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International Trade, Resource Curse and Demographic Transition

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Abstract

Demographic transition and international trade are introduced into classical models of development and rural urban migration by Lewis, Fei and Ranis, and Harris and Todaro. The basic result is that people working in the sector using natural resources have a higher birth rate and give less education to their children than people working in the modern sector using human capital as the sole input. Rural-urban migration thus changes parents' decisions on fertility and children's education: urbanization and demographic transition are two sides of the same coin. The model is also consistent with growth empirics finding no statistically significant relationship between education and growth while at the micro-level individual incomes are significantly affected by education. A closed economy never faces the resource curse. The autarkic growth rate is a weighted average of human capital growth rates in rural and urban areas with the weight equalling the share of rural goods in final demand. A resource abundant country opening to international trade may face resource curse if it completely specializes in the production of the resource intensive good. Its terms of trade can decline over an extended period if its population growth rate is high. This mechanism of terms of trade deterioration focuses solely on demographic factors and differs from the original Prebisch-Singer hypothesis. The result also shows the potential importance of birth control in development.

JEL Classification: F11, J13, J24, 013, 018, 019

Keywords: International trade, Resource curse, Rural-urban migration, Demographic transition

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1. Introduction

One of the best documented facts on economic growth is that globally growth rates have diverged at least since the early 1800's (Lucas 2002, Pritchett 1997). There are several explanations for this phenomenon starting from colonialism (Acemoglu, Johnson and Robinson 2001, 2003). Recently an attempt has been made to connect the divergence to demographic transition. By demographic transition (see Lee, 2003) I mean the process in which the onset of growth (and industrialization) is first accompanied by an increase in population growth rates[1] and later by a decline in birth rates with per capita incomes growing all the time. The connection between growth and fertility is built through the decisions within families. Families face the quantity-quality trade-off in deciding how many children to have. Parents can invest in children's education at the cost of having fewer children. The choice depends on what incentives the economic environment provides for the human capital accumulation. With good incentives children get education which feeds to growth. Higher growth in turn improves incentives further. Typical models (e.g. Lucas 2002, ch. 5, Galor and Weil 2000) study the factors that allow economies to escape the Malthusian steady state where increases in income lead to population expansion and return to low per capita incomes.

Aside from demographic transition other reasons for the divergence of global incomes have also been proposed. One such on which this paper focuses is the resource curse: countries with abundant natural resources have on average grown slowly compared to resource poor economies. The evidence is produced e.g. in Auty (2001), Gylfason (1999, 2001) and Perälä (2004). Currently the curse is most often associated with the political economy of resource abundance: the contest for resource rents can lead to civil wars and create corruption. Resource abundance thus leads to inefficient allocation of talent (Murphy, Shleifer and Vishny 1991). A more classic explanation is the Prebisch-Singer thesis which claims that the relative prices of resource abundant goods will fall over time implying that terms of trade of resource rich countries will decline.

In this paper, I focus on the role of international trade in creating resource curse. The feature separating the model built from the rest of the literature is that educational and fertility decisions are differentiated on the basis of parents' location: in rural areas where people are working in agriculture, decisions differ from those made in urban areas, where people work in the modern sector (some empirical evidence is presented in the next section).[2] Trade will, at least initially, improve the terms of trade of resource abundant economies. This shifts resources away from the human capital intensive production, and reduces incentives to accumulate human capital: people will move back to rural areas,

[1]In most cases due to the decline in mortality.

[2]Greenwood and Seshadri (2002) focus on the fertility differential between educated and uneducated parents and the connection between urbanization and demographic transition in a two-sector model. Yet, their model does not have any rural-urban migration. To model the transfer of resources between the sectors they assume that demand for agricultural products is income inelastic, an assumption not needed here. Finally, they do not have natural resources as an input to rural production and produce solely numerical results. de la Croix and Doepke (2003) have argued for the importance of differential fertility rates in explaining growth performance. The differential explored in this paper is based on parents' occupation but it also implies that relatively wealthier (in terms of human capital) parents have smaller number of children and give more education exactly as in de la Croix and Doepke.

where they want to have more children and provide less education. Hence, trade delays demographic transition and increases international growth differentials. If the increase in the birth rate is large enough, the terms of trade of the resource abundant country can decline over extended periods after improving initially. Moreover, the decline does not go on forever. This formalizes the possibility to terms-of-trade deterioration for countries specializing in production to resource intensive goods emphasized by Prebisch (1950) and Singer (1950). Yet, the mechanism producing the result in this paper does not have anything to do with the explanation provided by Prebisch and Singer as they emphasized the low income elasticity of demand for these goods. Here the focus is solely on demographic factors (which depend interestingly on the share of agricultural products in final demand).

The Prebisch-Singer hypothesis has raised heated debate, but currently there seems to be quite robust evidence that the terms of trade of countries exporting primary commodities have declined over a long period (Bunzel and Vogelsang 2003). In addition, there is also evidence that liberalizing trade has led to a terms of trade deterioration in some countries exporting primary commodities (Gilbert and Varangis 2004, McMillan and Rodrik 2002).

The model I develop is consistent with the stylized facts of demographic transition with both differential ferility and rural-urban migration being the building blocks of the explanation. It provides one explanation to the empirical growth research puzzle: in macro studies, it is hard to find any connection between education and growth, while in micro studies, there is a strong link between individual's education and incomes. Here the relationship between education and growth is convex while wages are strictly increasing in human capital and thus education.

Along with Galor and Weil (2000), Hazan and Berdugo (2002), Iyugin (2000), Kalemli-Oczan (2003) and Kögel and Prskawetz (2001) I use an overlapping-generations framework. In contrast to most of these models (Kögel and Prskawetz 2001 is an exception), I use a two-sector framework with intersectoral migration.[3] I am essentially putting demographic issues into the traditional Lewis-Fei-Ranis model of development augmented with rural-urban-migration. The migration model resembles closely the classic Harris-Todaro model in the sense that the urban wage is fixed each period by technology and past human accumulation decisions. There is no urban unemployment, however, as all prices are flexible.

Lucas (2004) builds an infinite horizon model of rural-urban migration.[4] His main point is to model a continuous process of migration, not just one shot jump, of people from rural areas (where there is no technological progress in production methods) to cities where production uses human capital. Continuous migration follows from assuming that

[3]In Hazan and Berdugo (2002) there are firms using either of two technologies to produce the same good. Workers can choose the type of firm they want to be employed in. Lucas (2001) ch. 5 contains a model where each representative family has access to two technologies to produce the same good. Neither one of these papers contains an analysis of rural-urban migration. In Kögel and Prskawetz (2001) (which basically adds fertility decision in Matsuyama 1992) there is no education and the driving force of growth is the exogenous change in agricultural productivity. Modern sector growth is driven by increasing returns due to specialization in the form of increasing varieties of intermediate products. Finally, labor movement between sectors do not have any implications for development as such in Kögel-Prskawetz while here they are crucial.

[4]I came across this paper after writing the first draft of my paper.

in cities there are externalities in human capital formation (there is no human capital formation in rural areas contrary to evidence in e.g. Kochar 2004) with the late migrants benefiting as an externality from the human capital formation of early migrants. Lucas' model is an one-sector model with two technologies but here rural and urban goods are different and their relative price matters for the migration decisions. This makes it harder to get a continuous flow of migrants from rural areas as the relative price of rural goods tends to increase due to migration. The key are the fertility and human capital accumulation decisions in rural and urban areas: rural fertility is higher than urban providing the pool of migrants. There is thus no need to assume externalities in human capital accumulation. Finally, one of the main points here is to tie rural-urban migration to demographic transition and to the role of international trade in economic growth. Both of these issues are beyond the focus of Lucas's model.

Recently, Galor and Mountford (2003) have, also in an OLG framework, noted the potential role of international trade in explaining the global divergence[5]. Their model is based on a Ricardian model of trade while the model here is of Heckscher-Ohlin (or Ricardo-Viner) variety. Galor and Mountford assume that countries initially differ across sectors in productivity when old technologies are used. Then they show that the more productive economy has an incentive to adopt new technologies, when they become available. International trade accelerates the transition of the more productive economy to sustained growth, while the process is delayed in the more backward economy. My model does not rely on any inherent technological differences in explaining the growth differences but ties them to differences in endogenously determined relative factor endowments in economies with explicit internal migration. Hence, I can e.g. focus on the crucial role of timing the opening of the country to international trade. My model ties the resource curse to the deterioration of terms of trade of the resource abundant economy, whereas in Galor and Mountford, the terms of trade deterioration is not possible. Also here, the rural-urban migration is crucial for development as it has been in the history, while in Galor and . In Galor and Mounford parents' fertility and educational decisions do not depend on the place of residence.

Another related study is Matsuyama (1992). In a two-sector infinite horizon model, he argues that an exogenous increase in agricultural productivity increases growth in a closed economy if the demand for agricultural products is income inelastic (as in Prebisch-Singer argument): improvements in agricultural productivity will then shift labor to manufacturing, where productivity growth is assumed to be of learning-by-doing variety. In an open economy, countries with high agricultural productivity specialize in agriculture, and thus their manufacturing sector declines reducing overall growth. In this paper, a similar type of mechanism is working: relatively resource abundant countries shift resources away from the modern sector when trade is opened. Yet, it does not mean that their welfare is reduced, as their terms of trade will improve, if they remain incompletely specialized. Matsuyama ignores the terms of trade effects. In this paper, labor movements are associated with changes in endogenous fertility and educational decisions which affect growth. Interestingly enough, endogenously determined fertility, on which opening of

[5]There is a heated debate on the role of economic openness in economic growth. Recent studies seem to show that the role of openness is small or insignificant once institutional quality is controlled for in estimations (Bosworth and Collins 2003).

trade has an effect, can have effects similar to improvements in agricultural productivity. In this respect, the present paper can be seen as endogenizing something that is exogenous in Matsuyama. Finally, our results do not depend on the assumption of inelastic demand for agricultural products but they would only be strenghtened were one to use that assumption.

2. The Model and the Closed Economy Equilibrium

People live in an overlapping generations economy for two periods. In the first period they are educated by their parents. There is by now much evidence that parent's have a strong influence on children's human capital (Oreopoulos, Page, and Stevens 2003 and Black, Devereux, and Salvanes 2003). In the second period, they work, make fertility decisions, and educate their children. People can work either in rural area in their farm, or in the modern sector of the urban area. In the rural sector production requires unskilled labor and resource to be called land. At the beginning of their working career (beginning of the second period of their life), people decide where to work. After that decision, they make the fertility and educational decisions. I first study the closed economy equilibrium

Consider first the decisions made in a representative farm household. Along with most of the literature[6], I assume that families have Cobb-Douglas preferences over their personal welfare derived from current consumption and over the incomes of their children. There is a trade-off between these two components of welfare, as raising and educating children takes parents' time, which reduces the time available for working thus reducing their consumption. The driving force of the model are the trade-offs rural and urban parents face. Parameter γ measures the degree of parents' selfishness, i.e. the weight they put to their own consumption. Since there are two goods produced in the economy, I also assume that the preferences over these goods are given by a Cobb-Douglas function with β = share of rural goods in total consumption. Preferences over goods are assumed to be independent of the residence, i.e. urban dwellers allocate their expenditure over goods in same proportions as residents in the rural area. The Cobb-Douglas specification implies that both goods will also be consumed and, hence, in the closed economy, produced in the country. Rural production requires labor and land as inputs. Rural production technology is also Cobb-Douglas with parameter α = weight of labor in input index. When parents know that all of their children have the possibility to work in the modern sector, and some of them will do it, the indirect utility function of a family living in the countryside at the beginning of their career in period t after deciding where to work is[7]

$$u_t^r = \left\{ \frac{p_t^r \left[n_t^r \left(1 - \left(\tau_0^r + \tau_1^r e_{t+1}^r\right) n_{t+1}^r\right)\right]^{\alpha} R^{1-\alpha}}{\left(p_t^r\right)^{\beta}} \right\}^{\gamma} \left\{ \frac{n_t^r \eta h_{t+1}^r n_{t+1}^r}{\left(p_{t+1}^r\right)^{\beta}} \right\}^{1-\gamma}, 0 < \alpha, \beta, \gamma < 1 \quad (1)$$

where p^r = price of the rural good, call it rye, n_t^r = number of members of the rural family working in the farm, n_{t+1}^r = number of children each of the n_t^r members of this

[6] Galor and Weil (2000) is a representative example. The alternative would be to assume that current family is concerned with the welfare of the families of their children. This is e.g. the route taken by Lucas (2002), ch. 5.

[7] Recently, Kochar 2004 has shown that in India the prospect of employment in urban areas and urban rates of return on human capital have an impact on educational decisions made in rural areas.

family will have, τ_0^r = time required in the rural area to raise one children regardless of the education given, τ_1^r = time required in the rural area per unit of education, e_{t+1}^r = education given to each child, R = land at the disposal of the family, β = share of rural goods in expenditure, and η = wage the children can earn in the urban sector per unit of human capital they have, determined by the modern sector production technology (see below). Each person is assumed to have 1 unit of time available that can be used either to work or to raise children including children's education. The crucial assumption underlying (1) is that current parents know that their children can work in either sector and mobility is perfect. Hence, children's income is given by the income they can earn in the urban sector. This income is directly proportional to the children's human capital. Also it is assumed that each adult has 1 unit of time which can be used to work or raise and educate children. In the farm, the total amount of time is thus n_t^r and I assume that each adult participates in raising the children. This is thus a model of an extended family, a family consisting of n_t^r members, each of whom has own children. The currently working urban generation maximizes u_t^r by choosing n_{t+1}^r and e_{t+1}^r. In choosing the education the family understands that it affects the future human capital of the children:

$$h_{t+1}^r = h\left(e_{t+1}^r, h_t^p\right), h_e, h_h > 0 \tag{2}$$

where h_t^p = parents' human capital. This makes the human capital of a child dependent on the mobility history of her parents in addition to current location of her parents. I assume away all externalities, though it would be rather easy to include them[8]. The first order conditions of the optimum are, after some straightforward manipulation[9] (first for n_{t+1}^r, then for e_{t+1}^r):

$$[\gamma\alpha + (1-\gamma)]\left(\tau_0^r + \tau_1^r e_{t+1}^r\right) n_{t+1}^r = (1-\gamma) \tag{3}$$

and

$$-\tau_1^r h_{t+1}^r + \left(\tau_0^r + \tau_1^r e_{t+1}^r\right) h_e = 0 \tag{4}$$

An interesting implication of (3) is that the total time rural household allocates to children's education is given by

$$\left(\tau_0^r + \tau_1^r e_{t+1}^r\right) n_{t+1}^r = \frac{1-\gamma}{\gamma\alpha + (1-\gamma)}(< 1) \tag{5}$$

In addition to showing that there is a quality-quantity trade-off in making the fertility decision, it also shows that rural production technology has an impact on it. The stronger

[8]One could e.g. include spill overs so that people who move to cities will improve their human capital to the urban level right after moving or that their children will learn from other urban families. Lucas (2004) follows this track. Not much would change after these changes. The only significant change would be that urban income inequality would be reduced from what the model now implies.

[9]Assuming that rural technology is Cobb-Douglas (in addition to the other assumptions) the resource endowment of the family does not have any effect on household decisions on fertility and education. With e.g. a general CES technology the impact would be ambiguous. de la Croix and Doepke (2003) build a model where wealth effect matter for the fertility and educational choices. Here the point is to derive a model where rural and urban people make different choices. As becomes apparent, one need not introduce wealth effects to model the difference.

the diminishing returns in labor are (the smaller α is), the larger is the time allocated to getting and raising children. This is intuitive: the less productive labor is in rye production the more productive it is (relatively speaking) in producing new children.

Consider next the urban household. Its (indirect) utility is, analogously to (1), given by

$$u_t^u = \left\{ \frac{w_t h_t \left[1 - \left(\tau_0^u + \tau_1^u e_{t+1}^u\right) n_{t+1}^u\right]}{\left(p_t^r\right)^\beta} \right\}^\gamma \left\{ \frac{w_{t+1} h_{t+1}^u n_{t+1}^u}{\left(p_{t+1}^r\right)^\beta} \right\}^{1-\gamma} \tag{6}$$

This is a utility function of a small, one member, family, not of an extended family like in the countryside. The technology available for raising and educating children is allowed to differ between rural and urban areas. The degree of altruism towards the next generation is assumed to be the same everywhere in the society. Also the technology of human capital accumulation is the same everywhere[10]

$$h_{t+1}^u = h(e_{t+1}^u, h_t^p), h_e, h_h > 0 \tag{7}$$

The optimal choices are characterized by the following equations:

$$\left(\tau_0^u + \tau_1^u e_{t+1}^u\right) n_{t+1}^u = 1 - \gamma \tag{8}$$

and

$$-\tau_1^u h_{t+1}^u + \left(\tau_0^u + \tau_1^u e_{t+1}^u\right) h_e = 0 \tag{9}$$

Comparing (5) with (8) directly yields the first result: Rural households spend more total time on children than urban households do. In particular, if the educational decisions are identical then rural households are more fertile than urban households.

To get ahead with the educational decisions I assume that (2) and (7) have the following specification:

$$h_{t+1}^j = \left(1 + e_{t+1}^j\right)^\theta h_t^p, 0 < \theta < 1, j = r, u \tag{10}$$

giving from (4) and (9)

$$\begin{aligned} e_{t+1}^j &= \frac{\theta \tau_0^j - \tau_1^j}{(1-\theta)\tau_1^j} \equiv e^j, \theta \tau_0^j - \tau_1^j > 0 \\ &= 0, \theta \tau_0^j - \tau_1^j \leq 0 \end{aligned} \tag{11}$$

The parameters must fulfill $\theta \tau_0^j - \tau_1^j > 0$ to have positive investment in education. I assume that the time cost of education is the same in both areas ($\tau_1^r = \tau_1^u$). The time cost of raising children in the urban area is larger than in the rural area, $\tau_0^u > \tau_0^r$. The idea here is that the children in rural areas can more easily stay around when the parents work than in urban areas and that there are some economies of scale in raising children

[10] Naturally, at time t, the human capital stock can differ, in general, between parents in cities and parents in the countryside. Similarly, human capital stock between parents in the same location can differ, depending on how long time ago their ancestors located there.

in extended families. These assumptions imply that $e^r_{t+1} < e^u_{t+1}$: less time is devoted to improving the quality of children in rural areas than in urban areas. Indeed, the threshold value of returns to education above which education is provided is larger in rural than in urban areas. In conclusion, a larger number of children are born for each generation in rural areas, and they receive less education than in urban areas.

Greenwood and Seshadri (2002) gives evidence on the rural-urban fertility difference for the USA. Finland provides another example of differentiated fertility rates. Finnish industrialization is usually said to have started during 1860's. During years 1936-1975 rural net and gross reproduction rates exceeded the urban rates (The Economic History of Finland 3 1983, Historical Statistics, Table 1.15). For earlier periods (1860-1920) there are no statistics on reproduction rates but the number of children born alive per family was larger in countryside than in cities (The Economic History of Finland 2, 1982, Table 20). At the same time the share of urban population began to grow rapidly: in 1860 6 per cent of population lived in cities, in 1920 16 per cent.

Our model implies that rural urban migration, ceteris paribus, shows up as a reduction in the birth rate. In this model then, demographic transition in the sense of declining birth rates, is equivalent to observing rural-urban migration. For future reference, one can calculate from (5), (8), and (11)

$$\begin{aligned} n^r_{t+1} &= \frac{(1-\gamma)(1-\theta)}{(\alpha\gamma+1-\gamma)(\tau^r_0-\tau_1)} \equiv n^r \\ n^u_{t+1} &= \frac{(1-\gamma)(1-\theta)}{(\tau^u_0-\tau_1)} \equiv n^u \end{aligned} \tag{12}$$

If no education is given then

$$\begin{aligned} n^r &= \frac{(1-\gamma)}{(\alpha\gamma+1-\gamma)\tau^r_0} \\ n^u &= \frac{(1-\gamma)}{\tau^u_0} \end{aligned} \tag{13}$$

For future reference one must also note that (using (11) in (5) and (8)):

$$\begin{aligned} n^r(1+e^r)^\theta &= \left(\frac{1-\gamma}{\alpha\gamma+1-\gamma}\right)\left(\frac{1-\theta}{\tau^r_0-\tau_1}\right)^{1-\theta}\left(\frac{\theta}{\tau_1}\right)^\theta \\ n^u(1+e^u)^\theta &= (1-\gamma)\left(\frac{1-\theta}{\tau^u_0-\tau_1}\right)^{1-\theta}\left(\frac{\theta}{\tau_1}\right)^\theta \end{aligned} \tag{14}$$

(14) implies that $n^r(1+e^r)^\theta > n^u(1+e^u)^\theta$ as as $\tau^u_0 > \tau^r_0$. Each child born in cities receive higher education, but the aggregate human capital created by an urban parent is smaller than the one created by a rural parent, as the rural parent has more children. The effect from fertility dominates as the total time allocated to both raising and educating children in countryside exceeds the urban time used for the same purposes. The result has an implication for the aggregate growth rate of the economy as argued below.

(14) also implies that $n^j(1+e^j)^\theta$ reaches its minimum (as a function of θ) at $\frac{\tau^j_0-\tau_1}{\tau^j_0}$ where $n^r(1+e^r)^\theta = \frac{(1-\gamma)}{(\alpha\gamma+1-\gamma)\tau^r_0}$ and $n^u(1+e^u)^\theta = \frac{(1-\gamma)}{\tau^u_0}$, i.e. at levels without education.

The intuition is that if returns to education increase, then initially fertility rate declines faster than the human capital from education. Only when the returns to education are high enough, a further increase in θ increases the total human capital created in families. Since $\left(\frac{1-\theta}{\tau_0^r-\tau_1}\right)^{1-\theta}\left(\frac{\theta}{\tau_1}\right)^{\theta}$ is a convex function, the maximum human capital is created if returns to education are either maximal ($\theta=1$) or minimal feasible. Thus, if $\frac{\tau_1}{\tau_0^j}<\frac{\tau_0^j-\tau_1}{\tau_0^j}$, i.e. $2\tau_1<\tau_0^j$, then

$$\max_{\theta} n^r\left(1+e^r\right)^{\theta}=\max\left\{\lim_{\theta\to\left(\frac{\tau_1}{\tau_0^r}\right)^+}\left(\frac{1-\gamma}{\alpha\gamma+1-\gamma}\right)\left(\frac{1-\theta}{\tau_0^r-\tau_1}\right)^{1-\theta}\left(\frac{\theta}{\tau_1}\right)^{\theta},\frac{1-\gamma}{\left(\alpha\gamma+1-\gamma\right)\tau_1}\right\} \tag{15}$$

$$\max_{\theta} n^u\left(1+e^u\right)^{\theta}=\max\left\{\lim_{\theta\to\left(\frac{\tau_1}{\tau_0^u}\right)^+}\frac{\left(1-\gamma\right)\left(1-\theta\right)}{\left(\tau_0^u-\tau_1\right)},\frac{1-\gamma}{\tau_1}\right\}$$

and if $\frac{\tau_1}{\tau_0^j}>\frac{\tau_0^j-\tau_1}{\tau_0^j}$ (i.e. $2\tau_1>\tau_0^j$) then

$$\max_{\theta} n^r\left(1+e^r\right)^{\theta}=\frac{1-\gamma}{\left(\alpha\gamma+1-\gamma\right)\tau_1} \tag{16}$$

$$\max_{\theta} n^u\left(1+e^u\right)^{\theta}=\frac{1-\gamma}{\tau_1}$$

One implication of (15) and (16) is that human capital formation and thus also economic growth can increase substantially after just a marginal increase in the returns to education, and even if only a very small amount of education is provided. (15) also tells that the human capital and economic growth rate may be at the highest level at small amounts of education. Yet, the model is perfectly consistent with the empirical growth research which has not found at the macro level any systematic relationship between the quantity of education and growth, while at the same time there is strong evidence of beneficial impact of education on earnings (and thus on productivity) at the micro-level (Bosworth and Collins 2003)[11]. Since equations (14) are convex in θ, they imply a convex relationship between education and human capital formation at the macro level. With convexity, a cross-country aggregate growth regression would thus most likely not find education to be a statistically significant explanatory variable, unless it is properly taken into account. In fact, Barro and Sala-i-Martin (1995) suggest that the convexity might be the source of insignicance. But even if one cannot find any significant statistically relation at the macro level at the micro level each person's income increases with education, and this is what the model here also implies.

To specify the equilibrium in the aggregate economy the production of the modern, urban sector is given by

$$Q_t^u=\eta\widetilde{H}_t,\eta>0$$

[11] Krueger and Lindahl (2001) obtain statistically significant effects of education on growth after correcting for measurement efforts. Bosworth and Collins (2003) use the same corrections but do not get statistically significant effects after controlling for other variables affecting growth.

where $\widetilde{H}_t$ = aggregate human capital stock of workers working in the urban sector in period t. This specification implies (assuming all markets to be competitive) that an uneducated urban worker (having human capital equal to 1 if her parents also are uneducated) gets wage η, and a worker with human capital h_t receives wage ηh_t.

Since human capital is used only in the urban sector, and the human capital grows as long as the urban good is produced, there will be rural-urban migration, at least over some generations. Below it is shown that rural-urban migration goes on forever. Mokyr (2002) has noted that historically rural-urban migration coincided with the switch of employment between traditional production and modern factory work, as the latter required that people be collected to the same place. This was necessary both for technological reasons and for the reason that cost of moving people declined relative to the cost of utilizing the knowledge on which modern production is based. The productivity of the urban production relative to rural production grows continuously improving urban relative income.[12]

At the beginning of period t the generation then entering the labor market chooses in which sector to work. In equilibrium the income in both sectors (net of costs due to fertility and educational decisions) must be the same. To formulate the migration decision I use the fundamental assumption in the traditional development model of Lewis (1954) and its extension by Fei and Ranis (1964): within a rural household, income is divided equally between family members. Hence, everybody's income is given by the average productivity of labor. Given the concave production function, this implies that rural employment is "excessive" or that there is disguised unemployment as the marginal productivity is lower than the average productivity. It is also a simple way to catch the notion of "tragedy of commons" associated with resource abundance and currently emphasized as a source of inefficiency leading to the resource curse.

Assume accordingly that the income is divided equally within the rural household. The natural equilibrium condition for migration would be the requirement that for each potential migrant the utility from staying in the countryside equals the utility to be received in cities. The problem is that rural individual utility is not defined in the model, as (1) gives the utility of the rural extended family, not the utility of an individual living in countryside. To equate individual utility with the average utility in the family would also be absurd. Instead, I assume that in equilibrium rural and urban incomes for potential migrants must be equal. This condition also underlies the rural utility function (1). Hence, the equilibrium condition for rural-urban migration becomes[13], using (5) and (8):

$$\frac{p_t^r \left[\widetilde{n}_t^r \frac{\alpha\gamma}{\alpha\gamma+(1-\gamma)}\right]^\alpha R^{1-\alpha}}{\widetilde{n}_t^r} = \gamma\eta h_t^r \tag{17}$$

[12]There is much evidence that productivity in agriculture is lower than in manufacturing (see e.g. Thirlwall 1994, pp. 54-56). One could relatively easily add human capital as an input to the agricultural production and assume its impact on productivity to be small relative to the urban sector. Alternatively, one could assume that there is some spillover from the urban sector to agricultural productivity. For analytical purposes these are left out, as the main point is in relative productivity.

[13]This formulation assumes that the ancestors of the people in countryside have always lived there, i.e. there has not been any urban-rural migration.

which can be solved for the number of people working in a rural household:

$$\widetilde{n}_t^r = \left(\frac{\gamma\eta h_t^r}{p_t^r \Gamma^\alpha}\right)^{-\frac{1}{1-\alpha}} R \tag{18}$$

where $\Gamma \equiv \frac{\alpha\gamma}{\alpha\gamma+(1-\gamma)}$ and $h_t^r = (1+e^r)^{\theta t}$. There will be less rural-urban migration the higher the price of agricultural goods, the smaller the human capital of people born in the countryside, and the higher the resource endowment of the rural extended family. Assume that there are N^r rural extended families and that the total number of people born in rural areas in period $t-1$ is n_t^{rb}. Then in period t the total working rural and urban populations are

$$\begin{aligned} N_t^r &= N^r \widetilde{n}_t^r \\ N_t^u &= N^r \left(n_t^{rb} - \widetilde{n}_t^r\right) + N^r n_t^{ub} \end{aligned} \tag{19}$$

where n_t^{ub} = urban population born in period $t-1$. In (19) one must remember that people born in cities also originally come from the same extended families as those born in countryside. To get solution for p_t, one must still solve for the equilibrium prices. Using (18) and (5) the aggregate supply of the agricultural good is

$$N^r \left(\frac{p_t^r \Gamma}{\gamma\eta h_t^r}\right)^{\frac{\alpha}{1-\alpha}} R \tag{20}$$

In equilibrium, all the working citizens earn the same base wage (because of migration), augmented by their human capital. From (17) we have that total income earned in a farm is $\gamma\eta h_t^r \widetilde{n}_t^r$. Aggregate expenditure on rye is then given by[14]

$$\begin{aligned} &\beta\eta \left[\gamma N^r H_t^u + \gamma N^r \widetilde{n}_t^r h_t^r + \gamma N^r \left(n_t^{rb} - \widetilde{n}_t^r\right) h_t^r\right] = \\ &\beta\eta\gamma \left[N^r \left(H_t^u + H_t^r\right)\right] \end{aligned} \tag{21}$$

where H_t^u = aggregate human capital of the people born in the urban area for each of N^r original families in period $t-1$, H_t^r = aggregate human capital in each family of the people born in the rural area in $t-1 = n_t^{rb} h_t^r$. Equating nominal expenditure to nominal supply, using (18) and (20), gives the equilibrium condition for the rye market and solving it gives the price equation:

$$p_t^r = \frac{(\beta\eta\gamma H_t)^{1-\alpha} (\eta\gamma h_t^r)^\alpha}{\Gamma^\alpha R^{(1-\alpha)}} \tag{22}$$

where $H_t \equiv H_t^u + H_t^r$ = aggregate human capital. This can be substituted in (18) to get the full reduced form presentation of rural-urban migration in period t. The solution is

$$\widetilde{n}_t^r = \frac{\beta H_t}{h_t^r} \tag{23}$$

These results can be collected in the first proposition:

[14]Note that each person's income takes into account the supply of labor net of time spent on raising and educating children.

Proposition 1 *In autarky for given levels of aggregate human capital and rural human capital, the relative price of the resource intensive good will be lower in a more resource abundant country but rural population is independent of the resource availability.*

The intuition here for the independence of the rural population from resource endowment is the following: while larger resource stock increases the productivity of rural labor it also implies that the price of the rural good is lower, which reduces incentives to migrate. With the assumed functional forms these effects cancel each other. This is clearly a knife-edge case but these two effects are present in more general models, whereby the net result is ambiguous. With a general homothetic utility function it is easy to show that larger resource endowment reduces (increases) rural-urban migration as the price elasticity of demand for rye is smaller (larger) than unity.

Note that (23) does not imply that there is no rural-urban migration as human capital grows. The rural birth rate is higher than the urban birth rate. If it is high enough, there is rural-urban migration even though simultaneously also the rural population grows. To see this, imagine period 0 at which modern production starts and there is migration to factories in the cities. Let the population at the beginning of period be n_0. Rural population in period 0 is β by (23) as human capital is equal to unity. Assume that $n_0 > \beta$. Aggregate human capital at the beginning of period 1 is $H_1 = \beta n^r (1+e^r)^\theta + (n_0 - \beta) n^u (1+e^u)^\theta$, and $h_1^r = (1+e^r)^\theta$. Since $H_0 = n_0$ and $h_0^r = 1$ there will be rural-urban migration in period 1 if at the beginning of period 1 there are more people in the rural area than eventually want to stay there. This holds as long as $\frac{H_1}{h_1^r}/\frac{H_0}{h_0^r} < n^r$, which is equivalent to $n^r (1+e^r)^\theta > n^u (1+e^u)^\theta$, which holds by (14).

In general, one can derive the dynamics for this economy as follows[15]: By definition the following holds for H_t^u

$$H_t^u = H_{t-1}^u n^u (1+e^u)^\theta + \left(n_{t-1}^{rb} - \widetilde{n}_{t-1}^r\right)(1+e^r)^{\theta(t-1)} n^u (1+e^u)^\theta \tag{24}$$

Also by definition $n_{t-1}^{rb} = \widetilde{n}_{t-2}^r n^r$. Using (23) twice (24) and can be written as

$$H_t^u = n^u (1+e^u)^\theta \left[H_{t-1}^u - \beta H_{t-1} + \beta n^r (1+e^r)^\theta H_{t-2}\right] \tag{25}$$

At the same time, aggregate human capital is by definition

$$H_t = \widetilde{n}_{t-1}^r n^r (1+e^r)^{\theta t} + H_t^u \tag{26}$$

which yields finally

$$\begin{aligned} H_t &= \beta \frac{H_{t-1}}{h_{t-1}^r} n^r (1+e^r)^{\theta t} + H_t^u = \\ &\quad \beta n^r (1+e^r)^\theta H_{t-1} + H_t^u \end{aligned} \tag{27}$$

[15]I derive the dynamics for the case where $e^j > 0$, j = r,u. Formally the dynamic system is the same for the other cases but in some situations there would be urban-rural -migration. For the case where e^j = 0 for both j = r,u, the results hold. In case where no education is given in the countryside but there is urban education there may be urban-rural migration. But even then this is not necessary, as will be shown in the next section.

The difference equation system (25) and (27) can be solved. The system governs the economy, as long as $\widetilde{n}_t^r < \widetilde{n}_{t-1}^r n^r$, i.e. as long as there is rural-urban migration. The condition can be rewritten as $\frac{H_t}{H_{t-1}} < n^r (1+e^r)^\theta$. Using the lag operator L (25) can be rewritten as

$$(1-yL) H_t^u = (-\beta y + \beta x y L) H_{t-1}$$

where $x \equiv n^r (1+e^r)^\theta$ and $y \equiv n^u (1+e^u)^\theta$.[16] Using this in (27) gives

$$\begin{aligned} H_t &= \beta x H_{t-1} + \frac{-\beta y + \beta x y L}{1-yL} H_{t-1} \Leftrightarrow \qquad (28)\\ (1-yL) H_t &= (1-yL) \beta x H_{t-1} + (-\beta y + \beta x y L) H_{t-1} \Leftrightarrow \\ H_t &= [\beta x + (1-\beta) y] H_{t-1} \end{aligned}$$

(28) implies the following result:

Proposition 2 *Assume that $e^j > 0$, $j = r, u$. Then there is always rural-urban migration, i.e. the migration flows never reverse.*

Proof: (28) gives $\frac{H_t}{H_{t-1}} = \beta x + (1-\beta) y$. There is rural urban migration (as shown above) if and only if $\beta x + (1-\beta) y < x$. This is equivalent to having $y < x$, i.e. $n^u (1+e^u)^\theta < n^r (1+e^r)^\theta$, which was shown to hold above.■

Using similar reasoning one can also find the reduced form difference equation governing urban based human capital H_t^u. It is

$$H_t^u = [\beta x + (1-\beta) y] H_{t-1}^u \qquad (29)$$

Aggregate and urban based human capital grow at the same rate. It equals also the growth rate of the modern sector production as

$$\begin{aligned} Q_t^u &= \eta \left[H_t^u + \left(n_t^{rb} - \widetilde{n}_t^r \right) h_t^r \right] = \qquad (30)\\ &\eta \left[H_t^u + \beta \left(\frac{n^r (1+e^r)^\theta}{\beta n^r (1+e^r)^\theta + (1-\beta) n^u (1+e^u)^\theta} - 1 \right) H_t \right] \end{aligned}$$

A remarkable feature in (28), (29), and (30) is that the growth rate depends on both fertility and educational decisions. Furthermore, it is a weighted average of the decisions made in countryside and cities. The weight is given by the share of traditional goods on total consumer expenditure. In the aggregate, in any given period, the addition to human capital is larger in the countryside than in the urban areas. In the countryside, children are less educated than in cities, but there are more children per resident than in cities. The latter effect dominates making $n^u (1+e^u)^\theta < n^r (1+e^r)^\theta$. Since rural population is basically determined by the demand for the resource intensive good, the growth rate of the modern sector is higher, the larger is the share of final demand allocated to the non-modern sector good. This type of an effect is absent from more standard endogenous

[16] I am assuming that $y \neq 1$.

growth models, and here it is derived from differential fertility and educational choices across sectors in the economy[17]. Also, the Verdoorn's law (Thirlwall 1994, pp. 60-61) holds here, as aggregate economic growth is equivalent to growth in the modern sector. But as was just argued, the demand for the goods produced in the traditional sector is a crucial determinant of the growth rate because of the demographic factors.

Note that the model implies that the rural output will grow at a lower rate than the urban output, as one should see for it to be consistent with stylized facts. Rural output grows at a rate (using (23)) $\left(\frac{\beta x+(1-\beta)y}{(1+e^{r})^{\theta}}\right)^{\alpha}$ which clearly is smaller than the urban growth rate $\beta x+(1-\beta)\,y$.

Another interesting aspect of the growth process here is that there will be an ever-widening urban-rural average income gap. This is because the rural personal human capital grows at a slower rate than the human capital of people living in cities. In addition, relative incomes of people in cities stay constant, but personal income dispersion will grow: there will be new migrants whose incomes become every period lower than incomes of the people who have resided in cities over many periods. Incomes of those people, who are descendants of people who moved to cities in period 0, grow all the time relative to new migrants' incomes. These people form the "urban elite".

Finally, one can note that the model is reminiscent of the unbalanced growth model of Baumol (1967). Baumol's concern there was that in an economy with two sectors if the productivity in one of the sectors grows faster than in the other then in the long run the slow productivity growth sector will end up taking all the resources. Here the economy also has two sectors in one of which productivity growth is faster. Yet, the more productive sector will expand also by drawing resources from the sector with low productivity. The difference to Baumol's model comes from demographics (rural population growth exceeds the urban population growth) and from human capital formation which provides incentives for the people to move to cities.

Equations (22) and (23) raise an interesting possibility, which is crucial for the main argument of the paper, that without international trade, resource abundant countries can have a higher growth rate in the modern sector than resource poor economies. They also imply that depending on the timing of the modernization, in the sense of birth of the modern sector, that the price of the resource intensive good can be higher in resource rich economies than in resource poor economies. This happens if resource abundant economies have a higher stock of human capital since then the demand for rye is higher implying higher price. In this case the initially resource intensive economies have been transformed to human capital intensive economies. On the other hand, if trade between resource rich and poor economies is opened early, the resource rich economy specializes in rye production and the resource poor in the industrial production. If we compare countries resource rich and poor countries that modernized at the same time with equal initial population, the growth of human capital and modern production is the same in both countries. The only difference between the countries then is that the more resource abundant country has lower price of rye. These remarks are collected in

Proposition 3 *Without international trade, resource abundance does not have any im-*

[17]E.g. in Murata (2002) the effect goes in the other direction. In his model the link between agriculture and the modern sector works through the inputs produced by the modern sector and used by agriculture.

pact on the growth of human capital nor on the modern production.

This result holds despite the fact that the model builds on the assumption that the rural employment is excessively large. The crucial point is that it holds for the closed economy. The next section studies how resource abundance and international trade interact.

3. International trade and resource curse

Assume now that there exist two countries in the world, H and F (indicated by the superscript). Assume that until period t (at the beginning of which trade is opened before people have made their migration decisions) they have developed as autarkic economies. Assuming identical preferences and technologies in both countries, (22) implies that in autarky equilibrium $p_t^{rH} < p_t^{rF}$ if

$$\frac{H_t^H}{R^H} < \frac{H_t^F}{R^F}, h_t^{rH} < h_t^{rF} \tag{31}$$

(31) holds, e.g. if both countries have started to develop approximately at the same time and H has a larger resource stock, $R^H > R^F$. Also if country F had at the onset of industrialization larger rural families, (23) implies that it had larger early rural-urban migration. It thus has, given $e_{t+1}^r < e_{t+1}^u$, a larger stock of human capital than H at any point of time. Finally, if F began to industrialize earlier than H, but had a larger resource endowment, it is possible that it is relatively resource poor at time t. From now on assume that (31) holds. This implies that when trade between the countries is opened country H will export rye in the trading equilibrium.

Using (20) and (21) and the appropriate condition for migration, the net excess demand for rye in any of the countries is (I have dropped the country superscript) as a function of the price of rye

$$\frac{\beta\eta\gamma}{p_t^r}\left[N^r\left(H_t^u + H_t^r\right)\right] - N^r\left(\frac{p_t^r\Gamma}{\gamma\eta h_t^r}\right)^{\frac{\alpha}{1-\alpha}} R, \tag{32}$$

$$p_t^r \leq \frac{\gamma\eta h_t^u\left(n_t^{ub} + n_t^{rb}\right)^{1-\alpha}}{\Gamma^\alpha R^{1-\alpha}}$$

$$-\left(1-\beta\right)N^r\gamma\left(n_t^{ub} + n_t^{rb}\right)^\alpha R^{1-\alpha}, p_t^r > \frac{\gamma\eta h_t^{u,high}\left(n_t^{ub} + n_t^{rb}\right)^{1-\alpha}}{\Gamma^\alpha R^{1-\alpha}}$$

which clearly is non-increasing in the price of rye. Note that $n_t^{ub} + n_t^{rb}$ equals the size of a rural family, if urban residents move back to countryside. Complete specialization in modern sector production is here never an equilibrium, as with (17) the average product of labor in rural production goes to infinity when labor supply to rural production approaches 0. (32) implies that world excess demand for rye is also non-increasing in rye price. Notice that in the condition for full specialization in production of rye (the RHS of the last inequality in (32)), $h_t^{u,high}$ denotes the largest human capital of the person who was urban resident in period t-1.[18] It is the human capital of a child born to a person whose ancestors migrated from countryside at the beginning of period 0. In (32), it is also assumed that if a

[18]This is the person whose ancestors moved to the modern sector when industrial revolution began.

country is completely specialized, the current generation expects complete specialization also in the next period (see below).[19] Since in autarky the equilibrium exists in both countries, we get

Proposition 4 *The international trade equilibrium price exists, is unique and lies between the autarky equilibrium prices.*

Consider first the situation when country H is completely specialized in production of rye (and F thus produces both of the goods). All urban people in H thus move at the beginning of period t back to rural area to the farms where their forefathers lived. Assuming that all these people also expect their children still to live in the countryside, they do not want to give any education to their children, and make their fertility decisions (in analogy to (1)) by choosing n_{t+1} to maximize

$$\left\{\frac{p_t^r\left[n_t\left(1-\tau_0^r n_{t+1}\right)\right]^\alpha R^{1-\alpha}}{\left(p_t^r\right)^\beta}\right\}^\gamma\left\{\frac{p_{t+1}^r n_{t+1}^\alpha R^{1-\alpha}}{\left(p_{t+1}^r\right)^\beta}\right\}^{1-\gamma}$$

giving

$$n_{t+1}=\frac{1-\gamma}{\tau_0^r}\equiv n^{rS} \tag{33}$$

which gives the birth rate in an economy without modern sector. (33) implies that the model can be consistent with the stylized facts associated with demographic transition (e.g. Lee 2003, Lucas 2002, Ray 1998). At the onset of industrialization and take-off to the sustained growth birth rate first increases and then begins to decline. Since in the presence of a modern sector the rural birth rate (from (5) and (11)) is $\frac{(1-\gamma)(1-\theta)}{\left(\tau_0^r-\tau_1\right)(\alpha\gamma+1-\gamma)}$, if $\frac{\left(\tau_0^r-\tau_1\right)}{\tau_0^r}<\frac{1-\theta}{\alpha\gamma+1-\gamma}$, the birth rate increases when industrialization begins and starts to decline with rural-urban migration[20] (see also the concluding section).

The world equilibrium is determined by the following equation (using (32)) (I am assuming, for simplicity that $N^{rH}=N^{rF}$):

$$\begin{aligned}&\pi_t\left(1-\beta\right)\left(\gamma n_t^H\right)^\alpha\left(R^H\right)^{1-\alpha}= \\ &\beta\eta\gamma H_t^F-N^r\pi_t\left(\frac{\pi_t\Gamma}{\gamma\eta h_t^{rF}}\right)^{\frac{\alpha}{1-\alpha}}R^F\end{aligned} \tag{34}$$

[19] Were they to expect incomplete specialization next period one would have to substitute $\frac{\alpha\gamma}{\alpha\gamma+1-\gamma}$ for γ in the last line of (32).

[20] This interpretation neglects the fact that in most countries reduction in mortality preceeded changes in fertility explaining much of the demographic transition. France and USA were exceptions (Lee 2003). My model shares this defect with most other models of demographic transition. Kalemli-Ozcan (2003) models the impacts of exogenous changes in the mortality rate on fertility decisions. Lehmijoki (2003, ch. 3) contains a model with endogenous mortality and fertility. Yet, even though I am focusing on fertility only, demographic transition is here tied to internal mobility and the share of population engaged in primary production which is a different angle and independent of the fertility-mortality discussion.

where $\pi_t \equiv$ world market equilibrium price of rye. The condition for complete specialization in H (last inequality in (32)) is clearly satisfied, if R^F is small enough, and H_t^F and R^H are large enough.

Since the equilibrium world market price in the period when trade is opened lies between the autarky prices, incomes in both countries necessarily increase But with complete specialization the modernization comes to at least a temporary end in H while it gets a boost in F since trade induces larger rural-urban migration. We can state this as a proposition

Proposition 5 *Opening of international trade can reverse modernization in an economy with low human capital relative to the resource stock.*

In H, trade induces urban-rural migration that can increase the aggregate birth rate. This happens if the increase in the birth rate due to urban-rural migration outweighs the decline in the rural residents' birth rate as a consequence of the reduction in investment to education. If $\frac{1-\gamma}{\tau_0^r} > \frac{(1-\gamma)(1-\theta)}{\tau_0^u - \tau_1}$ or $\frac{\tau_0^u - \tau_1}{\tau_0^r} > (1-\theta)$ then the people moving from urban to rural area increase their fertility. At the same time, the rural residents increase the share of time they devote to work. If one interpretation of the resource curse is that resource abundance prevents the economy from developing the modern sector, then clearly international trade can create the curse, while without trade there is none. In cross-country regressions, resource abundant countries would show slower productivity growth, in case they are open to international trade. This is the mechanism analogous to the one explored in Matsuyama (1992).

The previous proposition does not, of course, indicate that the resource abundant country suffers a welfare loss due to trade opening. It is of interest, however, to see how the equilibrium evolves over time. Thus, consider next what the world market price of rye is in period $t+1$. It is straightforward to calculate that the equilibrium condition is (assuming still that people in H expect that period $t+2$ equilibrium also involves complete specialization)

$$\pi_{t+1} S_t^H \left(n^{rS}\right)^{\alpha} = \beta\eta\gamma \left(H_t^F\right) \left[\beta n^r \left(1+e^r\right)^{\theta} + \left(1-\beta\right) n^u \left(1+e^u\right)^{\theta}\right] - \tag{35}$$

$$- \left(\pi_{t+1}\right)^{\frac{1}{1-\alpha}} \left(\frac{\Gamma}{\eta\gamma h_t^{rF} \left(1+e^r\right)^{\theta}}\right)^{\frac{\alpha}{1-\alpha}} R^F$$

where S_t^H = supply of rye from H in period t. We get immediately the following result:

Proposition 6 *If $n^{rS} \leq 1$ but $\beta n^r \left(1+e^r\right)^{\theta} + \left(1-\beta\right) n^u \left(1+e^u\right)^{\theta} > 1$ then $\pi_{t+1} > \pi_t$: the terms of trade of the relatively resource abundant country that is completely specialized in resource intensive good improve if its population growth rate is small enough.*

The proposition tells that even when modernization has stopped in the country, it can benefit from modernization in other countries through improvements in its terms of trade. A sufficient precondition for welfare gains is that fertility in the resource abundant country cannot be too high, while returns to education in the other country must be high enough. This is the mechanism through which, in a Ricardian model, technological progress in one country benefits other countries. Under the conditions of the proposition, the resource abundant country will always remain completely specialized in the production of rye and the modern sector would never be introduced into it, not at least by market forces alone.

It is possible that the terms of trade for the resource abundant country decline. The intuition is simple: Opening up to trade implies that the demographic process in the resource abundant country changes completely. The birth rate relative to the urban growth rate grows, and depending on the returns to education, may even get higher than the rural birth rate. Without rural-urban migration the whole growing population is employed in the production of the resource intensive good. Its supply increases by the factor $\left(n^{rS}\right)^{\alpha}$ (the LHS of (35)). At the same time (in the RHS of (35)) demand in F increases by the factor $\left[\beta n^{r}\left(1+e^{r}\right)^{\theta}+\left(1-\beta\right)n^{u}\left(1+e^{u}\right)^{\theta}\right]$ and supply falls by the factor $\left[\left(1+e^{r}\right)^{\theta}\right]^{\frac{\alpha}{1-\alpha}}$. To find a case where terms of trade deteriorate, consider the situation where $\tau_{0}^{r}<2\tau_{1}<\tau_{0}^{u}$ and $\theta=\frac{\tau_{0}^{u}-\tau_{1}}{\tau_{0}^{j}}$, i.e. there is no rural education (rural human capital growth is purely extensive, traditional knowledge stock is augmented by increasing the number of children), and returns to education are such that urban human capital growth is at minimal level (see the discussion above before (15))[21]. This makes, first of all, the supply of rye at F independent of time. Then we know that $n^{u}\left(1+e^{u}\right)^{\theta}<n^{rS}<n^{r}$. Assume also that $n^{rS}>1$ and $\left(n^{rS}\right)^{\alpha}>n^{u}\left(1+e^{u}\right)^{\theta}$ (which holds if α and/or τ_{o}^{u} are large enough). Then $\left(n^{rS}\right)^{\alpha}>\beta n^{r}+\left(1-\beta\right)n^{u}\left(1+e^{u}\right)^{\theta}$ if β is sufficiently small. The larger α is, the closer n^{rS} and n^{r} are (see (13)) (and with larger α β can also be larger and the inequality is still satisfied). Assume finally that R^{F} is very small to make $\pi_{t}S_{t}^{H}$ close to $\beta\eta\gamma\left(H_{t}^{F}\right)$ (and to justify the assumption that equilibrium entails complete specialization in rye at H). We get then

Proposition 7 *The terms of trade of the country specializing in production of the resource intensive good begin to decline, if i) the country has high enough fertility with ii)* $\left(n^{rS}\right)^{\alpha}>\frac{(1-\gamma)}{\tau_{0}^{u}}$*, iii) there is no rural education, iv) the share of resource intensive good in expenditure,*β*, is low enough, and v) the natural resource stock of the country exporting the modern sector good is small .*

Note that nothing here requires that $\beta n^{r}+\left(1-\beta\right)n^{u}\left(1+e^{u}\right)^{\theta}<1$, i.e. demand can grow and terms of trade can still deteriorate. The low share of expenditure on rye is needed to make the increase in net demand in F, due to population growth and human capital accumulation, limited. This is reminiscent of the Prebisch-Singer -argument for terms of trade deterioration but here the point is not the low income elasticity but the demographics of the country specializing in the production of the modern good.

The terms of trade decline in the previous proposition cannot last for ever, even though it can last for several generations. The condition for the full specialization is $\pi_{t+k}>\frac{\gamma\eta h_{t}^{u,high}\left(n_{t}^{H}\left(n^{rS}\right)^{k}\right)^{1-\alpha}}{\Gamma^{\alpha}R^{1-\alpha}}$, $k\geq1$. If the terms of trade continuously deteriorate and population grows (implying that income per capita from rural production declines), the inequality

[21] Note that this case does not violate the constraint that there is rural urban migration even though $e^{r}=0$ and $e^{u}>0$, as with the assumptions made $n^{r}>n^{u}\left(1+e^{u}\right)^{\theta}$.

turns eventually into an equality[22]. At that point modern production is reintroduced in country H[23]. In a way, we get the paradoxical result: A resource intensive country benefiting from trade may never modernize, but country suffering temporarily from trade will return back to production in the modern sector. However, its productivity will lag permanently behind the most advanced countries.

Given that demographics are crucial for the terms of trade to deteriorate the resource abundant country has obvious incentives to regulate fertility. If the population growth can be limited to $\overline{n} \leq 1 < n^{rS}$ then by Proposition 5 the resource abundant country can avoid the decline in its terms of trade as long as fertility decisions are such that aggregate human capital stock increases in the other country.

Consider finally the case where $2\tau_1 < \tau_0^r$, and children receive education everywhere. Assume though that $\theta = \frac{\tau_0^r - \tau_1}{\tau_0^r}$ giving $n^r (1+e^r)^\theta = \frac{(1-\gamma)}{(\alpha\gamma+1-\gamma)\tau_0^r}$. Define $\rho > 0$ so that $\tau_0^r \equiv 2(1+\rho)\tau_1$ This gives $(1+e^r)^\theta = \left[1 + \frac{\tau_0^r(\tau_0^r - 2\tau_1)}{\tau_1}\right]^{\frac{\tau_0^r-\tau_1}{\tau_1}} = [1+4\rho(1+\rho)\tau_1]^{2(1+\rho)-1}$. Thus, the smaller τ_1 and τ_0^r get the closer to unity $(1+e^r)^\theta$ will be. As was shown above, $n^u(1+e^u)^\theta < n^r(1+e^r)^\theta$ for all θ for which both rural and urban children are educated. Fix now α and β such that $(n^{rS})^\alpha > n^u(1+e^u)^\theta$ and $(n^{rS})^\alpha > \beta n^r (1+e^r)^\theta + (1-\beta) n^u (1+e^u)^\theta$ just like above. Assume finally τ_1 and τ_0^r to be so small that $(n^{rS})^\alpha > [1+4\rho(1+\rho)\tau_1]^{2(1+\rho)-1}$ and that the resource stock in F is small. From (35) we see that with these assumptions, the terms of trade of the resource abundant country deteriorate even when education is provided to all children in the foreign country. Hence

Proposition 8 *The terms of trade of the country specializing completely in the production of the resource intensive good can deteriorate after international trade is opened, even when in the rest of the world education is provided to all children.*

It is interesting that the real GDP per capita in the completely specialized resource abundant country declines if population grows as the growth rate is given by $(n^{rS})^{\alpha-1}$: the diminishing returns in agriculture reduces income. The real incomes can increase if and only if terms of trade improve. At the same time the real GDP per capita in the other country exporting the manufacturing good increases as $n^u < n^u(1+e^u)^\theta$, and $n^r \leq n^r(1+e^r)^\theta$. Yet, the previous propositions on terms of trade deterioration hold only for the case where the resource rich country has a higher aggregate GDP growth rate than the resource rich country as $(n^{rS})^\alpha > (n^{rS})^\alpha > \beta n^r(1+e^r)^\theta + (1-\beta) n^u (1+e^u)^\theta$. With the same reasoning as in the previous two propositions the terms of trade problem disappears if returns to education increase.

[22]Note that I am here assuming that the human capital inherited from parents does not disappear even if parents do not provide any education. One can drop the assumption and assume that it evaporates without education. In this case, one just substitutes 1 for $h_t^{u,high}$.

[23]With rational expectations, the generation that understands the reappearance of the modern sector, change their fertility and educational decisions. Given the assumption underlying the previous proposition that e^r is close to 0, if $n^r > n^{rS}$ (assumption consistent with the stylized facts of demographic transition), there may be a deep decline in terms of trade of the resource abundant country before the emergence of the modern sector.

Consider next the case, where both countries are incompletely specialized. Using (32), one can calculate the equilibrium price to be

$$\pi_t^{\frac{1}{1-\alpha}} = \frac{\beta\eta\gamma H_t^W}{\left(\frac{\Gamma}{\eta\gamma}\right)^{\frac{\alpha}{1-\alpha}}\left[\frac{R^H}{\left(h_t^{rH}\right)^{\frac{\alpha}{1-\alpha}}} + \frac{R^F}{\left(h_t^{rF}\right)^{\frac{\alpha}{1-\alpha}}}\right]} \tag{36}$$

where $H_t^W \equiv H_t^F + H_t^H$. Updating this for the next period gives[24]

Proposition 9 *If both countries are incompletely specialized then the terms of trade of the country exporting the resource intensive good improve if aggregate human capital grows, i.e.* $\beta n^r (1+e^r)^\theta + (1-\beta) n^u (1+e^u)^\theta \geq 1$.

While the proposition clearly implies that an incompletely specialized resource abundant country cannot loose from trade as long as world's human capital stock grows, it is clear that there will be less migration in it, which has an adverse impact on the growth of the modern sector. If trade is opened at the dawn of industrialization it is clear that it can induce higher birth rate, as in Galor and Mountford (2003).

Propositions 7, 8 and 9 can be interpreted to imply that the structure of free world trade may be biased against countries relying solely on resource based goods in their exports. In the framework of the model, a country can gain certainly from trade if it has accumulated enough human capital before it enters the world trading system, as then its production structure is diversified. High enough human capital stock allows it to diversify its production base, and detach itself from the demographic trap: The crucial mechanism creating the biased structure of world trade is the demographics in the resource abundant country. With a diversified production structure, the resource abundant country can benefit from the expansion of human capital in both countries. Perhaps the model is stretched too far, but in broad terms the experience in both China, India and South-Korea seems to be in accordance with the basic message. China and India have started to enter the world trading system, after staying out of it for quite a long period. Both of them have invested in education and birth control. In general, the successful Asian economies like South-Korea invested a lot to basic education, while opening their economies slowly to trade. The point is that the pattern of international specialization depends on the history of the economy.

4. Technology diffusion, trade and land markets

Until now the analysis has been based on the assumption that there is no technology diffusion. It has been assumed away both domestically and in the international economy. Domestically the assumption has been that human capital is accumulated only within families and there is no diffusion between families. While the assumption that families are important for human capital accumulation is realistic (e.g. Oreopoulos, Page and

[24]Naturally here as also above, if the terms of trade of the resource abundant country improve then the terms of trade of the resource poor country deteriorate.

Stevens 2003), one should allow for spill-overs. Nothing would basically change if one allowed spill-overs in the urban environment, e.g. in the form that the children of the migrants to cities are able to absorb the human capital of those whose families have stayed there for a long time. The same holds as well, if one allows for urban-rural spill-overs. Then people facing the migration decision would have higher human capital stock. Consequently, in equation (17), determining the rural-urban migration, the right hand side would be larger to reflect the enhanced earnings in cities. Domestic technology diffusion would then make it less probable that the resource abundant country would in a trading equilibrium specialize completely in producing the resource intensive good.

International trade has been shown to be an important channel for technology diffusion (Keller 2002). The model can be augmented easily to take this into account. With international diffusion, the human capital of the country with lower initial capital stock is being increased. Even if the diffusion takes place between cities only, it makes it less likely that the resource abundant country completely specializes in the production of the resource intensive good (see (32)). If the diffusion spreads also to the countryside, the conclusion is even stronger. Yet, even though trade is important for diffusion, its importance has grown substantially only lately (Keller 2002).

One must note that the analysis in the previous sections is based on the assumption that there is no market for land. With land market and individual land-ownership and commercial farming migration decisions would be based on marginal returns from staying in the rural area and from migration. Consequently, at the time land markets are established, one would observe larger rural-urban migration as the model now implies, since marginal returns to farming are below the average returns. Also land-ownership could be separated from the site where one is working. But still, assuming that the basic cost of raising children is lower in a rural than urban environment, the same idea of human capital enhancing migration and decline in the birth rate due to migration would still hold.

5. Concluding comments

The paper has built a two-sector model of international trade, development and demographic transition based on classical models of Lewis, Fei and Ranis, and Harris and Todaro. The basic idea is that in a dual economy demographic decisions depend on where people reside. Here people working in the sector using natural resources have higher birth rate and give less education to their children than people working in the modern sector using human capital as the sole input. These results are consistent with the stylized facts of demographic transition. Rural-urban migration is associated with a switch of employment from the resource intensive sector to the modern sector. Consequently, migration induces higher growth of human capital. The main question asked is whether an economy endowed with a larger resource stock will have lower rate of modernization and growth of human capital than a resource poor economy, and under what conditions the possible resource curse can be observed. There are two main results. First, an autarkic economy will never face the resource curse. Secondly, a resource abundant country opening to international trade may face resource curse if it completely specializes in the production of the resource intensive good. The country's terms of trade can decline over an extended period if its population growth rate is high, and the returns to education in the other country are large enough. This lends some support for the Prebisch-Singer -hypothesis, though the mechanism used here differs from theirs. The terms of trade decline analyzed here is created completely by demographic change induced by the opening of trade. The result also shows the potential importance of birth control in development.

The Prebisch-Singer hypothesis relied on the assumptions that demand for primary goods is income inelastic. In a growing economy the relative demand for the goods facing inelastic demand declines, which, ceteris paribus, implies that the relative prices of these goods fall. But in a general equilibrium one must also understand, what happens the supply of goods: why are resources not shifted to sectors, whose prices increase? Inelasticity of demand for primary goods is used by Matsuyama (1992) to generate labor flow to the modern production. The point in this paper is that one can abandon the assumption of income inelasticity and still get rural-urban migration and falling relative price of primary goods, when trade is opened, by focusing on demographic issues. Were one to assume income inelastic demand for primary goods (and drop the assumption of Cobb-Douglas preferences over commodities) here all the results would only strengthen as one can easily see. This holds especially for the terms-of-trade changes.

One by-product of the present paper is that it has produced a model of continuous rural-urban migration and a theory of urbanization as a source of economic growth. An additional result is that there exists an ever-increasing urban-rural wage gap. Another by-product is that the paper provides an explanation to the puzzle, why in growth studies the impact of education appears to be insignificant, while in studies based on microdata education is a significant determinant of incomes. The model implies that at the aggregate level the relationship between growth and education is convex while at the level of individuals there is a linear relationship between their human capital (determined by education) and incomes. The convexity is created by the quality-quantity trade-off in fertility decisions: fertility declines if more education is provided.

All the results have been derived without assuming any externalities. One can incorporate fairly easily externalities in human capital formation of the type analyzed in de la Croix and Doepke (2003), Lucas (2004) and Matsuyama (1992) and in many of the other studies cited above. It is obvious that the main results would not change. In fact, they would only strengthen.

The model can also easily be extended to contain a theory of industrialization, and escape from the Malthusian trap assuming that the existence of modern technology is known. The population would grow at the rate n^{rS} if the modern good is not produced. If $n^{rS} > 1$, the average product of labor would decline, and at some point it would equal η, the return one can earn from the modern technology, and modernization would begin. As explained in section 3, the demographic pattern of the model would then be consistent with the observed pattern of demographic transition.

6. References

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