developing the good at home. Research in the export sector is considered original because it adds to country specific knowledge and leads to the growth of similar and interrelated industries.

However, it has been documented that research in the import competing sector does add to the stock of knowledge in the sense that minor innovations are made to adapt the foreign technology to domestic factors. For example, Katrak (1989) showed that in India imports increased the likelihood that an enterprise would commence R&D activity. The initial increase in R&D may be because the "imported technology must be adapted to local environments. But adaptive activity may not be the only type of effort induced by the imported technology. In fact, the experience gained through adaptive effort may enable enterprises to respond to other needs for R&D: for instance ... to undertake minor innovations" [Katrak (1989), p. 124)]. This is further supported by the results of Dessus (1999) as he posits that "the significant contribution of imported intermediate inputs to TFP growth could reflect the fact that copying and 'reverse engineering' of a broad range of foreign products was a valuable source of technological learning and improvement during the earlier period of Taiwan's industrialization." In this paper, the focus is on the benefits from research in the export sector, which utilizes imported intermediate goods.

The representative agent growth model in this paper resembles that of the Colombian economy in that it identifies the source of the growth as knowledge generated by human capital investment in an export sector, the flower industry. Human capital investment in the flower export sector has positive externalities; the country's knowledge base increases resulting in the growth of similar industries, such as the fruit and vegetable sectors. Research is separated into the import–competing and export sectors. The export sector is divided into two subsectors, proxying the flower and fruit/vegetable sectors, to capture the interplay of knowledge between the two non-traditional export sectors.

2. Export promotion as a source of growth

There are growth theory models that consider export promotion as a source of growth (Edwards, 1993); however, it is not the human capital investment in the export sector that is the driving force behind growth in these models. The rationale for considering exports "is based on a possible positive externality and technological diffusion effects generated by more rapid exports" (Edwards, 1993). Empirically, experiments by countries in import substitution have been dismal failures. Given the results of India's and many Latin American countries' import substitution policies, the "tide seems to have turned in the favor of export oriented policies. Export promotion creates incentives for entrepreneurship, productivity, and thrift" (Lal and Rajapatirana, 1987). Lal and Rajapatirana's (1987) survey of the literature on trade as an engine of growth concludes trade induces growth only in the sense it limits the government.

Lewis (1955), however, argues that developing countries that are more integrated with the world have an advantage in technology generated in the advanced countries. Another of the justifications for export promotion is that it moves a country on to its production possibilities frontier by equating international to domestic marginal rate of transformation (Krueger, 1980). Another is that trade allows an industry to capture the benefits of a larger market; i.e., increasing returns to scale, efficient plant size, and other indivisibilities in the production process. Chen and Tang (1987) conducted an empirical study of the technical efficiency of import–competing and export oriented–firms in Taiwan. They use data from an annual survey of foreign firms by the Taiwanese government in 1980. The firms are separated into import–competing and export–oriented firms. They conclude that export–oriented firms tend to be 6–11% closer to the production frontier than import–substitution oriented firms (Chen and Tang, 1987). The exact degree to which the firms are closer to the production function frontier depends on the specification of the model.

Edwards (1993) has done some initial empirical work on the absorption rate of technological advances and growth. Edwards considers a small developing country that faces given world prices and innovations that are developed in advanced countries. Given these proxies and other variables, Edwards finds that outward orientation and export growth have positive impacts on income growth.

Recent theoretical work on the importance of an open trade policy has been done by Rivera-Batiz and Romer (1991a, b). They have developed various models focusing on the fact that trade restrictions can possibly impede the free flow of knowledge, and consequently decrease world wide growth rates. Their models are one sector growth models that focus on two similar developed countries. World wide integration allows the countries to capture the increasing returns to scale in the research and development sector (Rivera-Batiz and Romer, 1991a). Additionally, a substantial amount of empirical research has been done on the externalities of knowledge and learning by doing in the export sector. This research has focused, however, on the micro-level and the interplay between these externalities at the firm level. Aitken et al. (1997), examine the question of whether firms that enter foreign markets reduce entry costs for other potential exports through learning effects or establishing commercial linkages. They find that export spillovers are restricted to multinational activity (p. 128) In their case examining the Mexican manufacturing sector, foreign firms provided a 'catalyst' for domestic firms to export. Using data from the Colombian manufacturing sector, Roberts and Tybout (1997) find that prior exporting experience significantly affects current decision to export but it quickly depreciates over time. They also find evidence that export infrastructure such as trading companies and distribution agents are important. Another study by Clerides et al. (1998), using manufacturing data from Colombia, Mexico, and Morocco indicates that there is some evidence to support the finding that exporters reduce the costs of breaking into foreign markets for domestically oriented producers. Developing countries' comparative advantage lies in their agricultural sector and large pool of unskilled and semi-skilled labor; yet, none of these studies approach the agricultural sector or examine externalities related to it. This paper moves this research one step further by developing a model that illustrates externalities in the agricultural export sector and applies the model to Colombia.

3. An application to Colombia

Colombia has a natural comparative advantage in growing and exporting fresh cut flowers (Mendez, 1991). (Henceforth fresh cut flowers will be referred to as flowers). The climate and luminosity conditions around the Savanna of Bogotá are ideal for growing flowers. Around the Savanna of Bogotá variations in temperature and humidity are minimal. This imparts a tremendous cost advantage since greenhouses do not have to be enclosed, nor do they require temperature and humidity controls. Natural growing conditions, including light, water, and soil, allow flowers to be grown year round (Lochhead, 1999). Additionally, it has a cheap supply of labor and is close to the American market. The flower industry is Colombia's second largest employer, providing some 75,00 direct and perhaps 50,00 more indirect ones (The Economist, 1993).

Flower exports by Colombia have been increasing since 1960, and by 1995 flowers had become Colombia's fourth largest export. The flowers first grew around the plains of Bogotá but now have spread

Table 1
A comparison of flower and fruit/vegetable exports (value in thousands of US dollars)

Year	Flowers	Fruit/vegetables[a]
1961	1	131
1965	20	348
1967		438
1968		911
1969		1226
1970	1000	1837
1971	1800	2889
1972	3100	3492
1973	8400	4933
1974	16000	13308
1975	19300	14980
1976	21600	11447
1977	32600	22222
1978	53400	21433
1979	79200	24572
1980	111837	113735
1981	123527	147557
1982	127108	177610
1983	134548	166527
1984	143011	213098
1985	148299	175046
1986	171212	228174
1987	160417	235577
1988	204989	278121
1989	240458	287016
1990	247280	359360
1991	300297	486097
1992	371008	453148
1993	408222	467987
1994	465917	530867
1995	517759	477100

[a] Excludes bananas 1961–1979 from UN data tapes: Flowers: SITC 29 (Crude vegetable matter) Fruits/vegetables: SITC 05 (Fruits and vegetables) 1980–1995 from STATS Canada: Flowers: SITC 2926 and 2927, 2926 bulbs, tubers and rhizomes of flowering or of foliage, 2927 cut flowers and foliage. Fruits/vegetables: SITC 0574 + 0575 + 0579 + 0586 + 0589, 0574 apples, fresh, 0575 grapes, fresh or dried, 0579 fruit, fresh or dried, n.e.s., 0586 fruit, temporarily preserved, 0589 fruit otherwise prepared or preserved, n.e.s. Data source: UN datatapes, Asocolfiores.

to areas in Colombia's mountainous Andean regions (Americas, 1990). From 1970 to 1980, flower exports increased tenfold, to US$100 million, and then doubled again in the next 8 years to reach US$206 million by the end of 1988, and by 1995 had increased to more than $500 million and continues to grow (see Table 1). In the late 1970's, there were only 1500 acres under floral cultivation; however, now there are 400 flower farms that cultivate more than 10,000 acres (Lennard, 1997). Colombia is now the world's largest exporter of carnations and second only to The Netherlands in world aggregate exports of flowers. Colombian growers are now expanding their markets by simultaneously introducing and marketing new types of flowers in the United States.

The government encouraged exports by not taxing inputs into the production process. In the case of flowers, the importation of the motherstock was essential for the growth of the industry. The motherstock and basic technology of the flower industries in Colombia were imported from Israel and Italy in the 1970's. In Colombia, under the *Vallejo Plan*, there are no tariffs on goods that are inputs into the production process of an export. However, the importer must pay royalties on the use of the motherstock. Thus, there are now laboratories in Colombia which are trying to propagate the motherstock to avoid these royalties. Most technology was imported and then adapted to the country's special characteristics. The imported technology was general knowledge regarding fertilizer and pesticide requirements, diseases and the treatment of these diseases. The irrigation systems used are now produced nationally as are the fertilizers and pesticides.

Flowers are handled as highly perishable products. In essence, cut flowers are like fruits/vegetables and deteriorate through complex physiological processes (Hardenburg et al., 1990). Flowers must be monitored and handled with knowledge from the farm to the consumer. Selling flowers requires a substantial investment in infrastructure which includes both physical and human capital. The process by which flowers are imported and sold in the United States is as follows: "the flower farms sell the produce to an importer who ships the flowers into the US, usually through Miami or New York. The importers sell the flowers to wholesalers, who then sell to the retail shops. The process usually takes about 1 week, and can take as long as 2 weeks (Mollenkamp, 1999)." Since flowers are highly perishable and often only have a limited life, it is important that principals involved in the exporting process be educated as to the needs of the flowers.

Colombia is known for the high quality of its flowers (Deveny, 1985). The flowers are treated with preservatives to extend shelf life. The process for harvesting, treating, storing and packing flowers for export is intricate (Hardenburg et al., 1990). Human capital investment in the flower industry has been significant. Additionally, a well developed marketing system exists to distribute and sell the flowers once they are imported. Many of the marketing firms are Colombian owned which facilitates entry into the market by exporters of other perishable goods. This general knowledge base provides a basis for other exporters of highly perishables.

To illustrate the value of the spillover effects, in 1999 Dole Food began to move into the fresh cut flower market by buying flower farms, and importing and marketing firms of flowers (Bloomberg News, 1998). In early 1999, Dole bought four of Colombia's largest and most successful flower growers, which account for about 25% of production (Rohter, 1999). Dole will bring to the Colombian flower industry its vast experience in growing, refrigeration, and distribution in perishables (Rohter, 1999). Aitken et al. (1997) found that the spillovers from multinationals is significant in the manufacturing industry in Mexico. There is no reason to believe these spillovers do not also exist in the non-traditional agricultural sector.

Colombian tropical fruits earned almost 360 million US dollars in foreign exchange in 1989 (Colombia Today, 1990). Bananas, as always, have been the bulk of perishable exports, but other fruit exports have increased (see Table 1). The new fruits exported include pineapples, mangoes, lemons, figs, strawberries, melons, papayas, curubas, and passion fruit. The storage life of these fruits varies from 1–6 months for lemons to 5–7 days for strawberries and figs. Pineapples, mangoes, papayas, and passion fruits survive for approximately 2–4 weeks in storage. The export of fresh fruits such as figs and strawberries requires a coordinated refrigeration system since they must be stored at OEC with a relative humidity of 85–90% (Hardenburg et al., 1990). These conditions resemble those of the needs of flowers. Exporting flowers is more difficult than fruits and vegetables since they have a shorter shelf life, are more fragile, and require a clear protective packaging material (Kravetz, 1998). The potential for other industries to grow once the necessary infrastructure is in place is tremendous (Thomas, 1985). The infrastructure and knowledge base created by flower exports can be utilized by growers of other perishable products. With infrastructure being one of the most significant constraints to the growth of perishable exports, the expansion of the floral industry has had a positive impact on the export sector, especially those related to perishable goods (see Table 1).

4. Theoretical model

The model, in this paper, considers the effects of human capital separated into import competing and export sectors on long run growth rates. The model is a representative agent one with three sectors, one import competing and two export sectors, and three laws of motion for knowledge, wealth, and capital. The model is a continuous time optimizing one which states that human capital research in the export sectors generates positive externalities for the economy as a whole through an increase in the knowledge base.

The focus of the model is on externalities from the development of export oriented industries. The model is made specific to be able to relate it to the flower industry and how developments in this industry facilitated the growth of the fresh fruit/vegetable industry. Since fresh cut flowers resemble fresh produce and other highly perishable goods, the knowledge gained by exporting flowers can be utilized by other exporters. The use of Colombia is to bring a real world example to a highly theoretical model but this in no way limits the model's applicability to other countries.

In this model the economy produces an import substituting good [C_m] and two exportables: equivalent to flowers [C_f] and fruits/vegetables [C_v]. The import competing good will be identified as the manufactured good. The export sector encompasses the agricultural commodities. The import competing good is produced domestically with the following production function: $M(K_m, L_m, H_m)$. The inputs are physical capital [K], labor [L], and human capital [H]. All the physical capital [K_m] is imported so the question of effects of domestically producing capital goods is not considered.

The exportables are produced with the following production functions: $F(A, T_f, L_f, H_f)$ and $V(A, T_v, L_v, H_v)$. Both the export sectors use land [T], which is inelastically supplied, in addition to human capital [H], and labor [L]. The amount of land allocated to each subsector is fixed to simplify the math. The dynamics of the lag between planting a tree and production of the fruit are not considered in this model. It is assumed that once a fruit tree is planted it produces immediately. The export sector also has another input: knowledge [A] that is a by-product of human capital [H_f] in the flower subsector.

The source of growth, in the more recent endogenous growth models, has been specified by technologies that are functions of factors that can be accumulated without bound on a per capita basis (Romer, 1990, 1991, 1992; Grossman and Helpman, 1990, 1991). One such factor that has received considerable attention is human capital formation (Lucas, 1988). Romer (1992) separated the process into human capital, which is bounded, and knowledge, which is a by-product of human capital and unbounded. Human capital is bounded because once an individual dies he/she takes his/her skills with him/her. Yet, the knowledge he/she contributed to society remains and is, therefore, unbounded and can be a source of growth and is described by a linear law of motion.

Available human capital is distributed between the three goods. Human capital investment in the export sector is assumed to produce a by product that adds to the country's stock of country specific knowledge [A]. In the Colombian case, it is the knowledge on how to handle and market highly perishable flowers that can be used by other export industries to facilitate their expansion. Once the knowledge base on how to export exists other industries benefit from this externality. The law of motion for knowledge is:

$$\dot{A} = [\beta H_f]A$$

Knowledge is a linear function of the productivity factor [β], human capital in the export subsector of flowers [H_f], and existing country specific knowledge [A]. Human capital investment in the import competing sector [H_m] or the other subsectors of the export sector [H_v] adds nothing to country specific knowledge [A]. The transfer of technology in this case is from flowers to fruits. In general it should not matter in which subsector the advancements are made as long as they are accessible to all the other export sectors. For example, it should be irrelevant whether the knowledge is developed first in the flower or fruit industry. The key is that it was profitable for the flower industry to succeed given the initial investment. Therefore, to simplify the math only human capital in the export subsector of flowers is included as part of the law of motion for knowledge.

The government's budget constraint is:

$$\pi^{m}[C_m - M] - \pi^{f}[F] - \pi^{v}[V] + \pi^{i}[I] = rb - \dot{b}$$

There are tariffs on imports of the consumption [π^m] and investment [π^i] goods. There could be a tax [π^f,π^v are negative] or subsidy [π^f,π^v are positive] depending on the signs of π^f and π^v on the exportables. The agent can buy bonds [b] from the government. The government gets its revenue from import tariffs on the investment good and the manufactured good. Additional revenue comes from the sale of bonds. The government can also collect money by taxing the exportable goods. Since it is assumed that there are no transfer payments, the government's only expense is to make interest [r] payments on the bonds it has outstanding and/or subsidy payments on the exportables.

The representative agent's budget constraint is

$$\dot{b} = [(1+\pi^{\mathrm{m}})M + (1+\pi^{\mathrm{f}})F + (1+\pi^{v})V] + rb - (1+\pi^{\mathrm{m}})C_{\mathrm{m}} - (1+\pi^{\mathrm{i}})l$$

Flowers and fruits are not consumed domestically; while the manufactured good is. This consumption pattern is assumed because in general in a developing country when a commodity is successfully exported only non-export quality goods are left for domestic consumers. For example, only non-export quality flowers are sold domestically in Colombia (Americas, 1990).

The sources of revenue for the representative agent are income from exporting the agricultural goods and interest earned on bonds purchased from the government. The agent spends his income on the investment good, consumption of the manufactured good, and bonds.

The law of motion for capital is

$$\dot{K} = l - \theta K$$

Gross investment is a function of new investment [l] and the existing capital stock [K]. The capital stock depreciates at a constant rate θ.

The representative agent maximizes utility subject to the agent's budget constraint, laws of motion for capital and knowledge, and the following resource constraints:

$$L = L_{\mathrm{m}} + L_{\mathrm{f}} + L_{v}$$
$$K = K_{\mathrm{m}}$$
$$H = H_{\mathrm{m}} + H_{\mathrm{f}} + H_{v}$$

labor supply and human capital are assumed to be fixed to reduce the number of state variables and make the mathematics more manageable. In this model, the representative agent recognizes the benefits of human capital investment in the flower sector when making his production decisions. If the agent failed to recognize the value of human capital in the flower industry to generate knowledge, the long run growth rate of the economy would be lower than optimal. Changes in the tariff and subsidy rates are exogenous.

The utility function is assumed to be concave. The three goods are assumed to be normal goods. Now solving the model:

$$\max \int_0^{\infty} e^{-\delta t} U(C_{\mathrm{mt}})dt$$

subject to the resource constraints and:

$$(\sigma)\dot{b} = [(1+\pi^{\mathrm{m}})M + (1+\pi^{\mathrm{f}})F + (1+\pi^{\mathrm{v}})V] + rb - (1+\pi^{\mathrm{m}})C_{\mathrm{m}} - (1+\pi^{\mathrm{i}})l$$

$$(\mu)\dot{K} = l - \theta K$$

$$(\phi)\dot{A} = [\beta H_{\mathrm{f}}]A$$

The shadow value of wealth, capital, and knowledge are σ, μ, and ϕ respectively. The production functions for the goods are assumed to be Cobb–Douglas. Empirical work on the agriculture sector in Colombia in general utilizes Cobb–Douglas production functions (Elias, 1985) and have been shown to characterize the economy well. The use of Cobb–Douglas production functions does not diminish the applicability of the model to other countries as the Cobb–Douglas form is often used to describe production functions in a multitude of sectors.

The production functions exhibit diminishing returns and are defined as follows:

$$M(L_{\mathrm{m}}, H_{\mathrm{m}}, K) \equiv L_{\mathrm{m}}{}^{\alpha_1} H_{\mathrm{m}}{}^{\alpha_2} K^{(1-\alpha_1-\alpha_2)}$$

$$F(L_{\mathrm{f}}, H_{\mathrm{f}}, T_{\mathrm{f}}, A) \equiv L_{\mathrm{f}}{}^{Y_1} H_{\mathrm{f}}{}^{Y_2} T_{\mathrm{f}}{}^{Y_3} A^{Y_4}$$

$$V(L_V, H_V, T_V, A) \equiv L_V{}^{\omega_1} H_V{}^{\omega_2} T_V{}^{\omega_3} A^{\omega_4}$$

Given the production functions, first order conditions and co-state equations it is possible to solve for the relationship between the growth rate of the shadow value of wealth and the growth rate of consumption:

$$\frac{\dot{\sigma}}{\sigma} = -(\alpha)\frac{\dot{C}_{\mathrm{m}}}{C_{\mathrm{m}}} \tag{1}$$

where α is the coefficient of relative risk aversion.

Solving for shadow value of wealth (s) and substituting it into the co-state equation for the shadow value of knowledge, it is possible to get the growth rate for the shadow value of knowledge as:

$$\frac{\dot{\phi}}{\phi} = (\delta - \beta H_{\mathrm{f}}) - \left[\frac{\beta[(1+\pi^V)\omega_4 V + (1+\pi^{\mathrm{f}})Y_4 F]H_V H_{\mathrm{f}}}{(1+\pi^V)\omega_2 V H_{\mathrm{f}} - (1+\pi^{\mathrm{f}})Y_2 F H_V}\right] \tag{2}$$

An inherent feature of a balanced growth equilibrium is that the following relationships hold for a fixed stock of labor and human capital:

$$\frac{\dot{C}}{C} = \frac{\dot{A}}{A} \quad \text{and} \quad \frac{\dot{\sigma}}{\sigma} = \frac{\dot{\phi}}{\phi} \tag{3}$$

Along a balanced growth path the rate of growth of consumption and knowledge must be equal by definition.

Combining Eq. (3) and using the relationship between the rate of growth of consumption and wealth (Eq. (1)), the following is obtained:

$$\frac{\dot{\phi}}{\phi} = (-\alpha)\frac{\dot{A}}{A} \tag{4}$$

Thus, the rate of growth of the shadow value of knowledge equals the rate of growth of knowledge times the coefficient of relative risk aversion on the balanced growth path.

Now it is possible to solve for g^* in terms of the exogenous variables in the model. Using Eq. (4) and the law of motion for knowledge, the long run equilibrium growth rate is given as:

$$-\alpha\beta H_{\mathrm{f}} = (\delta - \beta H_{\mathrm{f}}) - \beta\left[\frac{(1+\pi^{V})\omega_4 V + (1+\pi^{\mathrm{f}})Y_4 F}{(1+\pi^{V})\omega_2(V/H_V) - (1+\pi^{\mathrm{f}})Y_2(F/H_{\mathrm{f}})}\right] \tag{5}$$

The long run growth rate is positive provided the denominator in Eq. (5) is negative. Should human capital in the fruit/vegetable or the flower sector go to zero, the growth rate is undefined. Therefore, even though human capital in the flower industry increases the knowledge base, moving all human capital to the flower subsector is not a sustainable equilibrium. As human capital in the fruit/vegetable sector tends toward very small numbers the long run growth rate becomes small and, eventually, negative. A sustainable equilibrium involves production in all sectors of the economy not just the flower subsector.

Totally differentiating Eq. (5) and solving for the effect of a change in the subsidy on flowers exports [π^{f}] on the long run growth rate yields Eq. (A.1) which is outlined in the Appendix A. The derivative of the long run growth rate with respect to a subsidy in the flower subsector is positive suggesting that if the subsidy to the flower subsector increases so does the long run growth rate. The only term with an ambiguous sign in Eq. (A.1) is (Z). However, in order to have a positive growth rate (Z) must be negative. Regardless of whether the equation for (Z) is positive or negative the entire derivative will be positive. An increase in the subsidy drives human capital into the flower subsector as it expands. More human capital in the flower subsector adds to the country's stock of knowledge having a positive effect on the long run growth rate.

An increase in subsidies in the fruit/vegetable sector will have a negative effect on long run growth rates (as can been seen in Eq. (A.2), which is presented in the appendix). The derivative of the growth rate with respect to the subsidy in the fruit/vegetable sector is unambiguously negative. Once again the only ambiguous term in the equation is (Z). However, examining both the cases for (Z) still reveals that the derivative will be negative. An increase in the subsidy to the fruit/vegetable subsector will drive human capital from the other subsectors into the fruit/vegetable subsector as it expands. This movement of human capital reduces the country's stock of knowledge since human capital in the fruit/vegetable subsector does not add to country specific knowledge. If knowledge were a function of human capital in the fruit/vegetable subsector also, the effect of human capital movement into the fruit industry on long run growth rates would depend on whether human capital in the flower or fruit subsector had the greatest effect on long run growth rates.

An increase in the tariff in the import competing sector will also have a negative effect on long run growth rates (note Eq. (A.3) in the appendix). Movement of human capital into the manufacturing sector will reduce the long run growth rate. In this case, the equation for (Y) is the only term with an ambiguous sign. If the equation for (Y) is positive then the derivative is unambiguously negative. However, if (Y) is positive, the overall growth rate will be negative. If the equation for (Y) is negative, the derivative will still be negative, even though, the first term in the numerator of E_1 will be positive and the last term in E_1 will be negative. A tariff on the manufactured good increases the profitability of the manufacturing sector and drives human capital into that sector. Thus, an increase in the tariffs in the manufacturing sector will lead to lower long run growth rates. How low the growth rate will fall depends on whether human capital moves into the manufacturing sector from the fruit/vegetable sector or the flower sector. (E_1) and (Y) illustrate the trade offs between the marginal utilities of human capital in the three sectors. If more human capital is pulled from the fruit/vegetable sector than the flower sector, the derivative could be positive or have a minimum negative impact. For the equilibrium to be sustainable, human capital in the import competing sector can not tend toward zero because this would drive the long run growth to zero or negative rates. The actual levels of the subsidies and tariffs are bound by the government's budget constraint.

5. Conclusions

In the model developed in this paper, the premise is that only human capital in certain sectors has externalities and can be a source of growth. While increased levels of general human capital have social benefits for the economy, sector specific human capital has the potential to drive growth in an economy. In particular, human capital in the export sector is a source of externalities because it adds to country specific knowledge. In this case, human capital in a non-traditional agricultural export sector, the flower sector, is a source of knowledge. However, if the other sectors as defined in the model also contributed to the knowledge base there could come a point in time when they would have a larger impact on growth rates.

Since human capital tends to be limited in developing countries, it should be utilized in sectors where the country's comparative advantage lies. Human capital in the export sector can increase the country's comparative advantage allowing it to capture an even greater market share and wider market base. In the case of many developing countries it is the agricultural sector in which comparative advantage lies. In the Colombian example, expansion of the floral export sector had a significant impact on the expansion of highly perishable fruit and vegetable exports. Yet, too much of a good thing can be bad, a policy to shift all human capital into the flower sector would create an unsustainable equilibrium. Thus, while there may be a role for policy makers it is limited since long range foresight by policy makers often is hindered by their short run objectives. Given this, the second best policy prescription is a neutral one that does not favor any one sector but rather allows resources to move to the sector where the are valued the most.

The model in this paper reflects the value of export promotion and externalities in human capital to long run growth rates of developing countries. Export promotion shifts human capital into the export sector, traditionally the agricultural sector, and increases the possibilities for higher long run growth rates. The recent trend by policy makers to shift the negative bias of domestic and foreign policies away from the agricultural sector and move toward more neutral policies may provide additional evidence by which to test this model in the future.

Appendix A

Totally differentiating Eq. (5) and solving for the effect of a change in the subsidy on flowers exports [p^{f}] on the long run growth rate yields

$$\frac{\partial \dot{g}}{\partial \pi^{f}} = \frac{-(\beta/Z)Y_4F - \beta[(1+\pi^{\mathrm{f}})/Z^2]Y_4Y_2(F^2/H_F) - \beta A[(1+\pi^{V})/Z^2]\omega_4 Y_2 V(F/H_{\mathrm{f}})}{D_1 + D_2}$$

where

$$D_1 = \beta - \alpha\beta + \frac{\beta}{Z}\left[(1+\pi^{\mathrm{f}})Y_4Y_2\frac{F}{H_{\mathrm{f}}} - (1+\pi^{V})\omega_4\omega_2\frac{V}{H_V}\right]$$

$$D_2 = \frac{\beta}{Z^2}[(1+\pi^{V})\omega_4 V + (1+\pi^{\mathrm{f}})Y_4F] \times\left[(1+\pi^{V})(\omega_2)(\omega_2-1)\frac{V}{H_V^2} + (1+\pi^{\mathrm{f}})Y_2 \times(Y_2-1)\frac{F}{H_{\mathrm{f}}^2}\right]$$

$$Z = (1+\pi^{V})\omega_2\frac{V}{H_V} - (1+\pi^{\mathrm{f}})Y_2\frac{F}{H_{\mathrm{f}}} \qquad \text{(A.1)}$$

Eq. (A.2) reveals that an increase in subsidies in the fruit/vegetable sector will have a negative effect on long run growth rates:

$$\frac{\partial \dot{g}}{\partial \pi^V} = \frac{-(\beta/Z)\omega_4 V + \beta[(1+\pi^{\rm f})/Z^2]Y_4\omega_2 F(V/H_V) + \beta A[(1+\pi^V)/Z^2]\omega_4(-\omega_2)(\omega_2-1)(V/H_V^2)}{D_1 + D_2}$$

where

$$D_1 = \beta - \alpha\beta + \frac{\beta}{Z}\left[(1+\pi^{\rm f})Y_4Y_2\frac{F}{H_f} - (1+\pi^V)\omega_4\omega_2\frac{V}{H_V}\right]$$

$$D_2 = \frac{\beta}{Z^2}[(1+\pi^V)\omega_4 V + (1+\pi^{\rm f})Y_4 F] \times\left[(1+\pi^V)(\omega_2)(\omega_2-1)\frac{V}{H_V^2} + (1+\pi^{\rm f})Y_2 \times(Y_2-1)\frac{F}{H_{\rm f}^2}\right]$$

$$Z = (1+\pi^V)\omega_2\frac{V}{H_V} - (1+\pi^{\rm f})Y_2\frac{F}{H_{\rm f}} \qquad (A.2)$$

Eq. (A.3) illustrates that an increase in the tariff in the import competing sector will also have a negative effect on long run growth rates:

$$\frac{\partial \dot{g}}{\partial \pi^{\rm m}} = \frac{-(\beta/Y)\omega_4 V - \beta[(1+\pi^{\rm f})/Y^2]Y_4\alpha_2 F(M/H_{\rm m}) + \beta[(1+\pi^{\rm m})/Y^2]\omega_4\alpha_2(\alpha_2-1)V(M/H_{\rm m}^2)}{E_1 + E_2}$$

where

$$E_1 = \beta - \alpha\beta + \frac{\beta}{Y}\left[(1+\pi^{\rm f})Y_4Y_2\frac{F}{H_f} - (1+\pi^V)\omega_4\omega_2\frac{V}{H_V}\right]$$

$$E_\alpha = \frac{\beta}{Y^2}[(1+\pi^V)\omega_4 V + (1+\pi^{\rm f})Y_4 F] \times\left[(1+\pi^{\rm m})(\alpha_2)(\alpha_2-1)\frac{M}{H_m^2} + (1+\pi^{\rm f})Y_2 \times(Y_2-1)\frac{F}{H_{\rm f}^2}\right]$$

$$Y = (1+\pi^{\rm m})\alpha_2\frac{M}{H_m} - (1+\pi^{\rm f})Y_2\frac{F}{H_{\rm f}} \qquad (A.3)$$

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