

Endogenous comparative advantages in developing economies

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Abstract

This paper focusses on endogenous comparative advantages in developing countries, in particular on labour reallocation from low-productivity informal sectors into high-productivity formal sectors. This mechanism is important for two reasons. First, it contributes to the growth potential of developing countries and the absorption capacity for further capital accumulation. Second, labour reallocation will keep developing economies specialized in low-skilled intensive products in the coming decades and it will keep the wages of low-skilled workers low. We analyse this mechanism by simulating an increase in the skill intensity of developing countries the coming decades. These simulations are carried out with WorldScan, a dynamic AGE model of the world economy. An increasing skill intensity in LDCs will stimulate the global supply of high-skilled intensive products more than the supply of low-skilled intensive products, but to a much lesser extent than one would expect in static analyses or in absence of informal sectors.

1 The comeback of comparative advantages¹

This paper discusses an endogenous change in endowments that enhances growth in developing economies. At the same time, however, this change tends to make current specialization patterns persistent. This prevents developing economies from rapidly converging to specialization patterns commonly found in OECD countries. The key factor that drives this persistence is the existence of low-productivity, informal sectors in less developed economies. An increase in the number of high-skilled workers will provoke an endogenous flow of low-skilled workers from these informal sectors to formal, high-productivity sectors. This endogenous flow counteracts the original shift in comparative advantages. It may thus keep developing economies specialized in low-skilled intensive activities.

This mechanism is important for several reasons. First of all, it determines the growth potential of developing countries. This potential is much larger than one would expect if one ignored the labour reserve in the informal sectors. Consequently, it also determines the capacity of developing economies to accumulate further capital. Furthermore, the endogenous inflow of low-skilled workers keeps the wages of low-skilled workers relatively low. Programs in developing countries that promote schooling, FDI and technological catching-up may even make international specialization patterns more pronounced. Instead of convergence of comparative advantages, these programs may lead to an increase of the global relative supply of low-skilled labour intensive products.

This paper fits in the framework of the so-called new trade theory. Traditional Heckscher-Ohlin theory lost much of its attractiveness when Leontief (1953) convincingly reported that U.S. exports were less capital-intensive than U.S. imports. This was inconsistent with the predictions of the traditional endowments-based theory, because the United States was considered to be relatively well-endowed with capital. Another observation, at odds with the traditional trade theory, is the fact that intra-industry trade between similar countries forms a large share in the world-trade volume.

Armington (1968) evaded these problems by assuming that products from different countries are always different, even if they originate from countries with identical endowments. However, one of the problems is that this approach leads to essentially uncomparable endowments, because even if endowments are the identical, they cannot be used to make the same products. Moreover, the Armington approach leads to questionable conclusions and policy advice. It implies for instance that a country can only grow faster than other countries at the cost of continuously deteriorating terms of trade. Under the Armington assumption even small countries can generate terms-of-trade gains by imposing export taxes. Furthermore, a productivity increase in one sector always benefits foreign countries.

The new theory of trade, which originates from pioneering articles by Dixit and Stiglitz (1977) and Krugman (1979), accounts for intra-industry trade. At the same time it avoids the

¹The paper benefited from comments by Casper van Ewijk and Theo van der Klundert.

rigidities of Armington's assumption. For at least four reasons new trade theory leads to a comeback of comparative advantages.

First of all, if the new theory is applied within a sectoral framework, countries will tend to specialize according to their comparative advantages. This happens in the same way as in Heckscher-Ohlin theory, while now intra-industry trade can be explained as well. Contrarily to what would happen under the Armington assumption, countries may now completely retreat from certain sectors, if they have a comparative advantage elsewhere.

Second, the new trade theory leads to conclusions and policy advices that are closer to the traditional theory of comparative advantages than to the Armington approach. Countries may grow faster than other countries without incurring terms-of-trade losses. A productivity increase in a certain sector may harm those foreign countries that are net exporters of products from that sector. Export tariffs may lead to a complete reallocation of sectoral production abroad.

Third, the theory introduces new kinds of endowments, like established market shares or brand loyalty. These endowments can be analyzed like the traditional endowments. Specialization in specific products may start as a coincidental process, but once specialization occurs, it tends to endure. The advantage of the new theory above the Armington assumption is that specialization patterns are not guaranteed forever. Instead patterns may change over time, e.g. as a result of changes in other comparative advantages.

Fourth, the new theory of trade is closely linked to new growth theory, which tries to explain growth potentials and catching-up. Endowments in an economy play a crucial role in the analysis of growth patterns.²

Although comparative advantages may play a role again in the new trade theory, the character of the endowments differs from those analysed in the more traditional theory. Instead of natural resources and climate, the key endowments now are more and more those affected by economic activity: physical capital, education, infrastructure, including networks of digital communication, R&D, clusters of firms that attract new firms and so on. This shift in emphasis from natural to man-made endowments implies a shift from a static to a dynamic analysis. Comparative advantages may change over time because of investment behaviour. The main issue now is not the availability of endowments, but the capacity to generate them.

In a dynamic analysis an exogenous shock may have a significantly different impact than in a static one. In many cases the endogenous accumulation of endowments explains virtuous circles. An initial growth impulse provokes additional investments in physical and human capital, in R&D and knowledge. Initial specialization may enforce itself over time through learning by doing, and because of positive externalities that attract similar activities. These virtuous circles do not just multiply the initial growth impulse. They often lead to a shift towards activities that yield a higher value-added too.

²See for example Romer (1986) and Lucas (1988)

Section 2 discusses a simple Heckscher-Ohlin model that gives some intuition behind endogenous endowments and the resulting comparative advantages, relative prices and specialization patterns. Section 3 introduces our general equilibrium model WorldScan. This model makes a distinction between low- and high-skilled workers. Both types of labour are imperfect substitutes. The labour skill split helps to explain specialization patterns. Additionally there is a distinction between informal and formal sectors in WorldScan. In less developed countries, especially in Asia and Sub-Saharan Africa, informal activities still provide employment to large parts of the workforce. Section 4 describes the results of simulations in which the skill intensity in developing countries increases during the next decades. This increase will ultimately boost the global supply of high-skilled intensive products more than the supply of low-skilled intensive products. However, the supply of the high-skilled intensive products rises in a less pronounced way than it would do in a static analysis or in the absence of informal sectors.

2 A model of endogenous endowments

This section aims to illustrate some basic intuitions on the consequences of endogenous endowments. We present a simple Heckscher-Ohlin model with two endowments, two sectors and two countries. In case one of the endowments is endogenous, what is then the impact of a change in the other, exogenous, endowment?

We first consider the case in which the supply of the endogenous endowment positively depends on its own price. This comes close to the main focus of our paper, which is the endogenous supply of low-skilled labour in formal sectors of developing countries. The analysis shows that in this case the impact of a change in another endowment, e.g. skilled labour, on relative prices may be rather modest. This implies that specialization patterns may be surprisingly persistent, even in case of serious schooling efforts in developing countries.

There are also other ways in which endowments can be endogenous. We show the case of endogenous investments in capital goods as an example of how endogeneity may have more surprising results. In that case an increase in an exogenous endowment may even result in a relative decrease in the global availability of that same endowment.

The first country has two endowments, X_1 and X_2 and two sectors, producing Y_1 and Y_2 . Production functions are of the Cobb-Douglas type with constant returns to scale.

$$Y_i = \gamma_i X_{1i}^{\beta_{1i}} X_{2i}^{\beta_{2i}} \quad \beta_{1i} + \beta_{2i} = 1 \quad i = 1, 2 \quad (1)$$

The consumption function, determining demand for good i , C_i , is derived from a Cobb-Douglas utility function such that

$$p_i C_i = \lambda_i [w_1 X_1 + w_2 X_2] \quad \lambda_1 + \lambda_2 = 1 \quad i = 1, 2 \quad (2)$$

The second country, denoted by an *, has identical production and consumption functions, but differs with respect to the supply of endowments. Assume that

- input intensities are determined by cost minimization
- all input and product markets are in equilibrium
- both products are traded without transportation costs, so that the law of one price holds, i.e. arbitrage makes prices equal in both countries.
- input prices are denoted by w_i and output prices by p_i . Product 1 is chosen as the numeraire, i.e. $p_1 = 1$.
- both countries are not completely specialized, such that both countries produce both goods. This implies that the relative availability of endowments does not differ too much between the countries so that the following conditions hold:³

$$\frac{\beta_{12}}{\beta_{22}} < \left[\varphi \frac{(X_2 + X_2^*) X_1}{(X_1 + X_1^*) X_2}, \varphi \frac{(X_2 + X_2^*) X_1^*}{(X_1 + X_1^*) X_2^*} \right] < \frac{\beta_{11}}{\beta_{21}} \quad \varphi = \frac{\lambda_1 \beta_{11} + \lambda_2 \beta_{12}}{\lambda_1 \beta_{21} + \lambda_2 \beta_{22}} \quad (3)$$

The equilibrium prices for the inputs and good 2 are then

$$w_1 = \gamma_1 \left(\varphi \frac{X_2 + X_2^*}{X_1 + X_1^*} \right)^{\beta_{21}} \quad (4)$$

$$w_2 = \gamma_1 \left(\varphi \frac{X_2 + X_2^*}{X_1 + X_1^*} \right)^{-\beta_{11}} \quad (5)$$

$$p_2 = \frac{\gamma_1}{\gamma_2} \left(\varphi \frac{X_2 + X_2^*}{X_1 + X_1^*} \right)^{(\beta_{21} - \beta_{11})} \quad (6)$$

If the endowments were exogenous, the interpretation of these results would be straightforward. Prices depend on relative endowments on a global scale. Not surprisingly, input prices are inversely related to the volume of the corresponding endowments in the global economy. If Y_2 or Y_2^* makes relatively intense use of input X_2 or X_2^* , i.e. $\beta_{21} < \beta_{11}$, then p_2 is negatively related to $(X_2 + X_2^*)/(X_1 + X_1^*)$. An increase in the relative global supply of an endowment makes those

³See Timmer (1987) for the derivation of these inequality constraints and for a general discussion of specialisation and diversification in a multi-endowment and multi-sector environment.

products cheaper that intensively use this endowment.

If one country increases the volume of its second endowment, then in both countries input prices of endowment 1 will increase and the relative price of good 2 will decline if that good makes relatively intense use of endowment 2. The trade pattern will also change. The country that increased its supply of endowment 2 will shift towards the production of the good that intensively uses endowment 2.

What happens if we make endowment 2 in the second country a function of its own price in real terms? Assume that

$$X_2^* = \left(\frac{w_2}{p_1^{\lambda_1} p_2^{\lambda_2}} \right)^\alpha \quad \lambda_1 + \lambda_2 = 1 \quad (7)$$

In this case X_2^* becomes a positively sloped function of X_1^* .

$$\frac{X_1^*}{X_2^*} \frac{dX_2^*}{dX_1^*} = \frac{\eta \mu_1^*}{1 + \eta \mu_2^*} \quad \text{with} \quad \mu_i^* = \frac{X_i^*}{X_i^* + X_i^*} \quad \eta = \alpha[(1 - \lambda_2)\beta_{11} + \lambda_2\beta_{21}] \quad (8)$$

If the supply of X_2^* becomes more sensitive to its own price, i.e. if α increases, then X_2^* becomes also more sensitive to changes in X_1^* . Extreme flexibility in the supply of X_2^* ($\alpha \rightarrow \infty$) would imply that the ratio between X_2^* and X_1^* never changes. Every additional unit of supply of X_1^* would evoke a proportional increase in the supply of X_2^* .

If we take the influence on the supply of X_2^* into account, we get the following impact of a change in X_1^* on the equilibrium price

$$\frac{X_1 + X_1^*}{p_2} \frac{dp_2}{dX_1^*} = \frac{(\beta_{11} - \beta_{21})}{1 + \eta \mu_2^*} > 0 \quad (9)$$

Think of X_1^* and X_2^* as skilled and unskilled labour in the formal sectors of a developing region, respectively. An increase in the number of skilled workers makes the unskilled-intensive products more expensive. However, this increase becomes smaller if α increases. Schooling initially leads to an increase in unskilled wages, but this evokes an increase in the supply of unskilled workers, which reduces the unskilled wages again. The impact also depends on the share of the country in the global supply of unskilled labour. If the share is large, as is the case for the aggregate of developing

economies, the impact of schooling on relative prices will be small.

For another example of endogenous endowments let us look at capital accumulation: investments in physical capital, R&D or schooling. Assume endowment 1 is capital and endowment 2 is endogenous labour. First we assume that both countries have a similar accumulation equation, where σ is the investment ratio, equal to the fixed savings ratio.

$$X_1 = (1-\delta) X_1(-1) + \sigma [w_1 X_1 + w_2 X_2] \quad (10)$$

Input prices in the long run are determined as

$$w_1 = \frac{\delta}{\sigma} \frac{\varphi}{1 + \varphi} \quad (11)$$

$$w_2 = \gamma_1^{1/\beta_{21}} \left(\frac{\sigma}{\delta} \frac{1 + \varphi}{\varphi} \right)^{\beta_{11}/\beta_{21}} \quad (12)$$

Note that w_1 , the return on capital, does not depend on the technology level γ_1 . Technological progress increases the price of the fixed endowment, but it leaves the price of the reproducible endowment unaffected. In such an economy technological progress will be reflected by a growing amount of physical capital, R&D or schooling per worker.

Both countries end up with the same relative endowments.

$$\frac{X_1}{X_2} = \frac{X_1^*}{X_2^*} = \left(\gamma_1 \frac{\sigma}{\delta} \frac{1 + \varphi}{\varphi^{\beta_{11}}} \right)^{1/\beta_{21}} \quad (13)$$

Changes in the exogenous endowments do not affect the global relative supply of endowments in this case. A shock in X_2 will ultimately lead to an equal change in X_1 . This means that an increase in X_2 will merely lead to an increase in all volumes in the economy of country 1.

If savings behaviour differs between countries, the solution becomes much more complex so that it cannot be expressed in convenient formulas anymore. In that case an increase in X_2 may even lower the relative supply of the second endowment on a global level. The intuition behind this result is the following. Assume that the first country has a high savings rate. Its production will then be relatively X_1 -intensive. The main consequence of a rise in X_2 is that all endowments in the first country grow. In other words, the first country becomes a larger part of the world economy. This implies that the global relative supply of the first endowment increases, although the initial impulse

was an increase in X_2 .

General equilibrium processes make the story more complicated, because the first country will also suffer a terms-of-trade loss, which lowers its relative importance in the world economy. Nevertheless, the unexpected result described above is possible. But even if the eventual consequence is not perverse and the endogeneity of endowments just mitigates the effect of changes in exogenous endowments, it is crucial to take the endogeneity into account, because it may explain why relative positions in the world economy are so persistent.

3 WorldScan: a global applied general equilibrium model

In this section we describe the general equilibrium model WorldScan in broad terms. We shall focus on the skill decomposition and on the classification of economic activities in less developed regions. We shall also discuss some main characteristics of a scenario that will be used in the next section. Readers who are interested in more details are referred to the Appendix of this paper and CPB (1999).

WorldScan has been developed to analyse long-term developments in the global economy. It is based on the neoclassical theories of growth and international trade. Standard neoclassical theory of growth uses three factors to explain production: physical capital, labour, and technology. WorldScan augments the simple version of this model in three ways. First, our model allows technology levels to differ across countries. It also incorporates the idea that developing countries can catch up by adopting foreign state-of-the-art technologies. Second, WorldScan discerns two types of labour inputs: high-skilled and a low-skilled labour. A country's endowment of high-skilled labour may grow through schooling. This will boost a country's growth rate. Third, in developing countries part of the labour force is employed in the informal, or 'low-productivity' sectors. All workers in these sectors are assumed to be low-skilled. They have no access to capital services and technology. Wages in the informal sector are substantially lower than those in the formal ones. The allocation of low-skilled workers between the formal and the informal sectors is driven by the wage difference. A country may pursue a policy that directs a larger part of its low-skilled labour force towards the formal sector. This will boost economic growth.

To account for transition dynamics, international trade is modelled in a special manner. Most AGE models apply the so-called Armington approach. The disadvantages of this assumption are discussed in Section 1. To overcome these problems we modify the static Armington utility function into a dynamic one, describing temporary brand loyalty. We assume that preferences with respect to the current product mix depend on realized market shares in previous periods. Countries can gain market share by temporarily offering their products at lower prices than their competitors. Once a market share is conquered, brand loyalty to the new product is established gradually, and prices can return to the level of competitors' prices.

Box 1 WorldScan, a global general equilibrium model

At the heart of WorldScan are the neoclassical theories of economic growth and international trade. The core of the model is extended to add more realism to scenarios. In doing so, we aim at bridging the gap between academic and policy discussions. The extensions include:

- an Armington trade specification, explaining two-way trade and allowing market power to determine trade patterns in the medium run. At the same time we let Heckscher-Ohlin mechanisms prevail in the long run;
- consumption patterns depending upon per capita income, and developing towards a universal pattern;
- a Lewis-type low-productivity sector in developing regions, from which the high-productivity economy can draw labour, enabling high growth for a long period.

The model distinguishes the following regions, sectors and productive factors

<i>Regions</i>	<i>Sectors</i>	<i>Productive factors</i>
United States	Agriculture	<i>Primary inputs</i>
Western Europe	Raw Materials	Low-skilled labour
Japan	Capital Goods	High-skilled labour
Pacific OECD	Consumer Goods	Capital
Eastern Europe	Intermediate goods	(fixed factor)
Former Soviet Union	Services	
Middle East and North Africa	Trade and Transport	<i>Intermediate inputs</i>
Sub-Saharan Africa		all sectors
Latin America		
China		
South-East Asia		
South Asia & Rest		

The High Growth scenario: main characteristics and trends

The simulations that we will present in section 4 take place within the so-called High Growth scenario. We will discuss the main characteristics of this scenario here briefly.

The High Growth scenario (OECD, 1997) aims to explore the linkages between OECD and non-OECD economies in the near and distant future. The scenario depicts a rather optimistic picture of the years to come, especially for developing countries. The main idea is that increasing growth of developing countries will lead to intensified linkages between OECD and non-OECD countries.

Developing countries pursue market-oriented policies in order to attain and sustain high growth rates. Countries that do not create favourable conditions for market-based development, are likely to fail. For example, developing economies should open up their markets to attract both foreign goods and investment. In this scenario, trade liberalisation is not restricted to trade blocs, but occurs on a global level. OECD countries will open up their agricultural markets. This will be beneficial to developing countries in particular.

In the High Growth scenario many poor countries will catch up with rich countries, although not completely. International specialisation becomes more and more pronounced during the scenario period. This is due to the liberalisation of the goods and services markets and to lower transport

costs. Besides, especially in developing countries factor endowments are projected to change significantly.

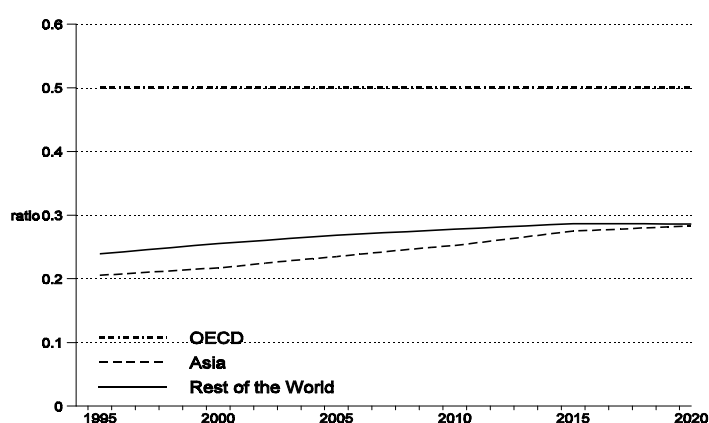
Skill composition

The distinction between low- and high-skilled labour in WorldScan is relevant for the analysis of both the labour market and the process of economic growth. Moreover, it enables a better understanding of specialization patterns. OECD regions will specialize in the production of goods that use high-skilled labour relatively intensively. Regions where low-skilled labour is relatively abundant will specialize in low-skilled intensive goods.

The regional classification of high- and low-skilled workers in WorldScan is based on stocks of human capital.⁴ Barro and Lee (1993, 1996) have constructed data on schooling levels of such stocks in about one hundred countries. They use a perpetual inventory method. The levels relevant to us are ‘none’, ‘primary’, ‘secondary’, and ‘higher’ education. For the latter three a further distinction is made between attainment and completion. Changes in schooling depend on mortality and inflow rates. The inflow is determined as the size of the young age cohort times the enrollment rates for specific schooling levels. The human capital stocks constructed by Barro and Lee apply to the age ranges 15-64 and 25-64. Their data cover the period between 1960 and 1990. Based on these human capital stocks Ahuja and Filmer (1995) construct projections that run until 2020. Their database concerns the total population of 6 years and older. Their projections do not include OECD countries.

We have used these data to obtain a labour skill split for WorldScan. Workers who have at least completed secondary education are classified high-skilled. Appendix A2 describes more details of the method that we have used to implement this classification.

Figure 3.1 Share of high-skilled labour in total labour supply from 1995 to 2020



⁴A division of labour skills into high- and low-skilled can be based on the professional status of employees or on their schooling levels. We have chosen for the second criteria. Reasons are discussed in CPB (1999).

Source: Own calculations based on Ahuja and Filmer (1995), and Barro and Lee (1996).

Figure 3.1 shows the supply of high-skilled labour. It will increase until 2020 in the non-OECD regions. This is mainly due to relatively well-educated young generations that replace less-skilled older ones. Even if enrollment levels remain constant from now on, the skill level of the total labour force will continue to rise until 2020 and thereafter.

It may take a long time before developing countries reach OECD enrolment levels. Nowadays many of them do not even supply basic education to their populations (see World Bank, 1995). Nevertheless, many non-OECD countries are getting closer, slowly but surely. Appendix 2 presents also the projections for all WorldScan regions.

As we mentioned before, the projected increase in high-skilled labour is based on the work of Ahuja and Filmer (1995). The analysis of projected enrollment rates by Unesco (1993) and CSSB (1999) confirms this trend, although it shows a large variety of trends for the individual countries. We select the enrollment ratios for secondary schooling from some developing countries and construct the share of the population between 18 and 65 that has attained secondary schooling at least. Table 3.1 presents the results.

Table 3.1 Share of population (18 years and older) that attained secondary schooling

		Brazil	China	India	Korea	Nigeria
1995		0.53	0.42	0.30	0.63	0.30
2020	enrollments fixed after 1995	0.70	0.43	0.43	0.84	0.32
2020	enrollments fixed after 2015	0.70	0.49	0.43	0.88	0.31

Source: Unesco (1993), except for China which uses CSSB (1999), United Nations (1995) and own calculations

The second row in Table 3.1 shows that the share that attained secondary education will rise substantially in India, Brazil and Korea, even if the enrolment rates are kept constant after 2020. This implies that the large increase in schooling can be completely attributed to demographic dynamics in this row. In row 3 only a small part of increasing attainment can be attributed to rising enrollments rates (the difference between row 3 and 2). In Korea the expected rise in enrolment rates is the most pronounced.

China and Nigeria are exceptions to this general trend. New statistics on China (CSSB, 1999) show an expected rise in enrolment levels. However, China still faces the consequences of the cultural revolution. During the late seventies and the early eighties Chinese enrolments in secondary education plummeted. They reached a level of 29% in 1984. Since that year enrolment rates have steadily risen again. However, it will take a long time before the effects of the decline in the early eighties dies out. If enrolments remain at the current level of 50% the educational attainment of the labour force will rise slowly from 42% in 1995 to 43% in 2020. However, CSSB (1999) expects a further rise in enrolment rates by nearly 10 percentage points during the next decade. This will lead to an educational attainment percentage of nearly 50% in 2020. Future educational attainments in Nigeria do not look promising. By the beginning of the eighties enrolment rates had climbed up to

around 40%. However, by 1990 they had fallen to 32% again. Unesco (1993) expects a slight deterioration. Even if they remain what they are now there is no reason for much optimism.

The informal Sector

The distinction in WorldScan between a high- and low-productivity sector dates back to Lewis (1954). He makes a distinction between a traditional subsistence sector and a modern capitalist sector. In his model the marginal productivity of workers in the traditional sector is (close to) zero. They work the land or provide simple services in cities. These workers do not have access to capital and modern technologies. In the modern sector technology, capital and labour are combined efficiently. The sector grows through the accumulation of capital and technical progress. This causes a rising demand for labour from the traditional sectors. WorldScan draws a similar distinction. Workers in developing countries are engaged in either formal or informal activities. Labour productivity in formal sectors is high, while it is low in informal sectors. The formal sectors use intermediate goods, high- and low-skilled labour, capital and technology for production. The informal sectors require only low-skilled labour.

Instead of Lewis' assumption of a completely elastic labour supply that originates from the informal sectors,⁵ we assume that labour allocation between the low- and high-productivity sectors depends on the wage difference. Peng, Zucker and Darby (1997) for example find that employment in Chinese rural industries is negatively correlated with the land-labour ratio. We interpret this as an indication that the productivity difference between agriculture and manufacturing affects the allocation of workers across the sectors.

WorldScan thus assumes a finite wage elasticity of labour supply. It postulates the following wage-setting function, which links the wage difference between low- and high-productivity sectors to employment in the low-productivity sector:

$$l = 1 - \left(\frac{\bar{w}}{\underline{w}} \frac{1}{C} \right)^{(1/\gamma)}, \quad \gamma > 0, \quad \text{if} \quad \left(\frac{\bar{w}}{\underline{w}} < C \right) \quad (17a)$$

$$l = 0 \quad \text{if} \quad \left(\frac{\bar{w}}{\underline{w}} \geq C \right) \quad (17b)$$

⁵The informal sector has both advantages and disadvantages. An advantage may be the proximity of one's native community or security against starvation. A clear disadvantage is the lower reward for labour.

Here l is the share of the informal sector in total low-skilled labour supply. $\underline{w}$ is the wage in the informal sectors,⁶ and $\bar{w}$ is the wage for low-skilled workers in the formal sectors. The former is determined as a weighted average of producer prices in agriculture and in services. The weights are the shares of the informal employment in these sectors. $(\bar{w} / \underline{w})$ is the wage ratio between the formal and the informal sectors and C denotes the maximum of this ratio. If the wage ratio reaches C , all workers will be employed in the formal sectors. So, l becomes zero. From this moment on the labour market will clear in such a way that total labour supply equals total demand in the formal sectors.

Clearly, this formulation ignores the micro-economics of reallocation, migration and wage formation. It is not asked why productivity differences arise, such differences are simply assumed. Productivity in both sectors develops at a different rate. This increases the wage difference, which in turn induces a labour reallocation between the sectors. The extent to which wage differences cause flows from low- to high-productivity sectors depends on the wage elasticity of labour supply γ .

The schooling variant to be discussed in the next section will impose an exogenous increase in the share of high-skilled workers in the labour force.⁷ These additional workers will all find employment in the high-productivity sectors. This will have a positive effect on the ratio between low- and high-skilled wages. In turn this will lead to an increase in the share of low-skilled workers employed in the formal sectors, according to the mechanism described in equation (17).

The lack of available data sources makes assessing the size of informal low-productivity employment difficult. Charmes (1990) uses the number of non-wage workers as a rough, macro-economic proxy. This approach is in line with the view that informal activities can be considered an adequate response to inadequate economic institutions (see among others ILO, 1992). The number of non-wage workers is a good indicator of the level of economic development. A developing country in which incomes per capita are low, is likely to have many non-wage workers and considerable employment in agriculture.⁸

To characterise the traditional sectors and their impact on the performance of developing countries we need to make assumptions about the wage difference $(\bar{w} / \underline{w})$. Unfortunately we do not have reliable estimates either. We have to rely on casual observations and on sensitivity analysis. The ratio $(\bar{w} / \underline{w})$ is set equal to 4 in 1995. We assume that in the same year the share of the low-skilled workers in the traditional sectors was equal to 0.75. The elasticity of labour supply, γ , is set at 0.8. From these assumptions we calibrate the parameter C (the maximum wage ratio before all workers are employed in the formal sectors) in equation (17.a) at 12.5. The development of relative wages

⁶Strictly speaking one may argue that workers in informal sectors do not earn wages. Nonetheless we will often refer to their incomes as wages.

⁷At the same time the size of the total labour force will be kept the same.

⁸Hof *et al.* (1999) find a close correlation between various development indicators. This suggests that the use of different indicators does not lead to drastically different answers.

over time is chosen such that equation (17.a) leads to a flow of workers to the formal sectors that is roughly in line with historical patterns, see Table 3.2.

Table 3.2 Employment in agriculture

% of total employment

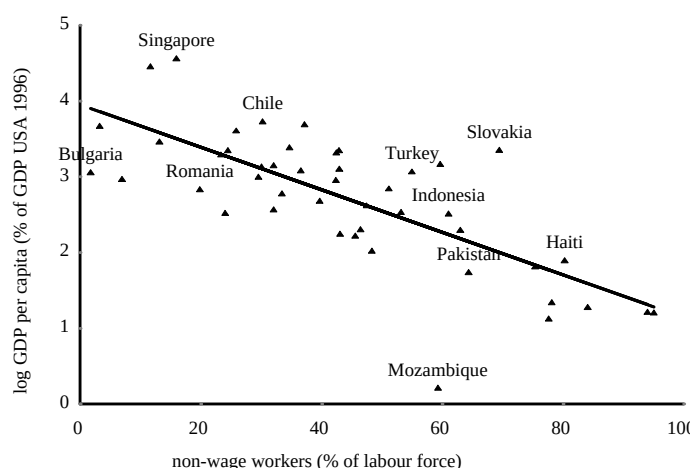
	1960	1990	average annual change
China	83.2	72.2	-0.4
India	75.4	64.0	-0.4
Indonesia	74.8	55.2	-0.7
Brasil	55.2	23.3	-1.1
Russia	30.4	13.7	-0.6
Korea	61.3	18.1	-1.4
Slovenia	63.8	5.7	-1.9
Japan	33.1	7.3	-0.9
Western Europe	16.7	4.7	-0.4
United States	6.6	2.8	-0.1

Source: ILO (1996)

Even data about the number of non-wage workers, are not readily available, let alone for more than year. Therefore we shall consider the changes in agricultural employment over time instead. Table 3.2 presents the share of agriculture in total employment in 1960 and in 1990 for various regions. The table shows that some countries have experienced a considerable fall in agricultural employment during that period. Typically, the countries that have gone through a process of rapid structural change, have also started catching-up with the rich countries. However, changes in the sectoral structure have also been quite pronounced in Brazil, where growth has been modest. Table 3.2 also shows that changes in some countries have just begun. In China, India and Indonesia the share of agricultural employment is still above 50% and even Brasil and Russia have a large share of agriculture, compared to western standards.

Figure 3.2 shows the relation between the share of non-wage workers and per capita GDP relative to the United States.

Figure 3.2 Relative GDP per capita and the share of non-wage workers in the labour force



source: ILO (1998), WorldBank (1995).

Lejour and Tang (1999) show that the share of non-wage workers falls by average nearly 1 percentage point when per capita GDP increases by 5 percent.

The flow of workers from informal to formal sectors is not the same in every region. It depends on the projected growth of GDP per capita. For example, in the High Growth scenario China's per capita growth rate is 7.5%. This means that per capita income will be 6 times as high in 2020. About 1 percentage point of the total Chinese labour force will under such circumstances shift from the informal to the formal sectors every year. This amounts to 28 percentage points during 25 years. In other regions WorldScan predicts a slower the pace of reallocation. The shift in the rest of Asia amounts to 20 percentage points on average.

The historical data shown in Table 3.2 make these projected shifts seem adequate. Table 3.3 gives the resulting characteristics of the low-productivity sectors in the base year 1995. Not surprisingly, in Asia and Africa informal employment is relatively high whereas in Latin America it has fallen to lower levels.⁹ In the latter region, a relative smaller share of the informal workers is employed in agriculture.

⁹The size of the traditional sectors can be measured in value-added or in terms of employment. These measures sometimes produce a different impression. For example, the informal sectors in China and India seem similar in terms of employment, but they look different in terms of value added. The reason is that in China low-skilled workers are relatively scarce, which makes their wages relatively high. The relative wage of informal sector workers in China is therefore also higher. This leads to a higher share of value-added produced in the Chinese informal sector.

Table 3.3 Low-productivity sectors in developing countries
value added, employment and GDP per capita in 1995

	Latin America	Middle East	Sub-Saharan Africa	China	South-East Asia	South-Asia & Rest
informal sector (as % of total value added)	1.3	0.9	6.5	24.7	3.5	14.6
informal employment (as % of labour supply)	24.9	23.5	59.7	63.6	37.1	61.6
informal agrarian employment (% of total informal employment)	39.4	50.6	68.8	85.6	55.1	80.1
GDP per capita (\$1000)	3.4	2.4	0.5	0.7	2.9	0.5

Source: own calculations, based on McDougall et al. (1998), World Bank (1995) and ILO (1998)

4. Simulation results

To illustrate the main ideas discussed in this paper we run three simulations with WorldScan. The main purpose of these simulations is to show the potential effects of a shock in one of the endowments in the world economy. We analyse the impact of a rise in the skill intensity in the scenario which was discussed in the previous section. We are especially interested in how the endogenous flow of workers from low productivity sectors into formal sectors is influenced. This flow is the result of two effects. First, even if the share of informal sector workers in the low-skilled labour force remains constant, it will decline as a share of total labour supply, because the low-skilled labour force will shrink relative to the high-skilled labour force as a result of schooling. If less people are low-skilled, there will be less people trapped in the informal, low-productivity sectors. In other words, education transforms also low-skilled workers in the informal sectors (or young workers that were predestined to work in the informal sectors) into high-skilled workers. Second, there will be an additional endogenous flow of workers from informal into formal sectors as a response to increased wage differentials.

To analyse the shrinking informal sectors, we first construct a baseline with a constant skill-intensity and then run two simulations. In the first simulation, the ‘Schooling Variant’, we introduce the rise in skill levels that was discussed in the previous section, but the informal sector remains a fixed share of the low-skilled labour force. In the second simulation we add the wage-induced flow to the schooling impulse. Thus, the difference between the second and the first simulation is the impact of endogenous, wage-induced labour supply to the formal sectors.

The results we present refer to the year 2020. Table 4.1 presents the size of the informal sector and the employment levels of high- and low-skilled workers in the baseline without schooling for some aggregated regions. In this baseline it is assumed that the number of high-skilled workers as

a percentage of total labour supply is constant over time and therefore equal to that percentage in the base year 1995.¹⁰

Table 4.1 **Number of workers in formal and informal sectors in 2020**
in the baseline without schooling; millions of persons
(between brackets as percentage of total formal employment)

	informal low-skilled	formal low-skilled	formal high-skilled
OECD	27 (7) ¹	183 (48)	201 (52)
Rest of the World	436 (54)	558 (70)	243 (30)
Asia	844 (67)	841 (66)	426 (34)
World	1306 (53)	1582 (65)	870 (35)

Source: WorldScan simulations

¹ Note that this number reflects the number of unemployed in the OECD. We assume that the rate of unemployment is exogenous, because we want to concentrate on the labour shift in the non-OECD regions.

In the OECD 50% of the labour force is high-skilled. Since mainly low-skilled workers are unemployed, high-skilled workers are slightly in the majority in total employment. In developing regions about 30 percent of formal employment and about 20 percent of the total labour force is high-skilled.

First, we show the effects of schooling without wage-induced labour reallocation. So, we introduce an increase in the share of high-skilled labour to total labour supply in the developing regions between 1995 and 2020 as is depicted in Figure 3.1. Total labour supply does not change, thus employment of low-skilled labour decreases. Because workers in the informal sectors form a fixed share of the supply of low-skilled labour, low-skilled employment decreases in both the formal and the informal sectors. In both Asia and the other non-OECD regions this leads to a nearly 10% decline in the informal sectors.

Table 4.2 **Shifts in labour supply due to schooling in 2020.**
Schooling variant in deviation from the baseline; millions of persons

	informal low-skilled	formal low-skilled	formal high-skilled
Rest of the world	-44	-67	111
Asia	-81	-91	172
World	-125	-158	283

Source: WorldScan simulations

¹⁰Because in this baseline the informal sectors decline as a result of increasing wage differentials between formal and informal work, the number of low-skilled workers in formal sectors increases slightly while the number of high-skilled workers in the formal sectors remain the same. In other words, in this technical baseline the skill intensity in formal sectors drops over time in developing regions.

If labour reallocation between the informal sector and the low-skilled segment of the formal labour market is allowed to take place, the reserve pool of labour supply will shrink further. Higher wages of low-skilled workers in formal sectors will attract more workers, who were previously engaged in informal activities. The resulting shifts that correspond with the ‘Reallocation variant’ are listed in Table 4.3.

Table 4.3 Shifts in labour supply due to schooling and labour reallocation in 2020.

Reallocation variant in deviation from the baseline; millions of persons

	informal low-skilled	formal low-skilled	formal high-skilled
Rest of the world	-178	67	111
Asia	-198	26	172
World	-376	93	283

Source: WorldScan simulations

By showing the skill-intensity in formal sectors in four different cases Table 4.4 summarizes the observation that shrinking informal sectors prevent rapidly increasing skill-intensities in formal sectors. The first column shows the skill-intensity in the technical baseline without increased average schooling levels. The other columns all consider an equal rise in schooling levels, but with different assumptions about the informal sector. The second column presumes a constant size of the informal sectors. In that case schooling only affects the labour composition within the formal sectors. The numbers in this column are not the outcome of a simulation.¹¹ The additional schooling efforts in developing regions would then lead to skill intensities of almost 50%, very close to those in the developed regions. The third column assumes the informal sector to be a constant share of low-skilled labour supply, as in the Schooling Variant. The fact that the informal sector shrinks already tempers the increase in skill-intensity. The last column represents the Reallocation Variant, in which wage-induced flows occur from informal to formal sectors. These flows dampen the change in skill intensity even further. Table 4.4 shows that it is difficult for developing regions to converge to input intensities in formal sectors that prevail in developed economies, due to interactions with the informal sectors.

¹¹It only shows in an illustrative way how skill intensities will change if the number of informal workers remains constant.

Table 4.4 Share (%) of high-skilled in formal employment in 2020¹

	baseline	constant	schooling	reallocation
Rest of the world	30	44	42	36
Asia	34	47	44	41
World	35	47	45	41

Source: WorldScan simulations

¹The last two columns present the shares in the two simulations that are discussed throughout this section. The second column shows a hypothetical situation in which the number of persons in the informal sector remains constant and schooling only affects the division of skilled and unskilled persons within the formal sectors.

In the Reallocation variant labour is attracted by formal sectors because the wage gap between formal and informal activities widens as a result of schooling. There are at least three channels through which the wage differential is affected. Firstly, the direct impact of schooling is that high-skilled labour becomes less scarce and that low skilled labour becomes less abundant in formal sectors. This leads to a downward pressure on wages of high-skilled workers and a upward pressure on wages of low-skilled workers. Secondly, schooling evokes additional capital accumulation. As a result, capital will grow faster than low-skilled employment and low-skilled wages will rise. Workers in informal sectors do not benefit from this growth impulse, because they do not have access to capital. Thirdly, higher income per capita induces a shift in consumption patterns, mainly away from agriculture towards services. This shift has two opposite impacts on the wage gap between formal and informal activities. It tends to depress low-skilled wages in the formal sector, because consumption shifts towards skill-intensive sectors. At the same time it lowers informal wages, because the relative price of agricultural products, a main determinant of informal wages, falls as a result of a relative drop in demand. This second mechanism prevails in the simulation and therefore the endogenous shift in demand patterns contributes to the outflow from the informal sectors.

Table 4.5 describes the resulting impact on the wage differentials. The first column shows per capita income in the informal sector as a share of low-skilled wages in the formal sectors in the baseline. This ratio varies between 10 to 20%, which corresponds to Lewis (1954) who states that incomes in the informal sectors hardly exceed the subsistence levels. The second column in Table 4.5 shows the cumulated impact on this ratio in the Schooling variant. This wage ratio halves in most developing regions. China and South Asia and Rest are an exception because the relative increase in the share of high-skilled workers to the total labour force is lower there than in the other regions. As a consequence, the effect of schooling is also smaller. It is this increase in the wage ratio that provokes an additional inflow of workers into the formal sectors. The consequence of that inflow is given in the third column, which again shows the deviation from the baseline as cumulated percentage. Since the additional flows are substantial as described above, wages in the formal sector will be pushed downwards. The impact of schooling on the relative incomes in the informal sectors is only half as large as the impact in the Schooling variant. This shows that a flexible informal sector functions as a reserve that keeps wages in the formal sectors low. It can keep developing regions in the role of low wage competitors, specialising in inexpensive low-skilled intensive products for a surprising long period.

Table 4.5 Ratio of informal wage to formal wages of low-skilled workers in 2020

region	ratio	cumulated percentage deviation from baseline	
	in baseline	schooling	reallocation
Middle East	0.11	-48	-25
Sub-Saharan Africa	0.18	-51	-26
Latin America	0.11	-46	-24
China	0.14	-15	-8
South-East Asia	0.11	-50	-25
South Asia and Rest	0.15	-21	-11

Source: WorldScan simulations

What is the impact of schooling and labour reallocation on relative wages in the formal sectors?

Table 4.6 summarizes these effects. The first column shows the ratios of low-skilled to high-skilled wages in the baseline in 2020. The ratios vary between 10% and 40%. The 10% in Sub-Saharan Africa reflects the scarcity of high-skilled labour. Only about 5% of the labour force is classified as high skilled. A much larger percentage of high-skilled workers can be found in China and South-East Asia, leading to relatively high wages for low-skilled workers. The other two columns show the impact of schooling in the two variants. The significant increase in the skilled labour force in the Middle East and North Africa, Sub-Saharan Africa, Latin America and South-East Asia, raises the wage ratios by about 75%. This almost doubles the ratios compared to the baseline, if there is no additional, wage-induced outflow from the formal sector. The effects in China and South Asia and Rest are smaller (30 - 40%) due to the modest growth in high-skilled labour, as is assumed in the scenario. Endogenous labour reallocation from the informal to the formal sectors (the third column in Table 4.6) significantly mitigates the change in relative wages. The increase in the wage ratio varies between 20% and 50% in the latter simulation compared to the baseline.

Table 4.6 Ratio of formal wages of low-skilled to high-skilled workers in 2020

	baseline	Percentage deviation from baseline	
		schooling	labour reallocation
Middle East	0.22	76	44
Sub-Saharan Africa	0.10	82	49
Latin America	0.32	71	40
China	0.38	31	21
South-East Asia	0.39	78	46
South Asia and Rest	0.31	42	27

Source: WorldScan simulations

Schooling in the developing regions has also some effects on the labour markets in the OECD regions by trade spillovers. These effects are, however, modest. Due to the increase in schooling the ratio of low-skilled to high-skilled wages rises by 0.5% points to 0.8% points. This is partly compensated by labour reallocation in developing regions, which enlarges the world-wide employment of low-skilled workers in the formal sectors. The wage ratio will decrease by about 0.3% points. The net effect of schooling and induced labour reallocation is thus less than 0.5% points.

The relative increase in wages of low-skilled workers raises the price of skill-*extensive* goods compared to those of skill-*intensive* goods. Table 4.7 presents the producer prices of Consumer Goods which are skill-extensive relative to those of Capital Goods which are skill-intensive. These relative producer prices increase in several developing regions by about 7% points. In China and South Asia and Rest the increase is lower, because the increase in high-skilled workers is relatively modest. The second column of Table 4.7 shows that the upward pressure on prices of skill-extensive goods is substantially mitigated by the endogenous inflow of informal workers into the formal sectors. The impact in the Reallocation variant is hardly more than half the impact in the Schooling variant.

Table 4.7: Price of Consumer Goods relative to price capital goods in 2020
relative deviations from the baseline with schooling and labour reallocation

simulation:	schooling	reallocation
United States	-0.2	0.1
Japan	0.2	0.0
Western Europe	0.3	0.0
Pacific OECD	0.6	0.3
Eastern Europe	0.2	0.0
Former Soviet Union	0.1	-0.1
M. East and N. Africa	6.6	4.0
Sub-Saharan Africa	7.6	5.2
Latin America	7.0	4.2
China	2.8	1.9
South-East Asia	6.4	4.0
South Asia & Rest	4.7	3.3

Source: WorldScan simulations

The change in endowments towards high-skilled labour in developing regions shifts the production structure towards Services and Capital Goods. It is therefore not surprising that the output of those sectors rises in developing economies, as a result of an increased skill intensity. This is shown in Table 4.8. However, it is important to note that also the production of skill-extensive goods increases, albeit to a lesser extent than that of skill-intensive goods. The increase in productivity growth induced by schooling in the developing regions stimulates production in all sectors. Even without the wage-induced outflow of labour from the informal sector, total employment in the skill-extensive sectors increases. Industrial countries tend to specialise less in skill-intensive sectors because of the change in comparative advantages in developing economies. However, the increase in the production of Consumer Goods is relatively modest because developing regions also increase their production in these sectors. In case of endogenous labour reallocation OECD's output in skill- extensive sectors like Consumers Goods is hardly affected. Although the original impulse is a rise in skill intensity in developing regions, those regions will hardly lose their competitiveness in skill-extensive products. Because the regions will experience overall growth as a result of schooling, they will even increase their share in global markets of skill-extensive products. This illustrates that because of the large reserve of low-skilled workers in informal sectors, developing economies will remain the main

competitors in international markets of skill-extensive products for a long period, even when those countries try to converge to developed economies via schooling.

Table 4.8: Production volumes of Consumer and Capital Goods in 2020
relative deviations from the baseline with schooling and labour reallocation

Production volume simulation:	Consumer Goods		Capital Goods	
	schooling	reallocation	schooling	reallocation
United States	6.4	1.6	-3.5	-2.3
Japan	4.7	1.6	-0.6	0.7
Western Europe	6.4	2.5	-2.1	-0.9
Pacific OECD	4.7	0.1	-4.4	-3.7
Eastern Europe	3.6	0.8	-3.0	-2.3
Former Soviet Union	2.1	-0.8	-2.4	-2.3
M. East and N. Africa	7.6	29.4	54.7	73.6
Sub-Saharan Africa	31.6	54.8	102.2	121.7
Latin America	4.2	21.0	39.0	51.1
China	7.1	8.9	13.4	18.6
South-East Asia	-3.4	13.7	36.0	48.2
South Asia & Rest	6.2	12.9	38.6	45.7

Source: WorldScan simulations

5 Conclusions

This paper concentrates on the role of endogenous endowments and the persistence of specialization patterns. We argue that the endogeneity of endowments and the endogenous interaction between endowments can affect comparative advantages in unexpected ways. In models with two types of exogenous endowments an increase in one endowments raises the relative global supply of that endowment. This conclusion does not necessarily hold if one of the endowments is endogenous. If two types of endowments are positively correlated an increase in the exogenous endowment induces an endogenous increase in the other. Then, the increase in the global supply of the exogenous endowment relative to the global supply of all endowments would be less than in the case that both endowments are exogenous. In extreme cases the relative global supply of the exogenous endowment might even decrease. As a result, comparative advantages may change in unexpected ways and specialization patterns may be influenced in an unexpected way as well.

We analyse such an increase in endowments by modelling the endogenous flow of workers from informal sectors into formal sectors in developing regions. For this purpose we use WorldScan, a large dynamic general equilibrium model of the world economy. The endogenous flow tends to make current specialization patterns persistent. Developing countries remain specialized in low-skilled intensive products. The mechanism leads to a continued downward pressure on wages of low-skilled workers in the global economy. The simulations with WorldScan analyse the impact of an increase in the skill intensity in developing countries during the coming decades. That increase will ultimately lead to a larger global supply of high-skilled intensive products. This is larger than the

increase in the supply of low-skilled intensive products, but it is much smaller than one would expect in static analyses or in absence of informal sectors.

These results are not only limited to the case of an increase in human capital in developing countries. An increase in savings and thereby capital accumulation or an increase in technology could have similar effects as human capital. Consider the case in which developing countries quickly copy new technologies from industrial countries. Then production possibilities over regions become similar but this is not necessarily the case for production patterns. The increase in productivity induced by new technologies will stimulate labour reallocation from low- to the high-productivity sectors. Consequently wages of low-skilled workers will remain relatively low, which makes the current specialization pattern persistent.

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Appendix A1 Calibration of the WordScan Model

The Data

The WorldScan model has been given empirical content at various levels. Our aim is to make the model reflect the current state of world economy. In order to obtain this goal we used various data sources. In this respect the GTAP database (McDougall et al., 1998) has played an important role. We used this data set to derive demand, production and trade patterns for the year 1995. Labour and capital intensities of the various sectors are also based on GTAP.

Substitution elasticities

Substitution possibilities in production and consumption determine the results of a model like WorldScan. WorldScan's production technology is described by a nested CES function. Its upper nest draws a distinction between value added and intermediary goods imposing an elasticity of substitution of 0.4. At a lower level value added is decomposed into primary factors: capital, low-skilled labour and high-skilled labour. The elasticity of substitution between these factors is 1 due to a Cobb-Douglas specification. Intermediary goods are combined according to a CES function, imposing a substitution elasticity of 0.8. The demand for the different consumption categories has been derived from a Cobb-Douglas utility function.

Substitution between goods from different origins is not perfect in WorldScan. We employ an Armington-type assumption. Price elasticities of demand may vary considerably over time because they depend on market shares. High market shares imply small price elasticities. The long-run substitution elasticities for raw materials, agriculture, manufacturing and services have been set at 17, 13, 7 and 5 respectively.

Appendix A2 Schooling in WorldScan

The data on the stocks of human capital produced by Barro and Lee (1996) and Ahuja and Filmer (1995) raise several questions with respect to our purpose to classify high-skilled and low-skilled labour. First, the differences between the United States and most other OECD countries are quite large between 1960 and 1990. The proportion of the population which only attained primary education is much higher in Europe, while the attainment in higher education is much lower there. Moreover, for most large European economies convergence tendencies to the United States do not show up. In our opinion, the implied differences in projected skill levels in these countries are not plausible if they are related to actual differences in skill-intensive production technologies in the OECD. Statistics of OECD (1997a) support this reasoning.

For these reasons, it seems reasonable to assume that education levels are similar within OECD regions. Moreover, WorldScan puts emphasis on differences between OECD and non-OECD regions. So, we are in particular interested in distinguishing differences in skill levels between the OECD and non-OECD. According to the Barro and Lee data (1996) the education levels in Eastern

Europe and the Former Soviet Union are comparable to those in the OECD. Therefore we assume that the stocks of human capital are similar in the OECD, Eastern Europe and the Former Soviet Union in our projections.

Besides the problem mentioned above, Ahuja and Filmer (1995) only provide projections for attained levels of education. However, we classify high-skilled workers as those who have completed secondary education or more. Other classification criteria would lead to a very large share of high-skilled workers in the OECD (e.g. if attained secondary education would be a criterion) or a negligible share of high-skilled workers in the non-OECD (e.g. if attained tertiary education would be a criterion). The following method is used to derive projections until 2020 for the population share which completed secondary education.

1. We calculate the drop-out ratios at the secondary schooling level for the relevant WorldScan regions on basis of the Ahuja and Filmer data for the years 1985, 1990 and 1995. For these years they provide data on both secondary education attained and completed. From this analysis we assume that the ‘projected’ drop-out rates from 2000 to 2020 are 55%. Based on these drop-out rates and the projections on secondary attainment by Ahuja and Filmer we derive the projections on the completion of secondary education until 2020.

2. We use the Barro and Lee data (1996) to compute the high-skilled ratios, defined as the number of high-skilled divided by the total labour force, for the OECD and non-OECD for the period 1960 to 1990. We define the relative high-skilled ratio as the high-skilled ratio in the non-OECD divided by the one in the OECD. We calculate the increase in the relative high-skilled ratio during the period 1960 to 1990 and extrapolate this increase until 2020.

3. We normalize the high-skilled ratio in the OECD and the transition countries at 50% for the whole simulation period in order to obtain a skill premium of about 60% in the model. There are two other reasons for this normalization. First, increases in the supply of skilled labour are often accompanied by increases in demand in the longer term. One of the causes is the shift in production technologies in favour of high-skilled labour. However, apart from increases in total factor productivity, production processes do not change in WorldScan. Second, the classification criterion for the skill split changes in time. Fifty years ago, people who attained some years of secondary education were classified as high skilled in the OECD and in future one may have to complete tertiary education to obtain this classification. Diploma inflation thus occurs.

4. From 1 to 3 we derive the high-skilled ratio for the non-OECD regions, relative to those in the OECD and the transition countries. The high-skilled ratio in non-OECD regions is 50% (3) times the increase in the relative high-skilled ratio in the non-OECD (2) times the growth rate of the high-skilled ratio in a particular region (1) compared to the average growth rate of the non-OECD regions.

The resulting projections are shown in Table A1.

Table A1 Share of high-skilled labour in total labour supply

region	level 1995	growth 1996-2020	level 2020
OECD + transition regions	50.0	0.0	50.0
Latin America	24.3	1.9	39.3
Middle East & North Africa	18.7	2.3	33.2
Sub-Saharan Africa	4.9	3.3	11.0
China	21.8	0.9	27.6
South-East Asia	27.4	2.0	45.1
South Asia & Rest	16.4	1.4	23.3

Source: Own calculations based on Ahuja and Filmer (1995), Barro and Lee (1996)

Appendix A3 Regional and sectoral concordances for WorldScan

1	United States	1	Agriculture and food production
2	Japan		Paddy rice, Wheat, Grains, Cereal Grains, Non grain crops, Vegetables, Oil seeds, Sugar cane Plant-based fibres, Crops, Bovine cattle, Animal products, Raw milk,, Wool, Forestry, Fisheries, Processed rice, Meat products, Vegetable Oils, Dairy products, Sugar, Other food products, Beverages and tobacco
3	Western Europe		
	United Kingdom, Germany, Denmark, Sweden, Finland, Rest of European Union, EFTA		
4	Pacific OECD	2	Raw Materials
	Australia, New Zealand, Canada		Oil, Gas, Coal, Minerals
5	Eastern Europe	3	Consumption goods
6	Former Soviet Union		Textiles, Wearing apparels, Leather etc, Wood products, Chemical, rubbers and plastics
7	Middle East and North Africa	4	Intermediate goods
	Turkey, Rest of Middle East, Morocco, Rest of North Africa		Pulp paper, Petroleum and coal, Nonmetallic minerals, Ferrous metals, Nonferrous metals
8	Sub-Saharan Africa	5	Capital goods
	South African Customs Union, Rest of Southern Africa, Rest of Sub-Saharan Africa		Fabricated metal products, Transport industries Machinery and equipment, Electronic equipment Motor vehicles and parts, Rest of manufacturing
9	Latin America	6	Services
	Central America and Carribean, Mexico, Argentina, Brazil, Chile, Uruguay, Venezuela, Colombia, Rest of South America		Electricity, Gas manufacture and distribution, Water, Construction, Financial, business and recreational services, Public administration, education and health, Dwellings
10	China	7	Trade and Transport
	China, Hong Kong		Trade and Transport
11	South East Asia		
	Republic of Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, Taiwan, Vietnam		
12	South Asia & Rest		
	India, Sri Lanka, Rest of South Asia, Rest of the World		