1. INTRODUCTION

Less developed countries tend to adopt existing technologies rather than invent new ones. In a closed economy, new technology already in use in the developed countries has to be internally produced. In an open economy, technology can also be transferred through importing of capital goods from developed countries or foreign direct investment (FDI). The issue debated in the literature is whether technical progress is more likely to occur in a closed economy (infant-industry argument) or in open economies.[1]

The issue addressed in this article is whether openness raises production efficiency, and the link that "learning" creates between trade policy and output growth patterns in developing countries (Arrow 1962, Romer 1986, Lucas 1988, and Quah and Rauch 1990). If knowledge transferred by trade is general,[2] openness should raise total factor productivity through increasing efficiency.

Up to now, there is no evidence in the literature on the relative importance of channels through which trade diffuses technology (Tybout 1998). The main contribution of this article is providing for the first time evidence on the macro level. Estimation of a stochastic production frontier for a panel of 57 countries[3] shows that FDI and imported capital goods are important channels for improving

[1] There are two views in the literature on the benefits of openness in relation with productivity in LDCs. On the one hand, there is the infant-industry argument: protection policy can help the high-skill industries (import-substitution industries), which use the production technology of industrial countries to develop. In the long-run, there will be a dynamic productivity gain (Nishimizu and Robinson 1984, 1986, Nishimizu and Page 1991, Pack 1992, Stockey, 1991, Rodrik 1992a,b, Rodriguez and Rodrik 1999, Matsuyama 1992). On the other hand, some studies find that trade liberalisation increases the production of high-skill intensive industries (import-competition industries), which use the production technology and the capital goods imported from developed countries (Pack 1988, 1999, Tybout 1992, Coe and Helpman 1995, Coe, Helpman, and Hoffmaister 1997, Robbins 1996, Levin and Raut 1997, Pissarides 1997).

[2] General human capital represents general knowledge associated to some technology, whereas specific human capital refers to technology specific to some industry. Technological change specific to some production process requires investment, whereas general (neutral) technological change does not.

[3] Observation period: 1960-1990.

efficiency. Analysis reveals, however, an important difference between the two channels. Knowledge diffused through FDI is more general (disembodied) than that from imported capital goods (embodied). Over the observation period, whereas all countries become more efficient, gains are especially evident for the group of Asian countries in the panel. This result can be linked to the early outward orientation and the favourable climate for FDI in the 80s.

The remainder of the paper is organised as follows. In the model developed in Section two, the high value-added sectors (i.e. import-substitution sectors) benefit from technological diffusion through trade liberalisation. Section three explains the stochastic frontier methodology used. The fourth section uses this stochastic frontier approach to test the model in Section two and analyses the results. A fifth section concludes.

2. THE MODEL

The model in this section builds on the argument that openness allows an economy's dynamic sector to develop. Drawing on the ideas of Lucas (1988), Matsuyama (1992) and Weinhold and Rauch (1999), the model links imports of intermediate goods and faster less developed country (LDC) growth. Trade openness leads to increased specialisation and this, in turn, accelerates productivity growth through dynamic economies of scale. The dynamic sectors (import-substitution) sectors benefit from technological diffusion by trade liberalisation.

Consumption side

The number of individuals is assumed equal to L. Each individual is endowed with one unit of labour per unit of time, and supplies this inelastically without disutility.[4] Therefore, total labour supply per unit of time is equal to L.

[4] Barro and Sala-i-Martin (1995) p. 62.