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The purpose of this paper is to assess the importance of human capital as a facilitator of technological diffusion in a sample of developing Mediterranean countries based on the predictions of endogenous growth theory. The evidence does not support the Benhabib and Spiegel (2002) non-linear specification that accommodates both the hypothesis of technological convergence and convergence clubs but the linear specification originally proposed by Benhabib and Spiegel (1994), confirming a role for human capital in both innovation and imitation activities. We also tested the complementarity between FDI, a form of embodied technology diffusion, and human capital but this hypothesis was not confirmed and investigated the importance of human capital for the diffusion of ICT confirming it is fundamental to benefit from these technologies. Finally, we analysed the importance of technological shocks for technological diffusion using a VAR model finding evidence of factor complementarity between TFP, physical capital investment and human capital in the absorption of any of the shocks considered.
1. Introduction

The purpose of this paper is to empirically assess the importance of human capital as a facilitator of technological diffusion in a sample of seven developing Mediterranean countries between 1960-2000. Developing Mediterranean countries are geographically and economically close to developed European countries and their economic prosperity, together with their subsequent political stability, is of major importance to European countries. Knowing the sources of growth in these countries can help us derive implications for policies that promote growth and convergence in the Southern Mediterranean countries.

Productivity differences are an important source of income differences across countries (see for instance, Easterly and Levine, 2001; Hall and Jones, 1999; Klenow and Rodriguez-Clare, 1997), so in order to understand growth the sources of productivity growth across countries have to be identified. Endogenous growth theory provides the theoretical explanations for technological progress which is responsible for sustainable long-term growth. For instance, the models of Romer (1990a), Romer (1990b), and Aghion and Howitt (1992) emphasize the importance of domestic innovation initiatives. Technological change is the result of the activity of an R&D sector that primarily uses the existing stock of knowledge and human capital as inputs. Nelson and Phelps (1966), Grossman and Helpman (1992) and Barro and Sala-i-Martin (1997) on the other hand, stress the importance of imitation activities or technology diffusion in technological change: countries further away from the technological frontier have a potential for faster growth by adopting the inventions developed elsewhere in the world. There are, however, cross-country differences in the effectiveness with which countries adopt foreign technologies, which in turn determine income differences. Nelson and Phelps (1966) stress the importance of human capital in narrowing the gap between the level of technology in practise and the theoretical level of technology2.

The roles played by human capital, either as an input in innovation activities or as a facilitator of the diffusion of technology from abroad, have been extensively analysed and confirmed by empirical growth literature. The benchmark study in this area is probably Benhabib and Spiegel (1994) but many other examples can be found, some of which are specific to developing countries (see for instance Coe, Helpman and Hoffmaister (1997), Mayer (2001), Engelbrecht (2002), Dowrick and Rogers (2002), and Papageorgiou (2003)). In the developing Mediterranean countries that are involved in little R&D3, technology diffusion is probably the most important source of productivity growth. It is therefore important to know whether the human capital stocks available in the developing Mediterranean countries constitute a break or promote technological convergence in these countries, in which case we would be in the presence of convergence clubs or poverty traps. The empirical growth literature either concentrates on wide samples of countries that include developed and developing countries, making it difficult to uncover specificities in certain groups of countries, or focuses on more restricted groups of countries, such as the OECD countries (see Temple (2001) for a review of empirical studies on human capital and growth focusing on OECD countries), Latin American countries (e.g., Easterly, Loyaza and Montiel...
focus specifically on developing Mediterranean countries and none to our knowledge deal with the issue of human capital and technology diffusion, a gap we would like to fill.

To assess the importance of human capital in technological change and, in greater depth, in technological diffusion in these countries we began by replicating the Benhabib and Spiegel (2002) empirical methodology that extends their Benhabib and Spiegel (1994) study to accommodate the possibility that there are convergence clubs in the process of technological growth and convergence, in the tradition of Azariadis and Drazen (1990) and Durlauf and Johnson (1995). In addition to considering a different sample of countries, we extended their empirical analysis to a panel data framework, since it would have been impossible to use cross-section econometric techniques to analyse a sample of seven/thirteen countries.

In the Benhabib and Spiegel (1994) study the authors develop a model to explain the importance of human capital in growth, inspired by the Nelson and Phelps (1966) model in which the potential speed of technology diffusion is inversely related to the degree of technological backwardness of the follower country and its absorption capability for new technologies depends on its human capital level. They assume that the technological diffusion path is exponential, i.e. the technological leader acts as a locomotive for growth in the follower country, so that the follower always converges to the leader and empirically technological growth can be written as a linear function of human capital. The Benhabib and Spiegel (2002) study extends the framework of analysis in order to accommodate the possibility of the existence of human capital thresholds in which technological convergence may occur, i.e. the existence of convergence clubs. The empirical counterpart of this model is an equation for TFP growth non-linear in human capital: if there is convergence, the diffusion path is exponential, whereas if there are convergence clubs the diffusion path is logistic.

The replication of the Benhabib and Spiegel (2002) study did not produce good results. We estimated the Total Factor Productivity (TFP) growth rate non-linear specification proposed by Benhabib and Spiegel (2002) using traditional econometric methods, Non Linear Least Squares (NLLS), but there was no evidence that human capital influences TFP growth either directly through its impact on the domestic innovation rate or indirectly by speeding up technology diffusion. These results led us to conclude that the non-linear specification is not appropriate in explaining productivity growth in our samples, which might be due to the fact that the countries in our sample possess a human capital level that is already above the threshold necessary to exploit the advantages of technological backwardness, i.e. they are not in a poverty trap.

In light of the above results, we tested the linear specification of the original Benhabib and Spiegel (1994) study since this might be the one best suited to the evidence on human capital and TFP growth in our samples. We called this linear specification the Nelson and Phelps (1966) methodology and used Ordinary Least Squares (OLS) with robust errors, fixed effects models and random effects models to estimate it. The results confirmed the two influences of human capital on productivity growth, although surprisingly the direct effect on the domestic innovation rate is much stronger that the indirect effect through technology diffusion. This is good news since, according to this specification, the technological followers will always converge to the leader.

The low impact of human capital on imitation activities, however, led us to explore the hypothesis that human capital is more important for TFP growth through embodied technology diffusion than through disembodied technology diffusion, represented before by the TFP gap to the technological leader. Technology diffuses through many channels but the availability of data for our seven developing Mediterranean countries made us restrict our analysis to the study of the complementarity between human capital and technology transfers through FDI. We also analysed the role of human capital as a facilitator of the diffusion of a particular type of technology, Information and Communication Technologies (ICTs), which play a major part in productivity growth. In both cases we took Borensztein, Gregorio and Lee (1998) and Lee (2001)

(1997)), or Sub-Saharan African countries (e.g., Easterly (1997), Hoeffler (2000)). Few, however,