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ESSAYS ON FINANCIAL MARKETS AND ON EFFECTS OF INFORMATION & COMMUNICATION TECHNOLOGY

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The present dissertation analyzes some features of financial markets efficiency and the effects of Information & Communication Technology on economic growth and on fertility rates. It is divided into four empirical essays.

The first essay aims to implement the literature on stock market anomalies, by testing the performance of "value" and "growth" portfolio strategies formed on deviations between observed and discounted cash flow fundamental (DCF) values.

It presents evidence on the excess returns obtained when contrarian strategies are played on the basis of the above described more sophisticated trading strategies, which are reasonable proxies of the behaviour of "fundamentalist" traders.

The significance of "value" and "growth" strategies in different subperiods is adjusted for several risk measures including: i) covariance of portfolio returns with GDP growth; ii) exposition to systematic nondiversifiable risk; iii) exposition to additional risk factors (return's skewness, small size and financial distress risk factors). About this last point, by combining Fama and French (1995) and Harvey and Siddique (2000) approaches, it extends the original one-factor CAPM to a four-factor CAPM model.

The results show that, both in the American (US) and European (EU) stock exchanges, "short term DCF value" strategies (based on a monthly selection of the stocks with the lowest observed to fundamental ratio in the previous period) have mean monthly returns which are higher than, not only the corresponding growth strategies, but also passive buy and hold strategies on the total sample portfolio (the benchmark).

Moreover they are not riskier in terms of covariance with GDP growth.

These results persist when returns are adjusted for risk, since risk adjusted intercepts of excess returns of value portfolios in four-factor CAPM estimates are still positive and significant.

The findings seem to suggest that semi-strong efficiency did not hold during the last 12 years. This is true for both EU and US sample, thus in the comparative evaluation of domestic financial systems the success of contrarian strategies seem not to be country specific and therefore not depending on specific features of different financial systems.

The second essay is dedicated to the study of how much “fundamental” and “non-fundamental” components matter in determining stock prices according to differences in regulatory environments and in the composition of financial market investors. A "two-stage growth" discounted cash flow (DCF) model, calibrated on the risk premium and on the terminal rate of growth, is built up to proxy the benchmark for the so called “fundamentalist” traders, while “non-fundamental” price components are interpreted as signals reducing asymmetric information (such as firm size, the number of earnings growth forecasts and the chartist momentum).

Empirical results on two samples of American (US) and European (EU) stocks show that the “fundamental” price earning ratio (P/E) explains a significant share of cross-sectional variation of the observed P/E. However, for US stocks (where there is more diffusion and transparency of information and more pervasive presence of pension funds, that may be expected to increase the share of long term investors adopting a fundamentalist perspective) the relationship between DCF fundamental and observed P/E is stronger than in the EU case.

It also documents that: i) the fundamental P/E has superior explanatory power with respect to simpler measures of expected earnings growth usually adopted in the literature and this for both samples; ii) the relevance of the “non-fundamental” components mitigates the role of the fundamentals; iii) only for the EU sample current deviations from the fundamentals are affected by ex post adjustment of publicly available information.

If we associate this last finding with that on the relatively different impact of fundamental values we find two pieces of evidence consistent with the *Market Integrity Hypothesis* (King and Roell, 1988; Bhattacharya and Daouk, 2000; Milia, 2000): reduced “insider trading” effects are generally related to higher reliance on fundamentals extracted from publicly available information.

Thus differences in regulatory environments and in the composition of investors between the US and EU financial systems may help to explain these comparative findings.

The third essay analyzes the contribution of Information & Communication Technology (ICT) to levels and growth of per capita GDP. In this perspective, it is argued that ICT can enhance economic growth by generating new vintages of capital goods which add value to traditional physical products (see Jalava and Pohjola, 2002) or by removing the "bottlenecks" which limit access to knowledge, with the effect of increasing the productivity of labour (see Quah, 1999).

Two different proxies are used in order to measure the technological factor: i) *Chain-Weighted ICT1 index,* which is composed by normalized data on telephone mainlines, on personal computers and on internet users; ii) *Chain-Weighted ICT2 index,* which is composed by normalized data on telephone mainlines, personal computer, internet users and by two different prices for internet access. These are internet provider access prices and internet telephone access prices ($ per 30 off-peak hours).

The econometric analysis compares the relative significance of the two hypotheses in level and growth estimates and find that, when separately taken, both hypotheses improve upon the classical Mankiw, Romer and Weil (1992)- Islam (1995) framework.

Moreover the Davidson-MacKinnon (1981, 1993) J-test for non-nested models shows the superiority of the first hypothesis when we use the ICT1 index (which includes ICT components which represent high-tech vintages of physical capital) and the superiority of the second hypothesis when we use the ICT2 index (more related to the bottleneck hypothesis, since it includes indicators of access prices).

Finally it is demonstrated that a mixed hypothesis which incorporates both dimensions of the ICT contribution to growth at the same time is preferred to the focus on only one dimension. The consistent improvement of "within" country significance in panel estimates documents that this approach captures two dimensions of time varying-country specific technological progress that previous standard approaches in the literature could not take into account.

Finally the forth essay is dedicated to the study of the role of technology (and, in recent times, especially of ICT technology) as a factor which, by affecting women's empowerment and productivity, could have significant effects on fertility decisions.

To estimate the relationship between ICT and the fertility rates across different countries it is used a random coefficient model which takes into account model misspecifications, like omitted variables and heterogeneity.

The empirical results show that ICT diffusion has significant negative effect on fertility rates, after controlling for human capital and institutional quality.

Moreover this effect is highly heterogeneous across macroareas (five subgroups of countries are optimally identified) and the random coefficient method provides improvements with respect to the estimation approaches that assume homogeneous parameters (such as conventional OLS fixed effects, where the impact of ICT, measured in the aggregate, vanished). The incapacity of the seconds in finding significant effects for ICT on fertility rates depends from the impossibility of disentangling the general effect from some significant group specific deviations from it.

Furthermore, subgroup deviations from non random general parameters seem to be strongly affected by three latent factors: pro fertility religious norms of Catholic and Islamic culture, the degree of secularization and education of a country, and the digital divide.

In this sense, the variables measuring access to ICT seem to proxy the impact on fertility of openness to world highly secularized culture. Such impact is stronger in countries where ICT has a significant diffusion and where it seems to prevail over religious norms (Catholic and South Europe countries) while it is much weaker in low income countries suffering from the digital divide and in countries where religious norms are so strong to overcome the ICT openness effect.

Short term value strategies:

a comparative analysis in the US and EU markets

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Abstract

The paper aims to implement the literature on stock market anomalies by testing the performance of "contrarian" portfolio strategies formed on deviations between observed and discounted cash flow fundamental (DCF) values in the US and European stock markets.
The significance of cross-sectional "short term DCF value strategies" in different subperiods is adjusted for several risk measures including: i) covariation of portfolio returns with GDP growth; ii) exposition to systematic nondiversifiable risk; iii) exposition to additional risk factors (return's skewness, small size and financial distress risk factors).
Our findings show that, both in the US and EU stock exchanges, "short term DCF value strategies": i) have mean monthly returns which are higher than, not only the corresponding growth strategies, but also passive buy and hold strategies on the total sample portfolio (the benchmark); ii) yield excess returns which are still significant after risk adjustment in 4-CAPM models; iii) are not riskier in terms of covariation with GDP growth. EU stocks have similar patterns when compared to US stocks in each of these features.

1. Introduction

The literature on explanatory variables of cross-sectional stock returns discusses the existence of size and book to market premia evaluating whether excess returns from portfolios of small size and low market to book stocks persist after risk adjustment.

While evidence on the existence of premia related to size and book to market factors is widespread (Lakonishok, Schleifer and Vishny, 1994; Clare, Smith and Thomas, 1997; Heston, Rouwenhort and Wessels, 1995, Bagella, Becchetti and Carpentieri, 2000), the discussion whether excess returns from these two variables are simply proxies of additional risk factors different from stock betas, or indicate the existence of market anomalies, is still open.

Some tentative explanations try to reconcile these cross-sectional findings with the Efficient Market Hypothesis. According to them size and book to market premia disappear once: i) multifactor CAPM (Fama-French, 1992, 1993 and 1996); ii) lead-lag relationships between large and small firm stocks (Lo and MacKinlay, 1990); iii) time-varying betas (Ball-Kothari, 1989) and iv) survivorship bias are properly taken into account.

A second group of papers rejects the validity of these interpretations and affirms that return premia on small size and low market to book stocks are too high and must be partially explained by investment strategies of noise (De Long et al., 1990), near rational (Wang, 1993), liquidity or “weak-hearted” traders overreacting to shocks and extrapolating past stock price dynamics (Bagella et. al., 2000; Lakonishok, et al., 1994).[1]

More specifically, Lakonishok et al. (1994) and Haugen (1995) argue that the value premium in mean monthly returns arises because the market undervalues distressed stocks and overvalues growth stocks.

The limits of this literature are that theoretical arguments and the observed microstructure of contemporary financial markets are only loosely related. Furthermore, contrarian empirical tests consider strategies (such as those of building size, book to market, or past winners' portfolios) which are relatively less sophisticated with respect to some of the observed strategies adopted by financial investors.

The marginal contribution of our paper goes in this last direction. We devise consistent "fundamentalist" investment strategies by building portfolios of value and growth stocks ordered on deviations between fundamentals[2] - calculated according to discounted cash flow (DCF) rules - and observed values. We therefore present evidence on the excess returns obtained when value strategies are played on the basis of the above described "more sophisticated" trading strategies which are reasonable proxies of the behaviour of fundamental traders.

Our paper is divided into five sections (including introduction and conclusions). In the second section we illustrate the methodology adopted for the

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[1] An agency cost related interpretation of this behaviour suggests that investment fund managers may also be extrapolative as their choice of past winners may be easier to explain to sponsors (Lakonishok et al., 1994).

[2] The evaluation of fundamentals is common practice in finance since an important school of though bases its trading strategies on price deviations from fundamental values. An alternative approach is followed by the so called "chartists" which adopt trend-following strategies buying (selling) a rising (falling) stock even if it is above (below) the fundamental value predicted by the first group of traders. The strategic interaction between fundamentalists and chartists is the focus

estimation of the fundamental value of the stock. In the third section we provide descriptive evidence on mean monthly returns for value and growth portfolios. In the fourth section GMM three and four-CAPM estimates evaluate the profitability of "value" portfolio strategies formed on deviations between observed and fundamental stock values and test the stability of contrarian strategy premia in different subperiods.

2. Stock market anomalies: a synthetic reference to the state of art

The literature defines "stock market anomalies" return patterns which are not explained by the capital asset pricing model of Sharpe (1964) and Lintner (1965).

Well known stock market anomalies are: i) the reversal in long-term returns when stocks with low long-term past returns tend to have higher future returns (De Bondt and Thaler, 1985); ii) risk adjusted excess returns related to size, book-to-market equity, earning/price, cash flow/price and past sales growth (Basu 1983, Rosenberg, Reid and Lanstein 1985, Lakonishok, Shleifer and Vishny 1994, Bagella-Becchett and Carpentieri, 2001).

Fama and French (1993) argue that the anomalies disappear when adjusted for additional risk factors. Their 3-factor model implies that the expected return on a portfolio in excess of the risk-free rate [E(Ri)-Rf] is explained by the sensitivity of its return to three factors: i) the excess return on a broad market portfolio [Rm-Rf]; ii) the difference between the return on a portfolio of small size stocks and the return on a portfolio of large size stocks [SMB factor]; iii) the

of several theoretical and empirical papers (Goodhart, 1988; Frankel and Froot, 1990; Sethi, 1996) difference between the return on a portfolio of high book-to-market value stocks and the return on a portfolio of low book-to-market value stocks [HML factor].

The expected excess return on portfolio p is:

$$E(R^t{}_P) - R^t{}_f = \alpha_P + \beta_P[E(R^t{}_m) - R^t{}_f] + \gamma_P E(SMB^t) + \delta_P E(HML^t) + \varepsilon_P{}^t$$

The factor sensitivities or loadings, $\beta_P, \gamma_P, \delta_P$ are the slopes in the time-series regression

$$R^t{}_P - R^t{}_f = \alpha_P + \beta_P(R^t{}_m - R^t{}_f) + \gamma_P SMB^t + \delta_P HML^t + \varepsilon_P{}^t$$

If the three-factor model describes expected returns, the regression intercepts should not be significantly different from zero.

Fama and French (1992, 1993, 1995, 1996) find that their null hypothesis is not rejected since excess returns disappear when adjusted for the two additional risk factors. In contrast to them, other authors show in their empirical analysis that return premia on small size and low market to book stocks do not disappear and must be partially explained by investment strategies of noise (De Long et al., 1990), near rational (Wang, 1993), liquidity or "weak-hearted" traders overreacting to shocks and extrapolating past stock price dynamics (Bagella et. al., 2000; Lakonishok, et al., 1994).

A third intepretation of the existing empirical evidence considers contrarian strategy premia a spurious result for at least three reasons: i) they may be the result of data-snooping as the relevance of book to market and size factors may be sample specific; ii) they may be affected by a survivorship-bias given that the COMPUSTAT database gives excessive weight to distressed firms (with high book to market values) that survived rather than to distressed firms that failed; iii) OLS techniques used for estimating CAPM models are not robust with nonnormal disturbances and noncostancy of variance. Alternative estimates on the same samples find that the significance of contrarian strategy premia is much lower when more robust GMM techniques, relying on weaker assumptions about residuals distribution, are adopted (MacKinlay and Richardson, 1991; Clare, Smith and Thomas, 1997).

In the next section we shift the debate into a new field by proposing a portfolio strategy which is more consistent with methods adopted by fundamentalists to calculate the fair value of the stocks. In this way we try to see whether fundamental contrarian strategies generate significant risk adjusted excess returns.

2. The simple DCF rule for portfolio selection

Accounting and economic literature usually adopt at least three different approaches to calculate the fundamental value of a stock: i) the comparison of balance sheet multiples (EBITDA, EBIT) for firms in the same sector; ii) the residual income method; iii) the discounted cash flow method.

The first approach has no rational grounds since, if market agents have nonhomogeneous information sets or adopt different trading strategies, the benchmark used for comparison may be overvalued or undervalued. A second problem is that, as far as firms diversify their activities and develop new products or services which cannot be easily classified into traditional taxonomies, industry classifications become tricky. Product diversification therefore makes it hard to assume that two firms classified into the same industry may have an identical risk profile so that their multiples may be effectively comparable (Kaplan and Roeback, 1995).

The problem with the second approach (residual income method) (Lee, et al., 1999; Frankel and Lee, 1998), is that the formula for evaluating the fundamental value of a stock uses a balance sheet measure whose accuracy and capacity of incorporating changes in the fundamental value of the stock is limited. A valuable example of this phenomenon is provided by Lee et al. (1999) who document the sharp uptrend in the price to book ratio which has risen three times between 1981 and 1996 for the Dow Jones Industrial Average. An interpretation for this result is that accounting methodologies lag behind in adjusting to changes in investors' market value assessments of firms whose share of intangible assets is changing over time. Moreover, book values tend to be seriously affected by historical or market value accounting choices on nonrealised capital gains/losses. This means that, depending on the rule adopted, the book value is not independent from market over or underevaluation.

This is the reason why, following Kaplan and Roeback (1995), we prefer to use the DCF approach. This approach is described also in previous contributions (Adriani, Becchetti, 2002; Becchetti-Marini, 2003; Becchetti-Mattesini, 2002) and is based on I/B/E/S forecasts. It has the advantage of using only current net earnings as accounting variable and is therefore relatively less prone to measurement errors as it does not require to compute the book value of firm assets and liabilities. According to the DCF model - and under the assumption that the discounted cash flow to the firm is equal to net earnings -, the "fundamental" of the stock be written as: $MV = X + \sum_{t=0}^{\infty} \frac{X(1+E[g_t])^t}{(1+r_{CAPM})^t}$

(1)

where *MV* is the equity market value, *X* is the current cash flow to the firm[3], $E[g_t]$ is the yearly expected rate of growth of earnings[4], $r_{CAPM} = R_f + \beta E[R_m]$ is the discount rate adopted by equity investors or the expected return from an investment of comparable risk, R_f represents the risk free rate, $E[R_m]$ the expected stock market premium and β is the exposition to systematic nondiversifiable risk. We consider the following "two-stage-growth" approximation of (1)

$$MVE = X + \sum_{t=1}^{5} \frac{X\,(1+E[g_U])^t}{(1+r_{CAPM})^t} + \frac{X\,(1+E[g_U])^6}{(r_{CAPM(TV)} - gn)(1+r_{CAPM})^6} \qquad (2)$$

where *MVE* is the "two-stage-growth" equity market value, $E[g_U]$ is the expected yearly rate of growth of earnings according to the Consensus of stock analysts[5]. According to this formula the stock is assumed to exhibit excess growth in a first stage and to behave like the rest of the economy in a second stage. The second stage contribution to the *MVE* is calculated as a terminal value in the second addend of (2) where $r_{CAPM(TV)} = R_f + E[R_m]$ and *gn* is the perpetual nominal rate of growth of the economy.

The analytical definition of the DCF model imposes some crucial choices on at least five parameters: the risk free rate, the risk premium, the beta, the length of the first stage of growth and the nominal rate of growth in the terminal period.

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[3] In the well known debate on the relevance/irrelevance of dividends we consider, as large part of the literature, that, under perfect information and no transaction costs, the dividend policy does not affect the value of stocks as non distributed dividends become capital gains (Miller-Modigliani, 1961). The value of equity may be equally calculated as the discounted sum of future expected dividends or the discounted sum of future expected cash flow to the firm.

[4] Actually, when estimating the model we should use the expected rate of growth of cash flow to the firm instead of the expected rate of growth of earnings. Even though earnings are obviously different from cash flow to the firm, our measure is not biased under the assumption that the expected rate of growth of earnings is not different from the expected rate of growth of cash flow to the firm.

[5] We use 1-year and 2-year ahead average earnings forecasts for the first two years and the long term average earning forecasts from the third to the sixth year. The use of the median estimate alternatively to the mean estimate does not change significantly our results. Robustness to mean/median forecasts is consistent with findings from Frankel and Lee (1998).

For the risk free rate we use the yield on the three month Treasury Bill[6].

For the risk premium we consider that our measure should be somewhere between the historical difference in the rates of return of stocks and T-bills and the implied risk premium[7] for equity markets. Both of these two extremes might be incorrect estimates for the risk premium. The former because it assumes that the long term historical premium is equal to the premium in our investigation period neglecting structural changes which may have occurred in the last decades. The latter because it assumes that financial markets are correct in evaluating stocks (this is not the case in presence of a bubble or of a nonzero share of noise or liquidity traders trading with arbitrageurs of limited patience)[8]. Since the risk premium is one of the most controversial and critical parameters, we determine it (and we do the same for the nominal rate of growth in the terminal period) by a calibration approach, under the constraint of a discount rate higher than the growth rate of the stock in the terminal value.

The third critical factor in the "two-stage" DCF formula is the terminal value of the stock. We arbitrarily fix at the sixth year the shift from the high growth period to the stable growth period. Sensitivity analysis on this threshold

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[6] We choose a short term risk free rate to match its time length with the average time length of portfolio strategies which will be illustrated in section 3. Results obtained when adopting a long term risk free rate (ten year yield on Treasury Bill) are not substantially different from those presented in this paper and are omitted for reasons of space.

[7] To calculate the current implied premium we use the Gordon et al. (1956) formula in which market value is equal to: expected dividends next year/(required return on stocks - expected growth rate) where the required return on stocks is the sum of the riskfree rate and the risk premium. In this formula, the extremely low implicit risk premium in the sample period may be interpreted as the availability to pay higher prices for a given expected growth rate even in presence of a low dividend payout.

[8] If we just adopt the implied risk premium without weighting it for the historical risk premium, we would implicitly assume that no fundamental value exists or that the fundamental is just what investors believe in a given historical period. In this case changes in the implied risk premium constantly update the fundamental value and the latter becomes just what investors are willing to pay for the stock.

shows nonetheless that this choice is not so crucial for the determination of the value of the stock.[9]

Finally, the literature generally proposes three alternatives for the choice of beta: the estimation of time varying firm specific or industry specific betas and a fixed unit beta[10]. We calculate the beta as the slope of the return of the stock on the return of the market index (the S&P 500 index for the US and the market country index for each EU firm) estimated over the last two years, on weekly observations.

3. DCF value and growth portfolio strategies: methodology and descriptive evidence

We select from DATASTREAM two samples: 309 US stocks from the S&P500 composite index and 98 EU stocks[11] from the DJSTOXX composite index.[12]

For all these stocks, data are collected from the January 1990 to March 2002. We follow Pagan and Schwert (1990) and DeBondt and Thaler (1985), in using monthly data, since daily data have substantial random white noise associated with them. To perform our simulation we calculate each month the

[9] We must in fact consider that the positive impact on value of an additional year of high growth must be traded off with a heavier discount of the terminal value which represents a significant part of the final value. Information on this sensitivity analysis is available from the authors upon request.

[10] Here again we have a vast literature on sophisticated methods for estimating time varying beta (Harvey and Siddique, 2000; Jagannathan and Wang, 1996)

[11]The US and EU samples are determined by the constituents of the index that were in the index from the beginning of the sample period (January 1990) to the end of the period (March 2002).

[12] The US sample has about three times more firms than the EU sample. This because we lack of some of the variables needed for calculating the fundamental value of the stock for many European firms in 1990.

observed to DCF fundamental price ratio for each of the US and EU index constituents and rank them in ascending order.

We then build 10 portfolios each of them composed by stocks whose ranking indicator is included into a given decile of the distribution of the observed to fundamental ratio (i.e. the 0-10 portfolio includes stocks whose observed to fundamental ratio falls in the lowest ten percent of the cross-sectional distribution of the indicator in the considered month). We call value (growth) stocks those with a relatively lower (higher) observed to fundamental ratio. As a consequence, the 0-10 and 90-100 portfolios respectively represent the two extreme value and growth strategies.

Portfolios are formed the first day of the month t on values that the ranking variable assumes in the last day of the month t-1. They are held until the end of the month t (1 month strategy), t+1 (2 months strategy), t+6 (6 months strategy), t+12 (12 months strategy). To avoid that MMRs from different strategies overlap, new portfolios are formed only at the end of each holding period, following the same rule.

For a first descriptive investigation on the stability of contrarian strategy premia we divide the analysis into two subperiods: January 1990-December 1995 and January 1996-March 2002.

Tables 1A-1F in Appendix present mean (arithmetic average), variance, skewness and Sharpe ratios[13] of monthly returns for value and growth strategies under different holding periods, from 1990 to 2002. Descriptive statistics provide evidence of a consistent value premium. Indeed they show that, for all periods (1-2-6-12 months holding periods), value strategies have mean monthly returns

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[13] The sharpe ratio is calculated as: $[R_p-R_f]/\sigma_p$ where R_p is the mean monthly return of the p-th portfolio (p=1,…,10), R_f is the monthly risk-free rate, and σ_p is the standard deviation of the R_p.

which are higher than, not only growth strategies, but also passive buy and hold strategies on the total sample portfolio (the benchmark), for both the US and EU sample.

To provide an example, the strategy of buying constituents of the S&P500 and DJSTOXX falling in the highest ten percent value stocks (lowest observed to fundamental ratio) and selling them after one month yields respectively a mean monthly return of 1.017 and 1.309 against respectively 0.287 and 0.129 percent of the opposite growth strategy, buying stocks with the highest observed to fundamental ratio, and 0.722 (0.798) and 0.708 (0.702) percent of the buy and hold strategy on the total sample portfolio (on the index). The variance of this value strategy, though, is higher with respect to buy-and-hold and growth strategies (tables 1A and 1B).

Since investors are conveniently assumed to be risk averse, they are concerned with the mean and variance of their portfolio returns. Thus, their optimal portfolios must be minimum-variance portfolios: they must have the smallest possible return variances, given their expected returns. A first inspection to risk-return properties of our results through Sharpe ratios show that value portfolios mean-variance dominate those of growth portfolios, if risk is evaluated only in terms of portfolio return standard deviation (an assumption which will be removed in the following sections). This is true both in the US and EU samples (Tables 1A-1F).

The empirical literature shows that premia from active portfolio strategies tend to decline over time as more investors become aware of the existing profitable opportunities (Becchetti-Cavallo, 2001). Does this occur also in our case?

Value premia from DCF contrarian strategies do not seem to follow this path since there is no significant decline over time of the relative profitability of value portfolios even when we split the sample into two equal subperiods (tables 1C-1F). On the contrary, the opposite seems to occur for the EU sample: the relative profitability of value portfolios increases over time (our DCF value contrarian strategy is not profitable in the first subperiod, but it yields a large average monthly abnormal return in the second subperiod). US MMRs from value portfolios exhibit a small decline in the second subperiod (for example 1-month strategy MMRs pass from 1.121 to 0.918 percent) but they are still higher in mean than MMRs from both buy and hold and growth portfolio strategies, while MMRs from EU value portfolios exhibit a significant increase in the second subperiod (for example 1-month strategies pass from 0.480 to 2.094 percent).

Parametric and non parametric[14] tests on the significance of the difference between MMRs from different strategies show that one month and two month value strategies for the EU sample are significantly more profitable in mean than both corresponding growth and buy-hold strategies, while, for the US sample, the hypothesis holds only for the one month strategy with the parametric test and only against the growth strategy (Tables 2A and 2B).

If we evaluate risk as covariance with GDP or consumption growth, following a consumption-CAPM approach (Breeden, et al. 1989), we may see that

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[14] Corrado and Zivney's (1992) compare the nonparametric sign test and the parametric t-test for abnormal security prices, in the context of event studies using simulations of security returns. They find that the nonparametric sign test is better specified and often more powerful than the parametric t-test. Additional support is provided by Zivney and Thompson (1989) showing that the sign test is always at least as powerful and as well specified as the t-test when applied to market adjusted returns. In studies of market efficiency involving unknown distributions of returns, the sign test exhibits greater power, resulting from proper test specifications. Further support for nonparametrics comes from Pagan and Schwert (1990), who look at daily and monthly stock price volatility, respectively, and show that stock returns are not normally distributed and often exhibit significant kurtosis and/or skewness. This invalidates the t-test associated with the ordinary least squares regressions.

betting on value stocks both in the EU and US samples is less risky than betting on growth stocks, since quarterly returns of value stock portfolios covary less with GDP rates of growth than those of growth stock portfolios (Tables 3A and 3B).

The presence of value premia in both samples suggests that this anomaly is not country specific. Our results though show that the US value premium is smaller than the EU value premium in all of the four period strategies. Following Foster, Smith and Whaley (1997) it might be argued that the presence of similar patterns in the two samples may depend on financial integration which can be tracked by correlations among portfolios. In Table 4 we show, however, that the correlations of value premia of US and European portfolios are quite low (table 4).

4. Multi-factor capital asset pricing tests on value premia

Fama-French (1995) demonstrate that intercept coefficients of 3-CAPM regressions are not significantly different from zero and argue that this proofs that returns premia on their factor portfolios are explained by latent risk factors captured by the two additional regressors and not by a failure of market efficiency. To check whether excess returns from our short term value strategies persist after being risk-adjusted, we follow Clare et. al. (1997) and Bagella et al. (2001) in estimating a system of time-series CAPM equations of monthly portfolio excess returns on those of an equally weighted market index, to explain returns from each set of the ten considered portfolios.

At first we correct for exposure to the three Fama-French (1995) risk factors, estimating for one month value strategies the 3-CAPM model, in which two additional risk factors, related to size and book to market values, are added to the traditional specification[15]. After it, since the excess returns are still significantly positive, by combining Fama and French (1995) and Harvey and Siddique (2000) approaches, we extend the 3-factor CAPM to a 4-factor CAPM model, in which an additional risk factor, related to return's skewness, is added (Harvey-Siddique 2000).

The rationale for the introduction of this fourth factor is that it is intuitively clear that the (nonnormal) unconditional return distributions cannot be adequately characterized by mean and variance alone since, *coeteris paribus*, right-skewed porftolios are preferred to mean-variance equivalent left-skewed portfolios. As a consequence, the latter should have lower expected returns.

Therefore, if asset returns have systematic skewness, expected returns should include rewards for accepting this risk. We formalize this intuition with a non linear specification which includes in the 3-factor CAPM equation an additional regressor which tries to capture the effect of skewness on observed returns (Tables 5C and 5D). Our choice is also consistent with Ghysels' findings (1998) showing that nonlinear multifactor models are empirically more successful than linear beta models. Our 4-factor equation is written as follows:

$$R^t{}_P - R^t{}_f = \alpha_P + \beta_P(R^t{}_m - R^t{}_f) + \gamma_P SMB^t + \delta_P HML^t + \eta_P(R^t{}_m - R^t{}_f)^2 + \varepsilon_P{}^t \quad (3)$$

[15] The rationale for adopting a multifactor capital asset pricing model is that some risk factors, to which small firms or financially distressed firms are particularly exposed, are not captured by portfolio's sensitivity to the stock market index. Shocks in asset values may for instance reduce the value of collateral affecting both solvency of financially distressed firms and the capacity to obtain credit of small firms in a framework of imperfect information (Bernanke and Gertler, 1987). Debt deflation may negatively affect financially distressed (low MTBV) firms more than others. Expectations of liquidity squeezes, in economies in which the three Kashyap, Lamont and Stein (1993) conditions for the existence of a "credit channel" may be applied, may generate negative effects on price and quantity of credit available to financially distressed firms, to firms with low earnings per share (and then low self-financing capacity) and to small firms that are more likely to be victims of financial constraints (Devereux and Schiantarelli, 1989).

where R_p is the monthly return of portfolio p (p=1,..,10), R_f is the monthly return of the 3-month treasury bill rate, R_m is the monthly return of the market portfolio, while SMB, HML and $(R^t{}_m - R^t{}_f)^2$ are three additional risk factors[16]. In order to test the stability of contrarian strategy premia, we estimate the system recursively from 1990 to 2002 using a five year window.

We estimate the system by using the GMM-HAC (Generalised Method of Moments Heteroskedasticity and Autocorrelation Consistent)[17] approach which sets the calculated correlations of the instruments and disturbances as close as possible to zero, according to a criterion provided by a weighting matrix (for a similar approach see MacKinlay and Richardson 1991; Bagella, Becchetti and Carpentieri 2000 and Clare et. al. 1997). GMM regressions rely on weaker assumptions than OLS as it does not require normality and constancy of variance. These two conditions are generally not met by short horizon stock returns which are usually characterised by excess curtosis and volatility clustering (Campbell, Lo and MacKinlay, 1997). As in Clare et. al. (1997), the same regressors are used as instruments (tables 5A-5D).

The estimates also show that value portfolios for the EU sample tend to be more exposed (with a more stable relationship) to book to market risk factors than size factors, while for the US sample this is true only for the period from 1994 to 2002. The interesting finding is that, differently from what occurs when looking at (small vs large) size and (low vs high) book to market portfolios (Fama-

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[16] The first two additional risk factors are computed as follows. We first divide the two samples each month into two subgroups: the 50% largest firms (group B) and the 50% smallest firms (group S). These two subgroups are then divided in turn into three subgroups containing respectively the largest 30% (group BH and SH), the mid 40% (group BM and SM) and the smallest 30% (group BL and SL) market to book values. SMB is then calculated, by using subgroup average returns, as ((SH+SM+SL)/3)-((BH+BM+BL)/3) and HML as (SL+BL)/2)-(SH+BH)/2).

[17] For a description of the GMM approach, see Hansen (1982) and Hansen and Singleton (1982).

French, 1998) value strategies' exposure to the two FF additional risk factors is very similar to that of growth strategies.

Our results also show that the effect of skewness helps to explain the cross-sectional variation of expected returns across assets and is significant even when factors based on size and book-to-market are included.

Value strategies still yield significant excess returns after being adjusted for the four risk factors.

The intercept for the 0-10 value portfolios drops from 1 basis points per month for the EU and 1.6 basis points per month for the US (for the all sample period) in the 3-factor to 0.9 basis points per month for the EU and 1.2 basis points per month for the US in the 4-factor. Similarly, the intercept for the 90-100 growth portfolios for the US rises from –0.9 basis points per month in the 3-factor to –0.7 basis points per month in the 4-factor, while for the EU it remains stable to –0.6 basis points per month.

The model for the US sample does capture more of the variation in average returns on the portfolio than the model for the EU sample. Indeed, the average of the 10-regression R^2 for the all period is only about 0.35 for the EU sample and 0.7 for the US sample.

To avoid the risk that covariances across the ten portfolios residuals bias our results we re-estimate the model as a ten-equation system. We construct a Wald test of the joint hypothesis that $\alpha_p = 0$ for all portfolios (whether all intercepts are zero). The Wald test, which is a test of mean variance efficiency, is distributed as a $\chi^2(10)$ under the null hypothesis, where 10 is the number of restrictions. We also test the restriction: $\alpha_1 = \alpha_{10}$ (distributed as a χ^2) to check the hypothesis that the 0-10 (extreme value) portfolio has excess returns which significantly outperform those of the 90-100 (extreme growth) portfolio.

Our evidence indicates that positive excess returns of the extreme 1-month value (0-10) portfolio for the overall sample period (1990-2002) persist after risk adjustment (and the null hypothesis of Wald tests are rejected) for both EU and US sample and for both 3 and 4-factor CAPM model (Tables 6A-6D).. The analysis of the subperiods shows that the value portfolio excess returns are significantly higher than the risk-free rate for all the rolling subperiods for both samples,. with the exception of the EU sample at the beginning of our sample period (the first five years window: 1990-1995) with the 3-CAPM model and of the beginning and of the end (respectively 1990-1995 and 1997-2002) with the 4-CAPM model, when the α-coefficient is not significant. Wald test results show that the joint hypothesis that $\alpha_p = 0$ for p =1. ..., 10 and $\alpha_1=\alpha_{10}$ (Tables 6A-6D) are rejected in all subperiods. These results imply the rejection of the mean variance efficiency hypothesis and confirm that value portfolios outperform growth portfolios.

6. Conclusions

A significant share of financial investors bases their trading decisions on the evaluation of the DCF (discounted cash flow) fundamental value of a stock regarded as the gravity centre around which prices move in the medium/long run. This paper aims at testing the relative profitability of fundamentalist trading strategies on the S&P500 and on the DJSTOXX constituents in the last decades.

In doing so the paper considers a simple DCF fundamental in which I/B/E/S earning forecasts are the only reference for dertermining the gravity centre of the stock value.

Results on the relative performance of DCF value and growth strategies in the last twelve years seem to support the hypothesis that value portfolios yield significant excess returns after risk adjustment.

One month value strategies (based on a monthly selection of the stocks with the lowest observed to fundamental ratio in the previous period) yield significantly higher mean monthly returns than both corresponding growth and buy and hold strategies for both US and EU market. These results persist when returns are adjusted for risk, since risk adjusted intercepts of excess returns of value portfolios in four factor CAPM estimates are still positive and significant. The success of contrarian strategies seem not to be country specific and therefore not depending on specific features of different financial systems.

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Appendix

Legend for tables 1.A-1.F:
SUMMARY STATISTICS for AVERAGE MONTHLY PERCENT RETURNS on equal-weight deciles formed on observed to fundamental ratio: 01/1990-03/2002, 147 months.

The 10 Portfolios (from 0-10 to 90-100) are formed according to ascending values of the observed to fundamental ratio (i.e. the first portfolio includes stocks whose observed to fundamental ratio falls in the lowest ten percent of the distribution in the considered month). Portfolios are formed the first day of month t on values that the ranking variable assumes in the last day of the month t-1 and held until the end of the month t (1 month strategy), t+1 (2 months strategy), t+6 (6 months strategy), t+12 (12 months strategy).
New portfolios are formed only at the end of each holding period.
The benchmark is the passive buy and hold strategy on the total sample portfolio and on the stock market index (S&P500 for the US and DJSTOXX for the EU).

The sharpe ratio is calculated as: $[R_p\text{-}R_f]/\sigma_p$ where R_p is the mean monthly return of the p-th portfolio ($p=1,\ldots,10$), R_f is the monthly risk-free rate, and σ_p is the standard deviation of the R_p.

MV/1000 is the average monthly market values of stocks selected in each portfolio divided by 1000.

Table 1.A EU: MEAN, VARIANCE and SKEWNESS of MONTHLY RETURNS from VALUE and GROWTH DCF strategies on DJSTOXX
(risk premium 7%; nominal rate of growth in the terminal period 3%)

1990-2002

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	buy-hold
					MEAN monthly returns (percent values)						
1month	**1.309**	1.209	0.965	0.827	0.581	0.422	0.815	0.370	0.453	0.129	0.708
2 months	**1.264**	1.021	1.095	0.976	0.581	0.488	0.587	0.590	0.545	0.010	TSP*
6 months	**1.360**	1.031	1.126	0.780	0.743	0.564	0.379	0.451	0.467	0.313	0.702
12months	**1.384**	1.151	1.096	0.814	0.746	0.352	0.690	0.349	0.186	0.458	DJSTOX
					VARIANCE						
1month	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.003	
2 months	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
6 months	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
12months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
					SKEWNESS						
1month	**-0.641**	-1.185	-0.295	-1.234	-0.496	-0.342	0.148	-0.510	-0.483	-0.468	
2 months	-0.563	-0.556	-0.519	-0.205	-0.640	-0.425	-0.166	-0.244	0.031	-0.258	-0.843
6 months	0.265	-0.093	0.014	-0.386	0.041	-0.061	-0.449	0.144	-0.139	-0.213	
12months	-0.429	-0.201	-0.684	-0.544	-0.013	-1.316	-0.018	-1.099	-0.107	-0.058	
					SHARPE RATIO						
1month	**0.131**	0.118	0.092	0.059	0.017	-0.015	0.065	-0.028	-0.008	-0.068	
2 months	**0.177**	0.140	0.161	0.131	0.028	-0.001	0.025	0.032	0.015	-0.133	
6 months	**0.329**	0.224	0.259	0.117	0.115	0.036	-0.056	-0.030	-0.016	-0.098	
12months	**0.430**	0.457	0.338	0.160	0.160	-0.101	0.149	-0.141	-0.199	-0.026	
MV/1000	37537.5	56695.9	93140.6	138259.3	230386.0	350929.2	369168.3	791921.7	1289230.2	794773.0	

TSP* = Total sample portfolio.

Table 1.B US: MEAN, VARIANCE and SKEWNESS of MONTHLY RETURNS from VALUE and GROWTH DCF strategies on S&P500
(risk premium 7%; nominal rate of growth in the terminal period 3%)

1990-2002

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	buy-hold
					MEAN monthly returns (percent values)						
1month	**1.017**	0.947	0.697	0.656	0.735	0.748	0.709	0.827	0.597	0.287	0.722
2 months	**0.916**	0.874	0.630	0.760	0.698	0.743	0.725	0.844	0.626	0.440	TSP*
6 months	**0.908**	0.651	0.702	0.651	0.586	0.882	0.739	0.769	0.623	0.664	0.797
12months	**0.904**	0.684	0.644	0.757	0.753	0.739	0.753	0.909	0.486	0.539	S&P500
					VARIANCE						
1month	0.003	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	
2 months	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
6 months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
12 months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
					SKEWNESS						
1month	-0.290	-0.162	-0.020	-0.493	-0.516	-0.132	-0.369	-0.071	-0.293	**-0.664**	
2 months	-0.876	-0.554	-0.414	-0.487	-1.046	-0.624	-0.664	-0.331	-0.846	-0.417	-0.268
6 months	-0.214	-0.946	-1.186	-0.557	-0.710	-0.641	-0.323	-0.140	-0.678	-0.786	
12 months	-0.250	-0.306	-0.825	-0.147	-0.132	-0.194	0.233	0.035	-0.568	-0.921	
					SHARPE RATIO						
1month	**-0.742**	-0.850	-0.881	-0.960	-1.071	-0.925	-1.016	-1.015	-0.988	-1.043	
2 months	**0.130**	0.135	0.066	0.112	0.097	0.118	0.119	0.151	0.074	0.016	
6 months	**0.253**	0.135	0.164	0.147	0.109	0.344	0.284	0.234	0.146	0.161	
12 months	**0.355**	0.187	0.177	0.264	0.303	0.305	0.379	0.444	0.059	0.087	
MV/1000	5305.3	5141.9	6517.6	6622.8	7059.7	8205.3	9165.9	11153.5	15565.3	17726.7	

TSP* = Total sample portfolio.

Table 1.C EU: MEAN, VARIANCE and SKEWNESS of MONTHLY RETURNS from VALUE and GROWTH DCF strategies on DJSTOXX
(risk premium 7%; nominal rate of growth in the terminal period 3%)

1990-1995

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	buy-hold
	MEAN monthly returns (percent values)										
1month	0.480	0.837	0.412	0.356	0.399	-0.099	0.178	0.446	0.650	0.211	0.388
2 months	0.540	0.748	0.446	0.409	0.345	-0.096	0.020	0.447	0.771	0.011	TSP*
6 months	0.646	0.572	0.418	0.275	0.240	0.023	0.050	0.535	0.539	0.266	0.367
12months	0.405	0.831	0.303	0.325	0.349	-0.118	0.145	0.226	0.471	0.342	DJSTOX
	VARIANCE										
1month	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
2 months	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
6 months	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
12months	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	SKEWNESS										
1month	-0.487	-0.125	-0.133	-0.821	-0.462	-0.212	-0.612	-0.392	-0.564	-0.420	
2 months	-0.378	-0.266	-0.567	-0.707	-0.307	-0.147	-0.728	-0.167	-0.639	-0.204	0.002
6 months	-0.015	-0.201	-0.190	-0.782	-0.791	0.016	-0.581	-0.576	-0.466	-0.353	
12months	0.778	0.520	-0.617	0.023	0.164	-1.702	1.092	-0.245	0.545	0.449	
	SHARPE RATIO										
1month	-0.033	0.039	-0.057	-0.065	-0.052	-0.176	-0.112	-0.048	-0.001	-0.094	
2 months	-0.028	0.027	-0.059	-0.077	-0.090	-0.236	-0.193	-0.070	0.033	-0.179	
6 months	-0.010	-0.043	-0.109	-0.165	-0.196	-0.336	-0.289	-0.118	-0.091	-0.191	
12months	-0.113	0.078	-0.195	-0.182	-0.249	-0.472	-0.537	-0.453	-0.149	-0.248	

TSP* = Total sample portfolio.

Table 1.D US: MEAN, VARIANCE and SKEWNESS of MONTHLY RETURNS from VALUE and GROWTH DCF strategies on S&P500
(risk premium 7%; nominal rate of growth in the terminal period 3%)

1990-1995

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	buy-hold
	MEAN monthly returns (percent values)										
1month	1.121	1.153	0.880	0.888	0.737	0.701	0.826	0.931	0.612	0.504	0.835
2 months	1.040	0.976	0.805	0.854	0.737	0.787	0.588	0.923	0.630	0.559	TSP*
6 months	0.983	0.800	1.010	0.826	0.551	0.613	0.765	0.837	0.746	0.705	0.762
12months	0.702	0.373	0.561	0.583	0.423	0.445	0.879	0.897	0.566	0.478	S&P500
	VARIANCE										
1month	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001	
2 months	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
6 months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
12months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	SKEWNESS										
1month	-0.295	-0.517	-0.260	-0.722	-1.291	-0.450	-0.336	0.266	-0.231	-0.081	
2 months	0.043	-0.650	-0.787	-0.109	-1.289	-1.222	-0.333	0.142	-0.489	-0.127	-0.369
6 months	0.064	0.151	-0.934	0.632	-0.273	-0.649	-0.838	0.972	-0.001	0.230	
12months	-0.006	0.212	-0.112	1.088	0.211	0.437	-0.124	1.184	0.715	0.778	
	SHARPE RATIO										
1month	-0.867	-0.927	-1.027	-1.072	-1.328	-1.125	-1.219	-1.148	-1.094	-1.199	
2 months	0.180	0.174	0.128	0.160	0.144	0.156	0.078	0.198	0.081	0.057	
6 months	0.271	0.244	0.355	0.286	0.098	0.139	0.281	0.329	0.234	0.217	
12months	0.185	-0.011	0.122	0.167	0.029	0.059	0.532	0.450	0.132	0.059	

TSP* = Total sample portfolio.

Table 1.E EU: MEAN, VARIANCE and SKEWNESS of MONTHLY RETURNS from VALUE and GROWTH DCF strategies on DJSTOXX
(risk premium 7%; nominal rate of growth in the terminal period 3%)

1996-2002

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	buy-hold
	MEAN monthly returns (percent values)										
1month	**2.094**	1.560	1.488	1.272	0.753	0.915	1.418	0.299	0.266	0.051	**1.01**
2 months	**1.930**	1.273	1.693	1.498	0.799	1.026	1.110	0.721	0.338	0.010	TSP*
6 months	**1.964**	1.419	1.724	1.207	1.169	1.021	0.658	0.379	0.407	0.352	0.990
12months	**2.084**	1.380	1.663	1.163	1.028	0.688	1.080	0.438	-0.018	0.541	DJSTOX
	VARIAN CE										
1month	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
2 months	0.002	0.002	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.003
6 months	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
12 months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	SKEWN ESS										
1month	-0.653	-0.315	-0.264	-0.965	-0.662	-0.323	0.728	-0.703	-0.694	-0.583	
2 months	-0.814	-0.784	-0.582	-0.122	-1.107	-0.735	-0.020	-0.327	0.639	-0.317	0.002
6 months	0.481	-0.064	0.152	-0.115	1.097	0.093	-0.301	0.409	0.006	0.054	
12 months	-0.885	-0.987	0.196	-1.134	-0.272	0.225	-0.777	-1.981	-0.397	-0.375	
	SHARPE RATIO										
1month	**0.338**	0.261	0.268	0.209	0.088	0.138	0.216	-0.011	-0.018	-0.066	
2 months	**0.362**	0.229	0.358	0.288	0.161	0.217	0.191	0.123	-0.001	-0.091	
6 months	**0.622**	0.450	0.582	0.364	0.408	0.396	0.159	0.018	0.029	0.002	
12 months	**1.347**	0.994	0.966	0.428	0.414	0.310	0.538	0.077	-0.236	0.127	

TSP* = Total sample portfolio.

Table 1.F US: MEAN, VARIANCE and SKEWNESS of MONTHLY RETURNS from VALUE and GROWTH DCF strategies on S&P500
(risk premium 7%; nominal rate of growth in the terminal period 3%)

1996-2002

	0-10	ott-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	buy-hold
	MEAN monthly returns (percent values)										
1month	**0.918**	0.751	0.523	0.437	0.734	0.792	0.598	0.728	0.583	0.082	**0.616**
2 months	**0.802**	0.781	0.469	0.674	0.663	0.701	0.851	0.770	0.621	0.329	
6 months	**0.848**	0.535	0.460	0.513	0.614	1.093	0.719	0.716	0.527	0.633	0.831
12months	**1.048**	0.906	0.703	0.881	0.989	0.949	0.663	0.918	0.428	0.584	S&P500
	VARIANCE										
1month	0.003	0.003	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.002	
2 months	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
6 months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
12months	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	SKEWNESS										
1month	-0.259	0.057	0.117	-0.331	-0.225	-0.013	-0.333	-0.206	-0.327	-0.825	
2 months	-1.306	-0.491	-0.191	-0.629	-0.916	-0.367	-0.864	-0.549	-1.064	-0.716	
6 months	-0.668	-1.509	-1.542	-1.060	-1.036	-0.432	0.311	-0.520	-1.279	-1.230	-0.190
12months	-0.342	-0.733	-1.547	-0.672	-0.494	-0.708	0.535	-0.601	-1.166	-1.814	
	SHARPE RATIO										
1month	**-0.665**	-0.800	-0.797	-0.893	-0.920	-0.798	-0.899	-0.927	-0.907	-0.952	
2 months	**0.094**	0.104	0.020	0.079	0.074	0.094	0.151	0.117	0.069	-0.023	
6 months	**0.249**	0.069	0.032	0.062	0.121	0.582	0.301	0.186	0.083	0.132	
12months	**0.393**	0.245	0.087	0.203	0.342	0.305	0.085	0.288	-0.102	0.000	

TSP* = Total sample portfolio.

Table 2.A EU: Significance of the difference in unconditional mean monthly returns of different portfolio strategies

Holding period	Compared strategies		Significance of differ. in MMRs T TEST	Non param. test Z	prob>Z
1month			2.9016	1.933	0.0532
2months	VALUE	vs	3.1362	2.123	0.0337
6months	GROWTH	porfolio	2.8655	1.382	0.1671
12months			2.3296	1.386	0.1659
1month	buyhold vs	GROWTH	-2.247	-1.035	0.3008
	buyhold vs	VALUE	2.5389	1.121	0.2624
2months	buyhold vs	GROWTH	-2.7362	-1.227	0.2198
	buyhold vs	VALUE	2.403	1.121	0.2621
6months	buyhold vs	GROWTH	-2.2181	-0.742	0.4579
	buyhold vs	VALUE	2.3948	0.784	0.4333
12months	buyhold vs	GROWTH	-1.3354	-0.52	0.6033
	buyhold vs	VALUE	2.2724	0.924	0.3556

Table 2.B US: Significance of the difference in unconditional mean monthly returns of different portfolio strategies

Holding period of strategies	Compared strategies		Significance of differ. in MMRs T TEST	Non param. test Z	prob>Z
1month			2.116	1.250	0.2112
2months	GROWTH	vs	1.209	1.47	0.1417
6months	VALUE	porfolio	0.514	0.577	0.5637
12months			0.762	0.231	0.8174
1month	buyhold vs	GROWTH	-1.8712	-0.545	0.5859
	buyhold vs	VALUE	1.4454	0.796	0.4292
2months	buyhold vs	GROWTH	-1.1125	-0.836	0.4034
	buyhold vs	VALUE	0.9195	0.761	0.4465
6months	buyhold vs	GROWTH	-0.1774	0.082	0.9343
	buyhold vs	VALUE	0.8086	0.619	0.5362
12months	buyhold vs	GROWTH	-0.5692	-0.058	0.9540
	buyhold vs	VALUE	0.7651	0.577	0.5637

The non parametric test is based on the Mann-Withney U-statistics computed as follows: $U = N_1 N_2 + \frac{N_1(N_1+1)}{2} - R_1$ and $U = N_1 N_2 + \frac{N_2(N_2+1)}{2} - R_2$ where N_1 is the number of observations in the first sample, N_2 is the number of observations in the second sample, R_1 is the sum of ranks in the first sample, R_2 is the sum of ranks in the second sample. The test is based on the lowest of the U values.

Table 3.A EU: Covariance between portfolio quarterly returns and GDP rate of growth

Percentile portfolios	90-02	90-95	96-02
0 --10	-1.454	-0.929	-3.028
10--20	-2.430	-0.534	-2.949
20--30	-0.994	-0.619	-1.551
30--40	-2.679	-0.758	-1.702
40--50	-2.437	-0.364	-2.137
50--60	-1.725	-0.857	-1.959
60--70	-0.029	0.117	-2.069
70--80	-3.882	-0.138	-1.688
80--90	-0.428	-0.419	-1.569
90--100	-1.431	-0.829	-0.194

Table 3.B US: Covariance between portfolio quarterly returns and GDP rate of growth

Percentile portfolios	90-02	90-95	96-02
0 --10	-24.419	2.294	-17.881
10--20	-4.880	3.353	-3.758
20--30	-7.771	2.009	-3.777
30--40	-1.719	4.368	-6.838
40--50	-0.328	2.990	-3.916
50--60	-1.604	-0.521	-0.579
60--70	-3.408	2.874	-2.310
70--80	-4.962	1.068	-3.077
80--90	-11.881	1.268	-10.011
90--100	-8.681	2.583	-11.692

Table 4 Correlation of US and European value portfolios

Percentile portfolios	90-02	90-95	96-02
0 --10	0.00201	0.00129	0.00271
10--20	0.00154	0.00091	0.00215
20--30	0.00133	0.00095	0.00171
30--40	0.00138	0.00087	0.00189
40--50	0.00111	0.00090	0.00130
50--60	0.00139	0.00090	0.00185
60--70	0.00127	0.00075	0.00178
70--80	0.00104	0.00086	0.00121
80--90	0.00110	0.00074	0.00144
90--100	0.00141	0.00078	0.00200

Legend for tables 5.A-5.D

THREE and FOUR-FACTOR TIME-SERIES REGRESSIONS for Monthly Excess Returns on equal-weight deciles: 01/1990-03/2002, 147 months.

The table reports coefficients and t-tests of a 3-CAPM system composed by p equations. The p-th equation is written as follows:

$$R^t{}_P - R^t{}_f = \alpha_P + \beta_P (R^t{}_m - R^t{}_f) + \gamma_P SMB^t + \delta_P HML^t + \eta_P (R^t{}_m - R^t{}_f)^2 + \varepsilon_P{}^t$$

where R_p is the monthly return of portfolio p (p=1,..,10), R_f is the monthly return of the 1-month Treasury bill rate, R_m is the monthly return of the market portfolio while SMB and HML are additional risk factors.

The 10 Portfolios (from 0-10 to 90-100) are formed according to ascending values of the observed to fundamental ratio (i.e. the first portfolio includes stocks whose observed to fundamental ratio falls in the lowest ten percent of the distribution in the considered month). Portfolios are formed the first day of month t on values that the ranking variable assumes in the last day of the month t-1 and held until the end of the month t (1 month strategy). New portfolios are formed only at the end of each holding period.

The system is estimated recursively from 1990 to 2002 using a five year window with a GMM (Generalised Method of Moments) approach with Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. The Bartlett's functional form of the kernel is used to weight the covariances in calculating the weighting matrix. Newey and West's (1994) automatic bandwidth procedure is adopted to determine weights inside kernels for autocovariances.

The same regressors are used as instruments.

Table 5.A EU: RISK ADJUSTMENT OF RETURNS with 3-CAPM model (10 equations system estimated by GMM simultaneusly) DJSTOXX
(risk premium 7%; nominal rate of growth in the terminal period 3%)

Percentile portfolios	α	β	γ	δ	t(α)	t(β)	t(γ)	t(δ)	R^2
90-02									
0 --10	0.010	0.813	0.436	0.740	**2.976**	5.902	2.073	4.964	0.437
10--20	0.007	0.691	0.629	0.495	**2.396**	5.264	2.905	2.735	0.372
20--30	0.004	0.691	0.251	0.280	1.509	6.985	1.633	2.342	0.349
30--40	0.002	0.740	0.258	0.177	0.668	7.033	1.184	1.350	0.312
40--50	0.000	0.608	0.382	0.163	-0.099	6.536	2.670	1.267	0.309
50--60	-0.002	0.597	0.267	0.118	-0.581	5.893	1.558	0.817	0.287
60--70	0.001	0.670	-0.055	-0.150	0.324	5.946	-0.243	-0.822	0.283
70--80	-0.003	0.697	0.123	0.010	-1.378	10.298	0.796	0.086	0.406
80--90	-0.004	0.708	0.056	-0.274	-1.142	8.759	0.242	-1.376	0.298
90--100	-0.006	0.808	-0.001	-0.154	**-2.049**	9.398	-0.005	-0.717	0.361
90-95									
0 --10	0.005	0.947	0.208	0.700	1.099	6.851	0.786	2.950	0.528
10--20	0.006	0.785	0.490	0.419	1.740	6.065	2.202	1.890	0.433
20--30	0.001	0.745	0.094	0.329	0.413	6.189	0.447	2.075	0.417
30--40	-0.001	0.811	0.237	-0.038	-0.291	6.298	0.739	-0.195	0.368
40--50	-0.001	0.884	0.430	-0.115	-0.256	8.647	2.113	-0.450	0.392
50--60	-0.006	0.719	0.157	-0.148	-1.876	8.177	0.593	-0.871	0.320
60--70	-0.004	0.830	0.096	-0.228	-1.427	8.190	0.487	-1.364	0.424
70--80	0.000	0.787	-0.101	-0.089	-0.069	6.925	-0.406	-0.421	0.368
80--90	0.002	0.718	-0.350	0.013	0.779	4.732	-1.549	0.084	0.330
90--100	-0.002	0.896	0.189	0.077	-0.499	8.051	0.700	0.340	0.439
91-96									
0 --10	0.011	0.887	0.147	0.837	**2.721**	5.843	0.665	3.550	0.515
10--20	0.008	0.768	0.425	0.413	**2.172**	4.471	2.240	1.775	0.380
20--30	0.005	0.673	0.082	0.387	1.593	4.371	0.426	2.205	0.325
30--40	0.004	0.696	0.038	0.217	1.139	4.351	0.175	1.113	0.324
40--50	0.000	0.802	0.460	-0.029	-0.004	7.904	2.232	-0.103	0.309
50--60	-0.003	0.694	0.178	-0.125	-0.994	5.893	0.678	-0.637	0.253
60--70	-0.001	0.859	0.109	-0.212	-0.231	6.006	0.582	-1.249	0.355
70--80	0.002	0.707	-0.169	-0.042	0.795	4.964	-0.805	-0.221	0.330
80--90	0.003	0.700	-0.417	0.109	0.913	3.684	-1.980	0.722	0.321
90--100	-0.001	0.894	-0.024	0.192	-0.298	6.672	-0.120	0.937	0.444
92-97									
0 --10	0.011	0.932	0.074	0.767	**3.178**	7.717	0.423	3.602	0.509
10--20	0.007	0.810	0.328	0.222	**2.120**	6.419	2.065	1.145	0.390
20--30	0.004	0.789	0.132	0.170	1.182	6.587	0.806	0.985	0.366
30--40	0.004	0.732	0.055	0.213	0.992	5.397	0.345	1.112	0.322
40--50	0.000	0.742	0.396	-0.038	0.115	6.362	2.271	-0.143	0.281
50--60	-0.004	0.661	0.176	-0.208	-1.212	6.671	0.860	-1.047	0.241
60--70	0.002	0.910	-0.180	-0.606	0.507	7.915	-0.769	-2.095	0.357
70--80	0.000	0.725	-0.053	-0.154	0.139	6.108	-0.273	-0.760	0.320
80--90	0.003	0.661	-0.413	0.105	1.095	4.762	-2.468	0.556	0.302
90--100	-0.003	0.821	-0.027	0.106	-1.154	6.319	-0.187	0.589	0.380

93-98									
0 --10	0.010	1.078	0.491	0.618	**2.491**	7.780	2.301	2.655	0.687
10--20	0.004	1.003	0.555	0.377	0.976	6.386	2.547	1.385	0.608
20--30	0.003	0.863	0.371	0.032	0.901	6.269	2.553	0.188	0.538
30--40	0.002	0.973	0.034	0.267	0.616	7.864	0.160	1.418	0.561
40--50	-0.002	0.763	0.425	-0.002	-0.454	8.166	2.465	-0.010	0.427
50--60	-0.007	0.767	0.489	-0.271	**-2.104**	7.307	2.716	-1.332	0.484
60--70	0.001	0.972	-0.160	-0.528	0.240	8.301	-0.563	-2.044	0.461
70--80	-0.002	0.760	0.174	-0.140	-0.500	9.163	1.275	-0.733	0.509
80--90	0.000	0.650	0.008	0.103	-0.088	7.567	0.039	0.601	0.411
90--100	-0.003	0.853	-0.153	0.325	-0.628	6.720	-0.847	1.523	0.496
94-99									
0 --10	0.012	1.053	0.377	0.800	**2.874**	8.464	1.782	3.504	0.644
10--20	0.004	0.997	0.371	0.556	0.962	7.196	1.568	1.843	0.610
20--30	0.007	0.867	0.143	0.354	1.470	7.048	0.825	1.510	0.504
30--40	0.005	0.970	-0.077	0.445	1.175	8.905	-0.410	2.107	0.569
40--50	0.000	0.697	0.178	0.335	0.130	6.698	1.108	1.427	0.385
50--60	-0.004	0.787	0.181	0.135	-1.207	7.575	0.917	0.592	0.430
60--70	0.000	0.897	-0.314	-0.330	-0.043	6.761	-1.116	-1.022	0.387
70--80	-0.001	0.792	-0.004	0.088	-0.333	12.836	-0.028	0.449	0.574
80--90	-0.001	0.723	-0.055	0.113	-0.127	7.765	-0.253	0.603	0.437
90--100	-0.003	0.832	-0.442	0.580	-0.691	6.329	-2.144	2.207	0.451
95-00									
0 --10	0.017	0.881	0.395	0.928	**3.627**	5.184	2.013	4.492	0.526
10--20	0.009	0.823	0.457	0.691	**1.884**	4.346	1.973	2.521	0.498
20--30	0.009	0.764	0.159	0.452	1.798	5.044	1.038	2.786	0.374
30--40	0.009	0.819	0.006	0.500	**2.165**	5.791	0.032	2.435	0.382
40--50	0.001	0.598	0.272	0.371	0.318	4.971	2.084	2.725	0.346
50--60	0.003	0.596	0.280	0.362	0.504	3.717	1.516	1.654	0.306
60--70	0.008	0.734	-0.367	-0.023	1.761	4.440	-1.128	-0.085	0.269
70--80	-0.004	0.748	0.146	0.088	-1.115	8.450	1.097	0.611	0.499
80--90	-0.003	0.704	0.026	-0.255	-0.729	8.388	0.107	-0.930	0.308
90--100	-0.011	0.896	-0.203	-0.125	**-2.017**	5.748	-1.096	-0.380	0.361
96-01									
0 --10	0.017	0.660	0.695	0.717	**3.206**	3.014	2.484	3.122	0.404
10--20	0.009	0.626	0.771	0.499	1.580	2.828	2.242	1.721	0.355
20--30	0.008	0.614	0.416	0.219	1.740	3.744	1.738	1.155	0.320
30--40	0.006	0.694	0.294	0.296	0.948	3.683	0.794	1.382	0.283
40--50	0.002	0.481	0.449	0.254	0.550	3.364	2.054	1.833	0.305
50--60	0.004	0.506	0.395	0.254	0.747	3.175	1.672	1.303	0.285
60--70	0.007	0.587	-0.116	-0.128	1.313	3.143	-0.289	-0.482	0.211
70--80	-0.006	0.619	0.347	0.024	**-2.050**	5.825	1.864	0.187	0.475
80--90	-0.010	0.629	0.431	-0.508	**-1.853**	6.778	1.380	-1.836	0.349
90--100	-0.011	0.780	-0.070	-0.344	**-2.386**	5.337	-0.286	-1.150	0.352
97-02									
0 --10	0.016	0.681	0.586	0.753	**2.844**	3.111	2.003	3.177	0.398
10--20	0.009	0.614	0.776	0.568	1.536	2.720	2.103	1.915	0.357
20--30	0.009	0.642	0.324	0.245	1.733	3.906	1.349	1.271	0.330
30--40	0.005	0.711	0.219	0.283	0.844	3.646	0.576	1.290	0.281
40--50	0.001	0.499	0.326	0.292	0.257	3.524	1.567	2.110	0.304
50--60	0.002	0.532	0.287	0.295	0.326	3.345	1.207	1.489	0.285
60--70	0.006	0.609	-0.260	-0.109	1.038	3.227	-0.629	-0.405	0.229
70--80	-0.006	0.639	0.291	0.049	**-2.104**	6.034	1.565	0.375	0.493
80--90	-0.010	0.640	0.402	-0.490	-1.698	6.730	1.224	-1.717	0.349
90--100	-0.011	0.785	-0.105	-0.310	**-2.080**	5.220	-0.408	-1.003	0.344

Table 5.B US: RISK ADJUSTMENT OF RETURNS with 3-CAPM model (10 equations system estimated by GMM simultaneusly) S&P500
(risk premium 7%; nominal rate of growth in the terminal period 3%)

Percentile portfolios	α	β	γ	δ	t(α)	t(β)	t(γ)	t(δ)	R^2
90-02									
0 --10	0.016	0.821	0.877	0.617	**4.754**	9.893	5.480	7.372	0.778
10--20	0.014	0.773	0.513	0.590	**4.421**	9.330	3.226	4.814	0.728
20--30	0.014	0.811	0.323	0.723	**3.856**	9.237	2.253	5.038	0.722
30--40	0.011	0.759	0.310	0.618	**4.359**	9.263	2.460	5.130	0.709
40--50	0.010	0.734	0.132	0.500	**4.707**	10.337	1.150	5.263	0.721
50--60	0.008	0.869	0.267	0.400	**3.037**	11.208	1.994	3.809	0.737
60--70	0.005	0.830	0.289	0.266	**2.625**	11.990	2.458	3.521	0.774
70--80	0.005	0.785	0.443	0.154	**2.187**	11.493	4.504	2.128	0.785
80--90	-0.001	0.896	0.267	0.015	-0.375	19.820	1.768	0.191	0.759
90--100	-0.009	0.854	0.539	-0.292	**-4.413**	18.707	2.756	-2.484	0.776
90-95									
0 --10	0.008	0.888	1.130	0.408	**5.814**	8.703	6.941	5.874	0.875
10--20	0.007	0.978	0.700	0.276	**3.326**	15.041	4.116	3.203	0.855
20--30	0.005	0.996	0.590	0.290	**2.607**	24.838	3.614	3.897	0.890
30--40	0.004	0.977	0.432	0.208	1.641	12.541	2.350	3.818	0.839
40--50	0.003	0.881	0.153	0.198	1.492	10.838	0.884	2.718	0.837
50--60	0.000	1.067	0.247	0.093	0.057	16.850	1.786	1.266	0.863
60--70	0.001	0.929	0.310	0.022	0.412	15.086	2.519	0.370	0.851
70--80	0.000	0.930	0.473	-0.102	-0.234	20.162	3.880	-1.412	0.860
80--90	-0.007	1.034	0.630	-0.294	**-2.534**	14.798	3.426	-3.588	0.858
90--100	-0.006	0.932	0.700	-0.181	**-3.104**	20.597	4.927	-2.376	0.865
91-96									
0 --10	0.007	0.988	1.103	0.323	**4.766**	12.909	7.332	4.123	0.852
10--20	0.007	0.850	0.655	0.252	**3.812**	16.658	4.748	3.001	0.818
20--30	0.004	0.881	0.449	0.204	**2.482**	15.853	4.608	2.581	0.826
30--40	0.004	0.898	0.490	0.236	1.672	16.479	2.856	3.339	0.775
40--50	0.004	0.826	0.202	0.223	**2.328**	15.603	1.476	3.084	0.798
50--60	0.001	0.949	0.393	0.113	0.364	18.566	2.926	1.380	0.792
60--70	0.000	0.903	0.294	0.022	0.157	15.337	2.331	0.307	0.792
70--80	-0.001	0.908	0.394	-0.009	-0.323	15.509	2.588	-0.102	0.782
80--90	-0.006	1.034	0.658	-0.300	**-2.457**	16.677	3.515	-3.239	0.822
90--100	-0.006	0.864	0.734	-0.201	**-3.133**	17.512	4.135	-2.440	0.785
92-97									
0 --10	0.008	0.953	0.834	0.406	**4.794**	13.996	5.910	5.268	0.832
10--20	0.007	0.880	0.726	0.313	**4.502**	18.604	5.767	3.651	0.812
20--30	0.003	0.858	0.414	0.286	**2.093**	17.389	4.378	3.594	0.810
30--40	0.001	0.915	0.463	0.259	0.759	17.361	3.146	3.898	0.812
40--50	0.005	0.853	0.177	0.310	**3.202**	16.999	1.611	4.311	0.819
50--60	0.002	0.880	0.413	0.148	0.832	19.360	3.206	1.816	0.810
60--70	0.000	0.915	0.127	0.043	-0.225	15.894	1.124	0.579	0.822
70--80	0.000	0.827	0.294	-0.035	-0.010	16.039	1.884	-0.394	0.766
80--90	-0.005	0.906	0.500	-0.235	**-2.312**	18.613	3.283	-2.120	0.808
90--100	-0.010	0.929	0.648	-0.226	**-4.370**	20.121	3.256	-2.934	0.781

93-98									
0 --10	0.007	1.065	1.007	0.493	**2.783**	10.679	6.012	3.317	0.849
10--20	0.007	0.919	0.793	0.346	**3.940**	14.988	7.101	3.303	0.877
20--30	0.002	0.891	0.426	0.270	1.330	10.258	3.278	2.082	0.785
30--40	0.001	0.893	0.474	0.253	0.733	20.722	4.413	4.123	0.888
40--50	0.007	0.818	0.160	0.403	**4.079**	18.583	1.279	5.477	0.859
50--60	0.000	0.926	0.341	0.127	0.205	21.797	3.012	1.852	0.880
60--70	-0.003	0.932	0.183	0.102	-1.618	17.554	1.101	1.087	0.860
70--80	-0.001	0.912	0.263	0.119	-0.524	18.889	1.986	1.262	0.859
80--90	-0.006	0.940	0.236	-0.191	**-2.333**	20.523	2.475	-1.505	0.869
90--100	-0.009	0.885	0.399	-0.212	**-4.208**	20.350	2.049	-2.543	0.835
94-99									
0 --10	0.011	1.000	1.198	0.701	**3.638**	10.199	5.758	6.190	0.838
10--20	0.010	0.939	0.679	0.691	**3.476**	11.990	3.267	3.771	0.817
20--30	0.007	0.917	0.404	0.632	**2.301**	9.936	2.439	3.793	0.757
30--40	0.005	0.936	0.598	0.573	1.770	13.536	3.797	4.337	0.826
40--50	0.008	0.855	0.270	0.611	**3.855**	12.414	1.478	6.209	0.817
50--60	0.003	0.931	0.476	0.251	1.081	16.995	2.379	2.685	0.816
60--70	0.002	0.935	0.218	0.322	0.606	16.903	1.079	2.700	0.833
70--80	0.004	0.939	0.322	0.326	1.264	21.280	2.520	3.008	0.866
80--90	-0.003	0.916	0.338	-0.012	-1.338	23.339	2.201	-0.124	0.871
90--100	-0.011	0.893	0.237	-0.257	**-5.642**	25.504	1.289	-3.592	0.849
95-00									
0 --10	0.018	0.918	0.858	0.749	**4.032**	8.497	3.569	7.663	0.774
10--20	0.015	0.834	0.645	0.718	**3.963**	8.294	2.640	5.562	0.773
20--30	0.013	0.909	0.260	0.882	**3.680**	8.145	1.207	5.532	0.754
30--40	0.012	0.834	0.467	0.777	**3.702**	8.595	2.202	6.757	0.790
40--50	0.011	0.802	0.143	0.670	**3.939**	7.895	0.647	6.252	0.756
50--60	0.011	0.855	0.445	0.440	**2.971**	7.501	1.693	3.371	0.727
60--70	0.005	0.866	0.229	0.366	1.299	8.435	1.123	3.560	0.757
70--80	0.007	0.800	0.400	0.245	**1.944**	7.556	2.547	2.762	0.760
80--90	0.001	0.884	0.074	0.091	0.209	16.272	0.450	1.108	0.798
90--100	-0.011	0.797	0.129	-0.383	**-4.007**	11.219	0.766	-2.642	0.792
96-01									
0 --10	0.021	0.818	0.664	0.780	**4.178**	7.366	3.260	8.696	0.758
10--20	0.019	0.734	0.253	0.806	**3.838**	6.927	1.013	4.846	0.707
20--30	0.018	0.791	-0.032	1.013	**3.263**	6.670	-0.144	5.292	0.712
30--40	0.015	0.725	0.056	0.876	**5.047**	7.235	0.307	7.171	0.712
40--50	0.014	0.716	0.020	0.689	**4.701**	7.993	0.117	5.583	0.734
50--60	0.013	0.820	0.195	0.571	**3.627**	8.667	0.881	4.050	0.716
60--70	0.007	0.818	0.193	0.408	**2.213**	8.982	1.044	3.672	0.760
70--80	0.008	0.753	0.329	0.299	**2.108**	8.382	2.489	2.941	0.778
80--90	0.002	0.876	-0.107	0.229	0.669	16.895	-0.538	2.064	0.752
90--100	-0.013	0.817	0.398	-0.352	**-4.040**	13.055	1.145	-2.001	0.753
97-02									
0 --10	0.024	0.802	0.684	0.802	**4.705**	6.875	3.036	8.818	0.749
10--20	0.019	0.719	0.200	0.825	**3.546**	6.448	0.722	4.681	0.697
20--30	0.021	0.788	-0.088	1.060	**3.469**	6.403	-0.358	5.173	0.707
30--40	0.017	0.710	-0.012	0.906	**4.894**	6.811	-0.060	7.090	0.702
40--50	0.016	0.684	0.031	0.705	**4.897**	7.515	0.164	5.324	0.710
50--60	0.015	0.821	0.154	0.611	**4.047**	8.306	0.626	4.084	0.713
60--70	0.009	0.800	0.243	0.408	**2.554**	8.597	1.166	3.459	0.754
70--80	0.009	0.747	0.364	0.308	**2.486**	8.045	2.477	2.868	0.772
80--90	0.003	0.859	-0.105	0.253	0.969	16.235	-0.467	2.096	0.744
90--100	-0.013	0.816	0.337	-0.342	**-3.684**	12.893	0.862	-1.959	0.743

Table 5.C EU: RISK ADJUSTMENT OF RETURNS with 4-CAPM model (10 equations system estimated by GMM simultaneusly) DJSTOXX
(risk premium 7%; nominal rate of growth in the terminal period 3%)

Percentile portfolios	α	β	γ	δ	η	t(α)	t(β)	t(γ)	t(δ)	t(η)	R^2
90-02											
0 --10	0.009	0.825	0.431	0.748	0.617	**2.156**	6.085	2.063	4.999	0.385	0.438
10--20	0.008	0.679	0.634	0.486	-0.627	**1.910**	5.265	3.029	2.796	-0.377	0.372
20--30	0.003	0.705	0.245	0.290	0.678	0.993	6.437	1.592	2.426	0.557	0.350
30--40	0.003	0.733	0.261	0.172	-0.387	0.731	7.040	1.214	1.337	-0.384	0.313
40--50	0.001	0.594	0.388	0.154	-0.665	0.236	6.616	2.808	1.192	-0.609	0.310
50--60	-0.002	0.595	0.268	0.116	-0.093	-0.438	5.632	1.584	0.812	-0.079	0.287
60--70	0.002	0.656	-0.049	-0.160	-0.704	0.571	5.898	-0.220	-0.875	-0.650	0.285
70--80	-0.003	0.693	0.125	0.007	-0.224	-0.989	10.777	0.818	0.060	-0.264	0.406
80--90	-0.002	0.683	0.067	-0.292	-1.269	-0.505	7.985	0.294	-1.512	-1.294	0.302
90--100	-0.006	0.805	0.001	-0.157	-0.177	**-1.902**	9.060	0.004	-0.728	-0.164	0.361
90-95											
0 --10	0.007	0.892	0.210	0.703	-2.341	1.355	7.051	0.831	3.051	-0.937	0.536
10--20	0.008	0.737	0.491	0.422	-2.022	1.537	5.841	2.311	1.946	-0.700	0.440
20--30	0.003	0.707	0.095	0.331	-1.621	0.723	5.480	0.470	2.118	-0.847	0.423
30--40	0.000	0.793	0.237	-0.037	-0.756	-0.058	6.064	0.747	-0.190	-0.411	0.369
40--50	-0.001	0.882	0.430	-0.115	-0.089	-0.179	8.648	2.120	-0.449	-0.037	0.392
50--60	-0.006	0.713	0.157	-0.147	-0.277	-1.464	7.171	0.597	-0.870	-0.166	0.321
60--70	-0.003	0.810	0.096	-0.227	-0.832	-0.839	7.747	0.499	-1.363	-0.426	0.425
70--80	0.000	0.776	-0.100	-0.088	-0.440	0.060	6.047	-0.409	-0.417	-0.157	0.368
80--90	0.004	0.678	-0.348	0.015	-1.719	0.882	4.216	-1.597	0.099	-0.465	0.335
90--100	-0.003	0.931	0.187	0.075	1.472	-0.794	7.997	0.680	0.325	0.755	0.442
91-96											
0 --10	0.016	0.888	0.190	0.822	-6.055	**3.312**	7.509	0.900	3.838	-2.196	0.545
10--20	0.014	0.769	0.474	0.396	-7.031	**3.391**	5.103	2.618	1.936	-2.189	0.426
20--30	0.008	0.674	0.107	0.378	-3.620	**1.976**	4.654	0.558	2.238	-1.049	0.340
30--40	0.005	0.696	0.045	0.215	-1.057	1.415	4.331	0.200	1.085	-0.311	0.326
40--50	0.003	0.802	0.487	-0.039	-3.886	0.644	8.221	2.401	-0.141	-1.988	0.323
50--60	-0.001	0.694	0.196	-0.131	-2.454	-0.321	6.088	0.745	-0.684	-0.822	0.260
60--70	0.003	0.860	0.139	-0.222	-4.287	0.878	6.491	0.725	-1.325	-1.364	0.375
70--80	0.006	0.708	-0.138	-0.053	-4.397	1.626	5.647	-0.660	-0.283	-1.509	0.355
80--90	0.010	0.702	-0.355	0.088	-8.794	**2.796**	4.230	-1.673	0.619	-2.772	0.403
90--100	-0.001	0.894	-0.021	0.191	-0.366	-0.172	6.639	-0.105	0.935	-0.130	0.444
92-97											
0 --10	0.015	0.933	0.141	0.745	-4.718	**3.390**	9.782	0.813	3.812	-2.174	0.527
10--20	0.013	0.811	0.417	0.193	-6.315	**3.187**	7.533	2.739	1.144	-2.915	0.425
20--30	0.006	0.790	0.174	0.156	-2.979	1.530	6.727	0.970	0.926	-1.221	0.375
30--40	0.005	0.733	0.083	0.204	-2.030	1.409	5.259	0.448	1.057	-0.631	0.327
40--50	0.005	0.744	0.477	-0.065	-5.696	1.057	8.503	2.827	-0.261	-2.543	0.305
50--60	-0.001	0.662	0.234	-0.227	-4.129	-0.142	8.263	1.111	-1.276	-1.980	0.258
60--70	0.004	0.911	-0.143	-0.618	-2.633	0.945	7.811	-0.598	-2.052	-1.088	0.362
70--80	0.005	0.727	0.019	-0.177	-5.072	1.560	8.036	0.095	-0.963	-3.208	0.351
80--90	0.010	0.663	-0.300	0.069	-7.931	**2.830**	6.403	-1.699	0.450	-3.379	0.375
90--100	0.000	0.822	0.025	0.089	-3.676	-0.081	6.474	0.163	0.528	-1.243	0.395

93-98											
0 --10	0.011	1.075	0.504	0.603	-0.459	**2.104**	7.348	2.315	2.450	-0.245	0.687
10--20	0.008	0.985	0.638	0.278	-3.049	1.584	6.077	3.168	1.151	-1.575	0.624
20--30	0.002	0.868	0.347	0.060	0.861	0.492	6.121	2.051	0.303	0.498	0.540
30--40	0.003	0.968	0.055	0.242	-0.771	0.786	7.650	0.242	1.267	-0.482	0.562
40--50	0.001	0.750	0.485	-0.074	-2.211	0.216	9.130	2.866	-0.299	-1.737	0.439
50--60	-0.005	0.758	0.531	-0.320	-1.531	-1.385	7.268	3.111	-1.690	-1.316	0.490
60--70	0.004	0.958	-0.094	-0.606	-2.385	0.915	8.103	-0.351	-2.270	-2.035	0.474
70--80	0.001	0.747	0.237	-0.215	-2.304	0.431	10.087	1.768	-1.184	-2.634	0.528
80--90	0.003	0.635	0.081	0.016	-2.676	0.762	6.523	0.393	0.101	-2.028	0.440
90--100	-0.003	0.853	-0.157	0.330	0.139	-0.833	6.972	-0.781	1.341	0.089	0.496
94-99											
0 --10	0.013	1.053	0.402	0.766	-1.032	**2.560**	8.692	1.985	3.363	-0.555	0.646
10--20	0.008	0.996	0.445	0.459	-2.956	1.662	7.184	2.041	1.689	-1.646	0.626
20--30	0.006	0.867	0.130	0.372	0.544	1.280	7.136	0.721	1.498	0.301	0.505
30--40	0.006	0.970	-0.056	0.418	-0.825	1.406	8.917	-0.281	1.944	-0.576	0.571
40--50	0.004	0.697	0.245	0.246	-2.699	0.957	7.473	1.564	1.032	-1.625	0.404
50--60	-0.003	0.787	0.205	0.104	-0.967	-0.807	7.361	1.023	0.436	-0.655	0.433
60--70	0.003	0.896	-0.245	-0.421	-2.757	0.806	6.800	-0.922	-1.293	-1.867	0.404
70--80	0.001	0.792	0.035	0.037	-1.545	0.214	12.497	0.238	0.183	-1.793	0.583
80--90	0.001	0.723	-0.020	0.066	-1.431	0.292	6.948	-0.090	0.365	-1.114	0.445
90--100	-0.004	0.832	-0.446	0.586	0.184	-0.946	6.394	-2.000	1.977	0.102	0.451
95-00											
0 --10	0.018	0.881	0.409	0.911	-0.853	**3.174**	5.440	2.109	4.349	-0.434	0.527
10--20	0.013	0.824	0.504	0.630	-2.964	**2.429**	4.754	2.257	2.536	-1.630	0.515
20--30	0.008	0.764	0.149	0.465	0.653	1.516	5.050	0.948	2.682	0.368	0.375
30--40	0.011	0.819	0.026	0.474	-1.244	**2.304**	6.156	0.129	2.338	-0.812	0.385
40--50	0.004	0.599	0.305	0.329	-2.074	1.007	5.889	2.322	2.301	-1.367	0.359
50--60	0.004	0.597	0.301	0.335	-1.341	0.761	3.843	1.592	1.464	-0.740	0.311
60--70	0.011	0.735	-0.329	-0.072	-2.386	**2.227**	4.789	-1.041	-0.262	-1.812	0.284
70--80	-0.001	0.748	0.173	0.054	-1.712	-0.460	8.301	1.253	0.363	-1.754	0.510
80--90	0.000	0.705	0.056	-0.294	-1.927	-0.101	7.644	0.229	-1.130	-1.842	0.319
90--100	-0.010	0.897	-0.188	-0.144	-0.956	**-2.067**	5.582	-0.994	-0.421	-0.464	0.363
96-01											
0 --10	0.015	0.683	0.680	0.739	0.974	**2.082**	3.194	2.489	3.169	0.511	0.406
10--20	0.009	0.621	0.774	0.494	-0.197	1.207	2.905	2.357	1.762	-0.096	0.355
20--30	0.006	0.638	0.400	0.242	1.017	1.074	3.632	1.667	1.245	0.715	0.323
30--40	0.006	0.686	0.299	0.288	-0.347	0.892	3.682	0.824	1.395	-0.261	0.283
40--50	0.003	0.465	0.459	0.239	-0.657	0.739	3.265	2.181	1.713	-0.523	0.307
50--60	0.004	0.499	0.400	0.247	-0.309	0.704	2.960	1.721	1.248	-0.196	0.285
60--70	0.009	0.564	-0.101	-0.150	-0.999	1.407	3.032	-0.258	-0.570	-0.749	0.215
70--80	-0.006	0.621	0.346	0.026	0.060	-1.581	6.191	1.881	0.200	0.068	0.475
80--90	-0.008	0.599	0.451	-0.536	-1.267	-1.213	5.743	1.464	-1.999	-1.416	0.354
90--100	-0.010	0.769	-0.063	-0.354	-0.459	**-2.089**	5.029	-0.259	-1.176	-0.348	0.352
97-02											
0 --10	0.013	0.714	0.558	0.786	1.366	1.633	3.381	1.969	3.184	0.721	0.402
10--20	0.010	0.609	0.780	0.563	-0.204	1.146	2.772	2.226	1.941	-0.096	0.357
20--30	0.006	0.671	0.299	0.275	1.229	0.969	3.845	1.254	1.374	0.875	0.335
30--40	0.006	0.704	0.225	0.275	-0.300	0.785	3.638	0.604	1.301	-0.224	0.281
40--50	0.002	0.491	0.333	0.284	-0.315	0.357	3.482	1.671	1.997	-0.264	0.305
50--60	0.001	0.538	0.282	0.301	0.222	0.187	3.240	1.200	1.445	0.140	0.285
60--70	0.007	0.593	-0.247	-0.125	-0.652	1.082	3.173	-0.614	-0.466	-0.521	0.231
70--80	-0.007	0.645	0.285	0.056	0.272	-1.689	6.639	1.555	0.429	0.312	0.493
80--90	-0.007	0.608	0.429	-0.523	-1.337	-1.023	5.671	1.330	-1.884	-1.453	0.355
90--100	-0.010	0.775	-0.097	-0.319	-0.388	-1.752	4.895	-0.377	-1.019	-0.281	0.344

Table 5.D US: RISK ADJUSTMENT OF RETURNS with 4-CAPM model (10 equations system estimated by GMM simultaneusly) S&P500
(risk premium 7%; nominal rate of growth in the terminal period 3%)

Percentile portfolios	α	β	γ	δ	η	t(α)	t(β)	t(γ)	t(δ)	t(η)	R^2
90-02											
0 --10	0.012	0.833	0.894	0.646	2.443	**3.938**	11.038	5.513	7.804	2.778	0.792
10--20	0.010	0.785	0.531	0.621	2.621	**3.606**	10.886	3.461	5.325	2.992	0.748
20--30	0.008	0.829	0.349	0.768	3.834	**2.658**	11.809	2.409	5.884	3.372	0.763
30--40	0.009	0.766	0.320	0.636	1.514	**3.555**	10.346	2.595	5.497	1.569	0.716
40--50	0.008	0.739	0.139	0.513	1.076	**4.551**	11.520	1.204	5.390	1.150	0.726
50--60	0.006	0.877	0.278	0.419	1.629	**2.386**	12.621	2.083	4.189	1.698	0.745
60--70	0.005	0.832	0.291	0.270	0.410	**2.571**	12.491	2.486	3.561	0.531	0.774
70--80	0.003	0.790	0.450	0.166	1.030	1.662	12.380	4.566	2.308	1.698	0.789
80--90	-0.001	0.897	0.268	0.017	0.221	-0.521	19.673	1.753	0.227	0.370	0.759
90--100	-0.007	0.848	0.531	-0.308	-1.331	**-3.311**	19.266	2.869	-2.638	-1.453	0.782
90-95											
0 --10	0.007	0.896	1.123	0.438	2.044	**4.258**	9.941	7.078	5.830	1.648	0.883
10--20	0.008	0.975	0.703	0.263	-0.847	**3.708**	16.713	4.087	2.984	-1.723	0.856
20--30	0.004	0.998	0.588	0.299	0.605	**2.156**	24.551	3.712	4.057	0.968	0.891
30--40	0.005	0.970	0.437	0.183	-1.757	**1.958**	15.551	2.365	3.068	-1.739	0.847
40--50	0.005	0.871	0.161	0.159	-2.621	**2.494**	20.803	1.046	2.120	-3.633	0.859
50--60	0.000	1.065	0.248	0.087	-0.409	0.199	18.808	1.837	1.091	-0.351	0.863
60--70	0.001	0.929	0.310	0.022	0.008	0.397	15.140	2.517	0.378	0.010	0.851
70--80	-0.002	0.936	0.469	-0.080	1.493	-0.890	21.216	3.753	-1.090	3.359	0.866
80--90	-0.007	1.034	0.629	-0.292	0.098	**-2.739**	14.987	3.430	-3.362	0.093	0.858
90--100	-0.006	0.933	0.699	-0.176	0.329	**-3.182**	20.239	4.903	-2.188	0.460	0.865
91-96											
0 --10	0.007	1.001	1.100	0.317	-0.594	**4.503**	11.710	7.181	3.982	-0.407	0.852
10--20	0.007	0.851	0.655	0.251	-0.086	**3.845**	12.873	4.763	3.000	-0.082	0.818
20--30	0.004	0.866	0.453	0.211	0.683	**2.044**	18.218	4.772	2.820	0.451	0.826
30--40	0.004	0.929	0.482	0.222	-1.423	1.825	15.401	2.828	2.994	-1.087	0.777
40--50	0.004	0.822	0.203	0.225	0.195	**2.072**	18.407	1.492	3.046	0.177	0.798
50--60	0.000	0.934	0.397	0.120	0.715	0.216	18.045	2.885	1.336	0.374	0.793
60--70	0.000	0.881	0.299	0.032	1.035	-0.135	12.466	2.354	0.436	0.626	0.794
70--80	-0.001	0.878	0.402	0.005	1.379	-0.676	12.926	2.579	0.057	1.018	0.785
80--90	-0.008	0.964	0.675	-0.268	3.166	**-3.345**	11.956	3.463	-2.500	1.890	0.832
90--100	-0.006	0.873	0.732	-0.205	-0.427	**-3.154**	15.545	4.192	-2.345	-0.436	0.785
92-97											
0 --10	0.008	0.958	0.839	0.401	-0.603	**4.426**	13.536	6.101	5.275	-0.504	0.833
10--20	0.008	0.888	0.735	0.305	-1.077	**4.358**	16.138	5.936	3.671	-0.646	0.813
20--30	0.005	0.880	0.436	0.268	-2.685	**2.404**	20.471	5.447	3.451	-1.461	0.819
30--40	0.002	0.926	0.475	0.249	-1.439	1.116	16.062	3.345	3.717	-1.137	0.815
40--50	0.004	0.841	0.164	0.320	1.510	**2.033**	19.029	1.422	4.497	1.271	0.823
50--60	0.002	0.885	0.419	0.144	-0.637	0.962	19.743	3.298	1.686	-0.446	0.811
60--70	0.000	0.920	0.132	0.039	-0.529	0.014	15.758	1.187	0.519	-0.526	0.822
70--80	0.000	0.829	0.296	-0.036	-0.172	0.053	15.597	1.864	-0.403	-0.127	0.766
80--90	-0.007	0.889	0.482	-0.220	2.106	**-2.692**	18.839	3.181	-1.987	1.938	0.813
90--100	-0.008	0.952	0.671	-0.246	-2.815	**-3.662**	19.139	3.615	-3.076	-2.403	0.789

93-98											
0 --10	0.006	1.061	1.039	0.551	1.591	**2.004**	10.852	5.165	3.623	1.148	0.855
10--20	0.006	0.913	0.839	0.431	2.288	**2.712**	18.484	6.660	4.751	2.717	0.894
20--30	0.000	0.881	0.504	0.415	3.910	-0.119	15.611	2.980	4.414	2.655	0.840
30--40	0.000	0.891	0.495	0.292	1.032	0.256	22.759	4.277	4.548	1.859	0.892
40--50	0.006	0.816	0.175	0.431	0.749	**3.527**	19.603	1.303	5.324	2.003	0.862
50--60	-0.001	0.923	0.369	0.180	1.424	-0.314	23.727	2.998	2.599	1.876	0.887
60--70	-0.001	0.937	0.151	0.042	-1.615	-0.962	20.724	1.029	0.455	-4.403	0.869
70--80	-0.001	0.912	0.263	0.119	-0.025	-0.495	18.988	1.934	1.178	-0.046	0.859
80--90	-0.005	0.941	0.229	-0.204	-0.348	**-2.141**	21.967	2.290	-1.626	-0.598	0.869
90--100	-0.009	0.885	0.400	-0.210	0.055	**-4.213**	20.127	2.069	-2.187	0.071	0.835
94-99											
0 --10	0.008	0.997	1.213	0.749	2.191	**2.304**	10.189	5.154	6.626	1.387	0.848
10--20	0.006	0.935	0.699	0.756	2.927	**2.123**	14.213	3.126	4.281	2.763	0.840
20--30	0.001	0.910	0.436	0.737	4.717	0.454	14.476	2.129	5.037	3.008	0.820
30--40	0.002	0.934	0.611	0.617	1.985	0.957	15.387	3.836	4.803	2.803	0.837
40--50	0.007	0.853	0.280	0.642	1.391	**2.937**	13.414	1.491	6.598	2.761	0.824
50--60	0.000	0.929	0.491	0.296	2.047	0.141	17.934	2.454	3.328	2.886	0.829
60--70	0.003	0.936	0.212	0.303	-0.864	0.968	17.509	1.096	2.402	-2.196	0.836
70--80	0.003	0.938	0.325	0.337	0.488	1.111	20.689	2.502	2.997	1.037	0.866
80--90	-0.003	0.916	0.339	-0.010	0.089	-1.285	23.139	2.213	-0.102	0.201	0.871
90--100	-0.011	0.893	0.236	-0.261	-0.176	**-4.951**	25.591	1.283	-3.373	-0.241	0.849
95-00											
0 --10	0.015	0.915	0.848	0.763	1.715	**2.809**	8.365	3.288	7.571	1.064	0.780
10--20	0.009	0.829	0.626	0.745	3.230	**2.598**	9.489	2.642	5.813	3.202	0.800
20--30	0.004	0.899	0.226	0.928	5.667	1.052	13.567	1.023	6.871	5.003	0.829
30--40	0.008	0.829	0.450	0.801	2.888	**2.512**	9.687	2.290	8.026	3.293	0.813
40--50	0.007	0.798	0.127	0.691	2.647	**2.725**	9.247	0.630	6.863	2.267	0.780
50--60	0.005	0.849	0.424	0.469	3.518	1.741	8.782	1.793	4.386	2.869	0.763
60--70	0.003	0.864	0.224	0.372	0.723	1.185	8.534	1.098	3.648	0.559	0.759
70--80	0.005	0.798	0.393	0.255	1.235	1.479	7.624	2.573	2.890	1.163	0.766
80--90	-0.001	0.882	0.067	0.100	1.016	-0.391	15.347	0.400	1.221	0.992	0.801
90--100	-0.009	0.799	0.137	-0.394	-1.387	**-2.839**	12.973	0.855	-2.741	-1.528	0.798
96-01											
0 --10	0.016	0.834	0.667	0.803	2.455	**2.720**	7.981	3.259	8.175	1.757	0.772
10--20	0.010	0.760	0.257	0.843	3.928	**2.013**	8.770	1.086	5.139	3.731	0.756
20--30	0.006	0.827	-0.026	1.063	5.457	1.147	9.642	-0.113	6.177	4.385	0.797
30--40	0.009	0.745	0.060	0.903	2.913	**2.487**	8.780	0.343	8.604	2.936	0.740
40--50	0.008	0.733	0.023	0.713	2.625	**2.766**	10.367	0.147	6.294	3.208	0.763
50--60	0.008	0.835	0.198	0.592	2.289	**2.250**	10.041	0.913	4.574	2.140	0.733
60--70	0.006	0.822	0.194	0.414	0.635	**1.970**	9.514	1.054	3.736	0.701	0.761
70--80	0.006	0.759	0.330	0.308	0.905	1.644	8.827	2.520	2.960	1.212	0.782
80--90	0.002	0.877	-0.107	0.231	0.159	0.534	16.576	-0.532	2.081	0.283	0.752
90--100	-0.009	0.806	0.396	-0.368	-1.740	**-2.173**	13.489	1.237	-2.204	-1.321	0.763
97-02											
0 --10	0.020	0.818	0.674	0.819	1.885	**3.051**	7.188	3.019	8.461	1.201	0.757
10--20	0.010	0.753	0.178	0.861	3.940	1.720	8.113	0.693	4.985	3.448	0.746
20--30	0.008	0.833	-0.118	1.109	5.357	1.273	9.000	-0.491	5.984	3.852	0.786
30--40	0.010	0.733	-0.027	0.931	2.716	**2.270**	8.072	-0.147	8.380	2.483	0.727
40--50	0.011	0.701	0.019	0.724	2.078	**2.803**	9.063	0.106	5.773	2.403	0.728
50--60	0.010	0.840	0.142	0.631	2.180	**2.500**	9.432	0.596	4.560	1.911	0.728
60--70	0.009	0.802	0.242	0.410	0.246	**2.498**	8.830	1.151	3.441	0.281	0.754
70--80	0.008	0.752	0.361	0.314	0.586	**2.170**	8.273	2.461	2.877	0.767	0.774
80--90	0.004	0.857	-0.103	0.251	-0.243	1.073	15.734	-0.468	2.092	-0.439	0.744
90--100	-0.008	0.800	0.348	-0.360	-1.937	-1.625	13.068	0.965	-2.192	-1.330	0.756

Table 6.A EU: Test of the restrictions on the alpha coefficients of the 3-CAPM system

3-CAPM SYSTEM

Period	H:α_i=0		H:α1=α10	
	χ2(10)	p-value	χ2(2)	p-value
90-02	41.46159	**0.000004**	17.40127	**0.000030**
90-95	31.83792	**0.000212**	2.896106	0.088794
91-96	43.83649	**0.000002**	9.188258	**0.002436**
92-97	52.90814	**0.000000**	16.44937	**0.000050**
93-98	41.31298	**0.000004**	5.358595	**0.020620**
94-99	33.95034	**0.000091**	7.202953	**0.007278**
95-00	31.06811	**0.000288**	14.10537	**0.000173**
96-01	52.72426	**0.000000**	22.16945	**0.000002**
97-02	45.64912	**0.000001**	17.87926	**0.000024**

Table 6.B EU: Test of the restrictions on the alpha coefficients of the 4-CAPM system

4-CAPM SYSTEM

Period	H:α_i=0		H:α1=α10	
	χ2(10)	p-value	χ2(2)	p-value
90-02	23.91325	**0.00444**	11.86936	**0.00057**
90-95	24.02398	**0.00426**	7.598661	**0.00584**
91-96	51.23326	**0.00000**	12.61675	**0.00038**
92-97	75.26249	**0.00000**	13.23219	**0.00028**
93-98	19.3614	**0.02229**	6.569923	**0.01037**
94-99	20.31583	**0.01606**	9.930331	**0.00163**
95-00	22.28742	**0.00801**	15.65226	**0.00008**
96-01	25.93743	**0.00209**	12.57887	**0.00039**
97-02	19.77246	**0.01937**	8.114276	**0.00439**

The tables report Wald tests on intercept coefficients of a 3-CAPM and a 4-CAPM system composed by p equations.

The p-th equation is written as follows:

$$R^t{}_P - R^t{}_f = \alpha_P + \beta_P (R^t{}_m - R^t{}_f) + \gamma_P SMB^t + \delta_P HML^t + \eta_P (R^t{}_m - R^t{}_f)^2 + \varepsilon_P{}^t$$

where R_p is the monthly return of portfolio p (p=1,..,10), R_f is the monthly return of the 1-month Treasury bill rate, R_m is the monthly return of the market portfolio while SMB and HML are additional risk factors.
The 10 Portfolios (from 0-10 to 90-100) are formed according to ascending values of the observed to fundamental ratio (i.e. the first portfolio includes stocks whose observed to fundamental ratio falls in the lowest ten percent of the distribution in the considered month). Portfolios are formed the first day of month t on values that the ranking variable assumes in the last day of the month t-1 and held until the end of the month t (1 month strategy). New portfolios are formed only at the end of each holding period.

Table 6.C US: Test of the restrictions on the alpha coefficients of the 3-CAPM system

3-CAPM SYSTEM

Period	H:α_i=0		H:α1=α10	
	χ2(10)	p-value	χ2(2)	p-value
90-02	69.85169	0.000000	43.19937	0.000000
90-95	83.74431	0.000000	50.71749	0.000000
91-96	75.95543	0.000000	35.50484	0.000000
92-97	76.9501	0.000000	36.35576	0.000000
93-98	75.98413	0.000000	23.46559	0.000001
94-99	88.52631	0.000000	35.66737	0.000000
95-00	109.3824	0.000000	40.27618	0.000000
96-01	87.94438	0.000000	32.69073	0.000000
97-02	82.81803	0.000000	33.0203	0.000000

Table 6.D Us: Test of the restrictions on the alpha coefficients of the 4-CAPM system

4-CAPM SYSTEM

Period	H:α_i=0		H:α1=α10	
	χ2(10)	p-value	χ2(2)	p-value
90-02	81.91268	0.000000	38.27392	0.000000
90-95	73.86972	0.000000	35.62564	0.000000
91-96	82.43986	0.000000	33.20645	0.000000
92-97	70.52229	0.000000	30.41486	0.000000
93-98	61.37873	0.000000	16.00493	0.000063
94-99	63.70924	0.000000	18.12615	0.000021
95-00	63.44794	0.000000	23.92344	0.000001
96-01	29.30586	0.000575	15.17125	0.000098
97-02	36.52785	0.000032	13.95435	0.000187

The tables report Wald tests on intercept coefficients of a 3-CAPM and a 4-CAPM system composed by p equations.

The p-th equation is written as follows:

$$R^t{}_P - R^t{}_f = \alpha_P + \beta_P(R^t{}_m - R^t{}_f) + \gamma_P SMB^t + \delta_P HML^t + \eta_P(R^t{}_m - R^t{}_f)^2 + \varepsilon_P{}^t$$

where R_p is the monthly return of portfolio p (p=1,..,10), R_f is the monthly return of the 1-month Treasury bill rate, R_m is the monthly return of the market portfolio while SMB and HML are additional risk factors.
The 10 Portfolios (from 0-10 to 90-100) are formed according to ascending values of the observed to fundamental ratio (i.e. the first portfolio includes stocks whose observed to fundamental ratio falls in the lowest ten percent of the distribution in the considered month). Portfolios are formed the first day of month t on values that the ranking variable assumes in the last day of the month t-1 and held until the end of the month t (1 month strategy). New portfolios are formed only at the end of each holding period.

**Deviations from fundamentals in US and EU stock markets:
a comparative analysis**

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Abstract

In this paper we build a "two-stage growth" discounted cash flow (DCF) model to test whether changes in the underlying market fundamentals help to explain movements in stock prices. Empirical results on two samples of US and EU stocks show that the "fundamental" price earning ratio (P/E) explains a significant share of cross-sectional variation of the observed P/E, his impact being stronger in the US market.

We also document that: i) the fundamental P/E has superior explanatory power with respect to simpler measures of expected earnings growth; ii) "non-fundamental" components, interpreted as signals reducing asymmetric information (such as firm size, the number of forecasts and the chartist momentum), mitigate the role of the fundamentals; iii) current deviations from the fundamentals are affected by ex post adjustment of publicly available information in the EU sample.

We argue that differences in regulatory environments and in the composition of investors between the US and EU financial systems may help to explain these comparative findings. Results appear consistent with the "market integrity hypothesis" assuming that reliance on publicly observable fundamentals is higher when insider trading is lower.

Key words: DCF fundamental value, price earning ratio, non-fundamental components, asymmetric information, insider trading

JEL classification codes: G10, G12, K42

1. Introduction

A crucial controversial issue in financial literature is whether stock prices are justified by fundamental values of the underlying economy. In his well known seminal contribution, Shiller (1981) argues that volatility in stock prices is too high to be justified by changes in market fundamentals alone. The logic behind his and similar tests is the following: if stock prices are determined by investors with homogeneous rational expectations (from now on also HRE), they should not be more volatile than economic fundamentals. Therefore short term deviations from fundamentals should be explained by violations of the HRE hypothesis such as those determined by insider trading effects.

As Lee (1998) postulates, other rationales for the role of non-fundamental factors may include noise (De Long et al., 1990), ”weakhearted”, liquidity, feedback trading, or irrational expectations, bringing investors’ sentiment into the forefront of stock-price determination. Examples of these behavioural models include the overconfidence and biased self-attribution model of Daniel et al. (1998) and the interaction model of newswatchers and momentum investors of Hong and Stein (1999).

According to the literature mentioned above, it is therefore clear that stock prices fluctuate around their fundamental values and must be analysed by looking both at fundamental and non fundamental components.

Within this framework we believe that two questions remain partially unanswered: i) how much fundamental and non fundamental components matter in determining stock prices according to differences in regulatory frameworks and in shaping financial institutions across different markets; ii) whether empirical findings support the hypothesis that publicly observed fundamental values should matter more where regulatory frameworks are designed to increase protection of small investors from insider trading.

To the first point, it is our opinion that differences in regulatory environments and in the composition of financial market investors between the US and EU systems may shed lights on how stock valuations may partially differ in the two markets. Even though clear cut distinctions among “archetypal market structures” exist only in theory, while they are much more blurred in the reality, we may find in the US financial markets (compared to EU markets) relatively stricter rules for information disclosure[1] and higher severity in the repression of the insider trading[2] together with a more pervasive presence of institutional investors (Allen-Gale, 1992). The role played by institutional investors in these markets is usually expected to increase the share of long term investors looking at fundamentals.

Are these differences identified by the literature still relevant and did they produce significant differences in the way fundamental and non fundamental values affected stock prices in the two markets in the last decade?

A second branch of the literature provides an interesting hypothesis which may help to develop this point of our research. We in fact know that, in a framework of asymmetric information, insiders can use their private information

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[1] The International Accounting Standards Committee (IASC) has set an International Accounting Standard and each year in his GAAP report National Accounting Standards are benchmarked against IAS. The 2001 GAAP report clearly shows that Accounting Standards of all stocks from European countries included in our index do not follow IAS recommendations in the disclosure of earnings per share and many other crucial bilance sheet items, differently from US Accounting Standards.

[2] Fund managers interviewed about the differences between US and European financial markets report that “A primary disadvantage is the lack of a centralized regulatory body (such as those in the US or UK). Similar to the US and in order to create more transparency, these regulatory bodies should implement insider-trading rules (e.g. filing of buy and sell activity of directors or major shareholders, filing of total positions held, etc.). When these rules are violated, there should be strict rules for punishment. Without this legal framework, the market will always be vulnerable to manipulation.” (CSFB, 2002).

to make extra profits by buying or selling owned stocks (Holden and Subrahmanyam 1992), or, by playing ad hoc strategies to hide their superior information to the market (Kyle, 1985). According to the *Market Integrity Theory* (King and Roell, 1988; Bhattacharya and Daouk, 2000) insider trading may reduce stock market efficiency when a relevant share of transactions is moved by preferential information instead of company fundamentals. This is in fact misleading for institutional investors, reducing returns on their investment in research and evaluation of fundamentals extracted on the basis of publicly available information. The consequence is a vicious circle in which more insider trading generates less research and reliance on (publicly observable) fundamentals and higher deviations of market prices from the fundamental values, undermining the market integrity (Milia 2000)[3].

Our comparative analysis on the determinants of US and EU stock prices aims to test hypotheses stemming from these lines of theoretical research. We wonder whether institutional and regulatory differences play some role in asset pricing and whether insider trading and relatively lower reliance on publicly available information on fundamentals are related.

The paper is divided into six sections (including introduction and conclusions). The second section presents a short survey of the literature on the determinants of the stock value. The third section develops a "standard two-stage

[3] When looking at the insider trading literature we must not forget that the market integrity hypothesis is opposed by alternative hypotheses emphasizing the positive effects of insider trading. Among them we remember the following arguments: i) "victimless crime": transactions carried out by insiders move stock prices in the same direction as preferential information. Consequently the counterpart of the insider also takes advantage of the insider's transactions (Herzel and Katz, 1987); ii) "the managers' compensation": the only effective way to compensate managers is through the exploitation of preferential information, because bonus and stock options are not flexible enough and financially viable for the company (Manne 1966); iii) "Market efficiency": the insider pushes

growth" discounted cash flow (DCF) model which is expected to proxy the benchmark for the so called "fundamentalist" traders. Within this framework, a significant part of the cross-sectional variation in stock prices or in price earning ratios (from now on also P/Es) should be explained by the fundamental value of prices or price earnings[4] and deviations of the fundamentals should be only indicators of delays in the adjustment of publicly available information (insider trading phenomenon). This section also outlines three hypotheses to be tested on the two samples of US and EU stocks. Such hypotheses are relative to: 1) the strong relevance of the DCF model (only the DCF variable matters); 2) the alternative arguing for the relevance of non-DCF components interpreted as signals of forecasting accuracy in a framework of asymmetric information; 3) the significance of insider trading effects.

The fourth section describes our estimation approach. The fifth section presents a descriptive analysis on the comparative features of the US and EU samples and estimates the determinants of P/Es in both samples. It finally provides a direct test on the significance of the observed differences between the US and EU stock markets, through a reestimation of the model with the US and EU samples jointly considered.

Our findings are easily summarized. The relationship between the DCF fundamental and the observed P/E is relatively stronger for US stocks, while, for both samples, the fundamental P/E has superior explanatory power with respect to the simpler measures of expected earning growth usually adopted in the literature. In spite of the strong significance of the DCF variable on the observed

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the stock price, (reflecting all available information -preferential included-) faster towards the value which better reflects the fundamentals of the company (Finnerty 1976).

values, the relevance of the “non-fundamental components” implies that something is missing in the traditional DCF evaluation. A comparative analysis of the US and EU samples shows that the impact of the fundamental is lower in the EU sample in which also insider trading effects occur more frequently. These findings are consistent with differences in regulatory environments (i. e. disclosure rules), in delays in the adjustment to publicly available information and in the composition of financial market investors.

2. The literature of P/E determinants: the state of art

Under the hypothesis that market agents have homogeneous rational expectations (HRE)[5] and the price of a stock reflects the value of current and future expected earnings[6] corrected for a risk adjusted discount factor, the cross-sectional dispersion of prices or price earning ratios (P/Es) should, in first place, reflect differences in risk and differences between current and future expected earnings across stocks (fundamental components). The non-fundamental components are generally evaluated in the literature as a residual from the fundamental component which is assumed to be normally distributed (Anderson et al. 2001). If the market is dominated by homogeneous rational expectations, the coefficient of the fundamental should not be significantly different from one, if the model is correctly specified.

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[4] One of the reasons for which we develop our analysis on price earning ratio is that this indicator allows to evaluate the impact of earnings on prices by knowing just the expected rate of growth of earnings and not the current absolute value of earnings.

[5] The HRE hypothesis implies that all investors agree i) on the observed values and on future predictions for the variables needed to calculate the fundamental value of the stocks and ii) on the model of the stock market value.

[6] The traditional DCF approach discounts dividends and not earnings. In recent times, though, many companies started to postpone dividend payments at later stages of their life cycle (Campbell, 2000). In parallel, several authors started using earnings more than dividends to predict stock returns (Campbell, 2000; Olhson, 1995; Ang-Liu, 1998; Vuolteenaho, 1999; Fama-French, 1998).

An empirical test of the discounted cash flow (DCF) model is provided by Kim and Koveos (1994) with a panel cross-country analysis. The authors find support for the negative effect of risk and for the positive effect of growth on price earnings. For this reason the P/E has been originally considered as an indicator of transitory earnings (Molodovsky, 1953), future earnings (Cragg-Malkiel, 1982; Rao-Litzenberger, 1971) or risk (Ball, 1978).

The hypothesis of HRE agents is more reliable if in the market there is a pervasive presence of institutional long term investors, such as pension funds, adopting a fundamentalist perspective. If, on the contrary, investors' information sets are highly heterogeneous and rational traders have limited patience, market prices deviate from the fundamentals and low P/E ratios may signal underevaluated stocks and portfolios of low P/E stocks should yield excess returns even after they are adjusted for risk (Basu, 1977; Jaffe, Keim and Westerfield, 1989).

However, even assuming highly heterogeneous information sets, the hypothesis that all market agents evaluate the price of the stock according to a discounted cash flow approach is still a useful benchmark which can be tested and rejected in favor of alternative hypotheses. This is what we do in the next section.

3. Analysis

3.1. Data description and estimation methods

We build our two samples by extracting from DATASTREAM 309 US stocks from the S&P500 index and 392 EU stocks from DJSTOXX index.[7]

The database provides information about the following variables: earning per share, price, dividend payout, 1-year ahead, 2-year ahead and long term I/B/E/S forecasted earnings growth rate, risk free rate, number of firm employees, number of I/B/E/S forecasts in the last three months and forecasts' standard deviation, firm depreciation/investment ratios. Data are collected monthly from January 1988 to March 2002, for a total of 172 monthly observations for any stock.[8]

The DCF approach that we consider here, following Kaplan and Roeback (1995), is based on I/B/E/S forecasts and therefore has the advantage of using current net earnings as the only accounting variable[9].

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[7] The US and EU samples are determined by the index constituents at the beginning of the sample period (January 1988) which are still in the index at the end of the sample period (March 2002). The list of constituents is provided in an appendix available upon request.

[8] This is the longest available time length for a comparative analysis on the Datastream database.

[9] Accounting and economic literature usually adopt at least three different approaches to calculate the fundamental value of a stock: i) the comparison of balance sheet multiples (EBITDA, EBIT) for firms in the same sector; ii) the residual income method; iii) the discounted cash flow method. The first approach is highly arbitrary as, if market agents have nonhomogeneous information sets or adopt different trading strategies, the benchmark used for comparison may be overvalued or undervalued. The second problem with this method is that industry classifications become always more tricky as far as firms diversify their activities and develop new products or services which cannot be easily classified into traditional taxonomies, (Kaplan-Roeback, 1995).
The problem with the second approach (residual income method), which is largely used in the literature (Lee-Myers- Swaminathan, 1999; Frankel-Lee, 1998), is that the formula for evaluating the fundamental value of a stock uses a balance sheet measure whose accuracy and capacity of incorporating changes in firm fundamental value is limited. A valuable example of this phenomenon may be given by descriptive evidence provided by Lee-Myers- Swaminathan (1999) who document the sharp uptrend in the price to book ratio which has risen three times between 1981 and 1996 for the Dow Jones Industrial Average. An interpretation for this result is that accounting methodologies lag behind in adjusting to changes in investors' market value assessments of firms whose share of intangible assets made by human and, more generally, immaterial capital is rising over time. This is the reason why, following Kaplan-Roeback (1995), we prefer to use the DCF approach.

According to this model, the fundamental price earning ratio[10] of the stock may be written as a weighted sum of the firm specific DCF and the overall market DCF value:

$$MV\ /X=\left[\sum_{t=0}^{\infty}\frac{(1+E[g_u])^t}{(1+r_{CAPM})^t}\right]\phi(\Omega)+\left[\sum_{t=0}^{\infty}\frac{(1+E[g_n])^t}{(1+r_n)^t}\right](1-\phi(\Omega)) \qquad (3.1)$$

where the first term and the second term represent respectively the forecast based on firm-specific and the forecast based on market wide information. $\phi(.)$, the weight given to the first forecast, is a function of a vector *(Ω)* of variables affecting the precision of the forecast itself. We considered that all values needed for calculating and discounting future cash flows are expected values and therefore we placed the expectation operator E[.].

Following Adriani, Bagella and Becchetti (2004a), *MV* in (3.1) is the firm market value, *X* is the current cash flow to the firm which we proxy with firm earnings[11], $E[g_u]$ is the expected yearly rate of growth of earnings[12] according to

[10] The computational advantage of the "DCF price-earning" is that it is extremely easy to calculate. In fact it does not require the knowledge of the absolute value of company earnings, but only that of five parameters (expected rate of growth of earnings for the high growth period, beta, risk free rate, risk premium and nominal rate of growth of the economy) only two of which are firm specific.

[11] In our choice we are aware of the dividend/earning controversy but we explain briefly why we consider our choice correct. Shiller (1981) points out that dividends (instead of cash flow) have to be used to evaluate correctly the fundamental, since dividends are what shareholders effectively cash. Even though non distributed dividends are reinvested with the DCF, the risk is to count them twice since their variation is incorporated in earning growth forecasts.

The puzzle, though, is that recent stock market values generate unreasonably low risk premia when the present value of the stocks is calculated by discounting future expected dividends (Claus and Thomas, 2001; Jagannathan et al., 2001) estimate negative implied risk premia for limited periods in the last two decades. Another argument in favor of the DCF is that the value of a stock is the net present value of cash flow in cases of a takeover which involves 100 percent of equity capital. Therefore, it is possible that in periods of stock market boom, with waves of mergers and acquisition and shareholders which rationally anticipate stock values for the bidder, fundamental values move toward DCF values.Moreover, it is possible to demonstrate, though that the issue of dividends versus cash flow has much lower relevance when we look at long time horizons and consider the available forecasts on earnings growth as proxies of both dividend and cash flow growth. In such case, the use of initial level of cash flow instead of dividends should cause a bias with second order effects on the fundamental price which is mainly determined by other variables (earning growth forecasts, interest rates, terminal rate of growth, etc.).

[12] Actually, when estimating the model we should use the expected rate of growth of cash flow to the firm instead of the expected rate of growth of earnings. Even though earnings are obviously different from cash flow to the firm, our measure is not biased under the assumption that the

the Consensus of stock analysts[13], $r_{CAPM}= Rf + \beta R_m$ is the discount rate adopted by equity investors or the expected return from an investment of comparable risk, R_f represents the domestic risk free rate (Tbill 3-month), R_m is the stock market premium, β is the exposure to systematic nondiversifiable risk.

In estimating (3.1) we must consider that agents know only some of its parameters. They in fact observe exposition to systematic nondiversifiable risk and some of the indicators contained in the vector of the Ω-variables affecting the precision of the firm specific forecast. Therefore, we follow Becchetti-Adriani (2004b) in assuming that they use the following approximation:

$$E / P = (E / P) * (1 + \theta(\Omega)) \quad \text{[14]} \tag{3.2}$$

If θ is small enough, we may approximate (3.2) as $E / P \approx E(E / P) * e^{\theta(\Omega)}$ and, by taking logs, we get:

$$\ln(E / P) \approx \ln(E(E / P)*) + \vartheta(\Omega) \quad \text{[15]}$$

where *E(E/P)** is the fundamental earning price ratio predicted by the DCF model.

To calculate *(E/P)**, following Claus and Thomas (2001), Adriani and Becchetti (2004b), Adriani-Bagella and Becchetti (2004a) we consider the following "two stage growth" approximation of (3.1):

$$MV / X = 1 + \sum_{t=1}^{5} \frac{(1 + g_U^E)^t}{(1 + r_{CAPM})^t} + \frac{(1 + g_U^E)^6}{(r_{CAPM(TV)} - gn)(1 + r_{CAPM})^6} \tag{3.3}$$

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expected rate of growth of earnings is not different from the expected rate of growth of cash flow to the firm.

[13] We proxy these expected rates of growth with the 1-year ahead, 2-ahead and long term IBES expected rate of growth (from the third to the sixth year). The use of the median estimate alternatively to the mean estimate does not change significantly our results. Robustness to mean/median forecasts is consistent with findings from Frankel and Lee (1998).

[14] The use of the E/P ratio instead of the P/E not changes the results but has the advantage of eliminating the problem of discontinuity around zero earnings.

[15] The distribution of E/P variable is extremely skewed and symmetric if we do not take logs. Another reason for using E/P in logs is that this specification allows to interpret the significance

The third addend of the formula is the terminal value of the stock. We arbitrarily fix at the sixth year the shift from the high growth period to the stable growth period. Sensitivity analysis on this threshold shows nonetheless that this choice is not so crucial for the determination of the value of the stock.[16] We must in fact consider that the positive impact on value of an additional year of high growth must be traded off with a heavier discount of the terminal value which represents a significant part of the final value. In the terminal value it is assumed that the stock cannot grow more and cannot be riskier than the rest of the economy. Therefore *gn* is the nominal average rate of growth of the economy and $r_{CAPM(TV)} = R_f + E[R_m]$.

Since significant divergences among analysts may occur on the rate of growth in the terminal period and, above all, on the risk premium (depending on the choice between historical and implied risk premium and on the different periods selected for estimating the historical risk premium), we start by estimating fundamental earning price ratio on different combinations of terminal rate of growth and risk premium values under the constraint of a discount rate higher than the growth rate of the stock in the terminal value.

3.2. Definition of the three hypotheses and econometric specification

By using the formulas described in the previous section to calculate the fundamental we formulate the following three propositions

of beta as a measure of the revision of analysts' expectations, when this variable is included as an additional regressor (see discussion in footnote 18).

[16] Information on this sensitivity analysis is available from the authors upon request.

Hypothesis 1: (Strong relevance of the DCF model). In a market populated by "fundamentalists" with Homogeneous Rational Expectations (HRE) there is an unbiased predictor of the E/P ratio. This variable is equal to the "fundamental" (discounted cash flow) E/P plus unpredictable noise due to measurement errors and other factors not included in the fundamental E/P[17]

Becchetti-Adriani (2004b) test this hypothesis on a sample of high-tech stocks. This hypothesis may be tested here as:

$$\ln(E/P)_{jt} = a_0 + a_1 \ln\left(E\left[E/P^{*}|\Omega\right]\right)_{jt} + \varepsilon_t \qquad (3.4)$$

H_0: $a_0=0$, $a_1=1$

where $E\left[E/P^{*}|\Omega\right]$ is the earning price ratio predicted by the DCF model and calculated as in (3.3). Under the null hypothesis $E\left[E/P^{*}|\Omega\right]$ is an unbiased predictor of E/P, the cross-sectional difference between observed and "theoretical" earning price is a zero mean random disturbance, the intercept is not significantly different from zero and Ω includes all information available to investors including parameters but not the E/P ratio.

The likely rejection of this hypothesis leads us to test the following alternative in which, together with the DCF fundamental, other factors proxying for accuracy of fundamentals affect observed earning price ratios.

Hypothesis 2: (DCF model adjusted for the asymmetric information). Additional variables mitigate the role of the traditional DCF evaluation and help to predict the variation of the observed E/P not captured by the DCF fundamental.

[17] Note that the existence of fundamentalists only is not sufficient for hypothesis 1 to hold. It is also necessary that there be no limits to arbitrage.

To test the significance of these additional variables Becchetti-Adriani (2004b) consider the following specification:

$$\ln(E/P)_{jt} = a_0 + a_1 \ln(E/P^*)_{jt} + \sum_{j=1}^{n} \gamma_j X_{jt} + \varepsilon_t \qquad (3.5)$$

and test H_0: $\gamma_j \neq 0$

More explicitly, we rewrite in our case (3.5) as:

$$\begin{aligned} \ln(E/P)_{jt} &= \alpha_0 + \alpha_1 \ln(E/P)^*_{jt} + \alpha_2 NUMIMP_{jt} + \alpha_3 \beta_{jt} + \alpha_4 DPO_{jt} + \alpha_5 F1NE_{jt} + \\ &+ \alpha_6 F1SD_{jt} + \alpha_7 BULL_{jt} + \alpha_8 BEAR_{jt} + \alpha_9 D/I_{jt} + \varepsilon_t \end{aligned} \qquad (3.6)$$

where *E/P* is the earning per share divided for the closing price of the j-th equity, *(E/P)** is the earning price ratio predicted by the DCF model and calculated as in (3.3), *NUMIMP* is the number of firm employees (proxy of the firm size), β is the slope of the return of the stock on the return of the market index (the S&P 500 index for the US and the domestic market index for each EU firm) estimated over the last two years on weekly data[18], *DPO* is the dividend payout, F1N*E* is a measure of the number of I/B/E/S forecasts in the last three months, *F1SD* is

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[18] Since beta is already in the E/P fundamental variable, the significance of beta in our estimate would suggest the presence of a forecasting error in the expected E/P, net of its negative effect in the DCF part of the stock value. Becchetti-Adriani (2003b), following Beaver and Morse (1978), show that, when the standard CAPM holds:

$$r_{it} = r_f + \beta_i (r_{mt} - r_f) + u_{it} \qquad (3.7)$$

and when agents make their forecasts on the grounds of the information available at time t-1, the forecast error is:

$$r_{it} - {}_{t-1}r^e_{it} = \beta_i (r_{mt} - {}_{t-1}r^e_{mt}) + u_{it} \qquad (3.8)$$

where ${}_{t-1}r^e_{it} = E[r_{it} \mid I_{t-1}]$. This, in turns, implies:

$$p_{it} = {}_{t-1}p^e_{it} + \beta_i (p_{mt} - {}_{t-1}p^e_{mt}) + u_{it} \qquad (3.9)$$

where $p_{it} = r_{it} + p_{it-1}$ is the log-price and we used the fact that p_{it-1} is known at time t-1. Let then x_i and x_m be respectively the (assumed constant) log-earnings for the i-th firm and for the market. Rewrite then (9) as:

$$x_i - p_{it} = x_i - {}_{t-1}p^e_{it} - \beta_i (p_{mt} - x_m + x_m - {}_{t-1}p^e_{mt}) + u_{it} \qquad (3.9')$$

then:

$$\ln \frac{X_i}{P_{it}} = \ln\left(\frac{X_i}{P_{it}}\right)^* + \beta_i \left(\ln \frac{X_m}{P_{mt}} - \ln\left[\frac{X_m}{P_{mt}}\right]^* \right) + u_{it} \qquad (3.10)$$

where $P_t \equiv \exp p_t$ and $X_t \equiv \exp x_t$.

the dispersion of analysts' forecasts proxied by the standard deviation of 1-year ahead I/B/E/S forecasts, D/I (the depreciation-investment ratio) is a variable proxing for the manipulation of earnings and, finally, BULL (BEAR) is a dummy variable proxying for market reaction to chartist signals of bull (bear) markets. The dummy assumes the value of one if the Hodrick-Prescott (1980)[19] trend of the stock is greater (smaller) than the 80th (20^{th}) percentile of the distribution and zero otherwise.

Based on our theoretical assumptions we justify the introduction of additional variables in our specification as follows. i) *NUMIMP* is a proxy for both firm market share and liquidity, the latter being a relevant control factor in the determination of stock value. ii) β tests for the presence of a forecasting error in the expected earning to price variable net of its negative effect in the DCF part of the stock value already incorporated in *(E/P)**. Moreover, we may also suppose that an increasing share of *noise traders* (*chartist*s) looks for large fluctuations in stock value over short time length in order to make profitable their short term trades. A reduced risk aversion may therefore justify the unexpected sign of the beta.[20] iii) with regard to the *DPO* variable, the typical dividend discounted fundamental model predicts the variable to be negatively related to the earning price ratio (Cho, 1994; Ohlson, 1995). Under asymmetric information, dividend payments are generally assumed to reduce agency costs between stockholders and managers (Easterbook 1984). In this framework dividends should proxy for

[19] We construct a quasi-linear trend of prices using a traditional Hodrick-Prescott (1980) filter, to take in account financial cycles and removing low-frequency movements. As it is well known, the HP filter is a two-sided linear filter that controls the smoothness of the series by minimizing the variance of the variable around the penalty parameter.

[20] An example of this may be given by the positive value of stocks which are near to bankrupt. An interpretation of why these stocks often maintain prices significantly above zero is because of their high volatility and of their gambling option value which attracts risk lovers trying to profit from what is called in the financial jargon a "dead cat bounce".

the permanent component of earnings and, therefore, for the capacity of management to maintain competitiveness (Cho, 1994). [21] iv) F1NE, the number of forecasts, is expected to reduce the problem of asymmetric information in the observation of firm fundamental as it is regarded as non-linearity and positively related to the speed of adjustment of prices to new information (Brennan-Jegadeesh-Swaminathan, 1993) and as positively related to the accuracy of earnings predictions (Firth-Gift,1999). Thus, an increase in F1NE should generate a positive effect on the perceived quality of information and therefore an increase in the P/E ratio. v) F1SD is a direct measure of nonhomogeneity in analysts' predictions, which may be interpreted as a sign of additional noise or reduced information on the firm. Thus, this variable is expected to be negatively and significantly related to the P/E ratio.[22] vi) D/I is a proxy for "creative accounting" or earning manipulation since depreciation rules can significantly affect the value of the multiple (Kim and Koveos 1994; Hayn 1995). Several authors in the literature argue that different rules for depreciation, M&A and R&D accounting (expenditure or investment) may significantly alter earnings comparisons and explain a good share of the variability of the P/E. Craig, Johnson and Joy (1987) find that firms with conservative accounting methods (techniques of accelerated depreciation or LIFO methodology for supply valuation) have higher P/Es. French and Poterba (1991) consider also the role of depreciation rules in "creative accounting", underlining that in the US there is a different set of accounting rules for tax purposes and financial reporting, allowing

[21] A firm which increases too much the dividend payout ratio may incur into two types of negative effects: i) it reduces funds available for reinvestment and therefore future rates of growth; ii) it may be forced to give a negative signal in the near future when that DPO proves not to be sustainable and needs to be reduced.

to choose between accelerated and constant depreciation rules, a choice which may significantly affect the ratio between prices and reported earnings.[23] Hayn (1995) argues that firms with a negative level of current earnings close to zero are more likely to manipulate earnings. Her results, indeed, reveal the presence in the E/P distribution of a discontinuity point around to zero, that is, an unusual concentration of observations slightly above such threshold and much less observations with small losses. vii) The expected positive effect of the variable BULL and the negative effect of the variable BEAR should shed lights on the chartist "momentum", that pushes investors to buy stocks when the price goes up and to sell them when the price goes down (although it is above or below its fundamental value) (Beja and Goldman 1980; Sethi 1996).[24]

Another crucial issue when analyzing deviations between observed and fundamental E/P ratios is whether they reflect delays in adjusting to publicly available information or the effects of insider information that will become public later on. To verify whether the second conjecture is true we formulate the following hypothesis

Hypothesis 3: (insider trading effects) Short run future adjustment of fundamentals to important news, such as those on earnings growth forecasts, significantly affects the current distance of the stock from its fundamental value.

To test this hypothesis we estimate the following equation:

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[22] Consider that significant links may exist between the number of estimates and their variance. Bhushan (1989) finds a positive relationship arguing that higher variability of forecasts increases the returns from private information and with it the demand of analysts' services

[23]For this reason, many analysts base their estimates on net sales to which they apply industry specific net sales/earning ratios to estimate "nonmanipulated" earnings.

[24] De Long et al. (1990) argue that the chartists can obtain more profits than the fundamentalists since they accept a higher level of risk. For similar approaches explaining financial asset prices on the basis of the relative weight of fundamentalists and chartists see Frankel-Froot (1990), Sethi (1996) and Franke-Sethi (1998).

$$\varepsilon_t = b_0 + \sum_{i=1}^{n} b_i \Delta X_{i,t+1-t} + \eta_t \tag{3.11}$$

H_0: $b_i < 0$

where ε_t is the distance of the observed E/P from the fundamental value, according to equation (3.6) and $\Delta X_{i,t+1-t}$ is the one period ahead change in the i-th X factor affecting the fundamental.

4. The estimation approach

To estimate the three hypotheses, we propose a mean group estimator (henceforth MGE) approach (Pesaran-Smith, 1999) which tests the significance of time series averages of cross-sectional regression parameters using confidence intervals based on their time series standard deviations (for applications in finance see also Fama-French 2000). A benefit of this approach is that time series standard errors of coefficients take into account the error due to the correlation of residuals across firms. This approach is superior to panel fixed effect estimates when the assumptions of an invidual firm effect constant across time or of common slopes for different firms are too restrictive as it is likely to be the case for our kind of financial data (Pesaran-Smith, 1999). On the other hand, the limit of MGE is that, if slopes are autocorrelated, the time series average slope is in general non normal and its sample variance is biased. For this reason we also present evidence of cross-sectional estimates in which our hypotheses are tested year by year. We carefully select variables in our specifications and control for multicollinearity, using the variance inflation factor (Marquardt 1970). Moreover, to check the robustness of the significance of different regressors to changes in our specification we progressively introduce them in the estimates.

5. Results

5.1 Descriptive analysis

Tables I.A (US) and I.B (EU) present descriptive statistics for the main sample variables showing interesting differences between the two samples. US stocks have a price earning ratio (P/Eobs) which is smaller in mean (respectively 25.97 against 38.67) than that of EU stocks. The difference in mean is highly significant if we look at non overlapping 95 percent confidence intervals.

The expected IBES 1-year ahead rate of earnings growth (g1) is higher in EU than in the US but only because of European outliers with abnormally high expected rates of growth. Indeed, median values clearly show that 1-year ahead rate of growth forecasts for US stocks are higher (7 percent against 3 percent). The difference in means emerges when we truncate bottom and top values of the series respectively to the 5th and to the 95th percentile. After truncation US stocks have a 9 percent rate of growth against a 6 percent of EU stocks. The 2-year ahead (g2) and the long term (glt) expected rate of earnings growth seem higher in EU than in the US but, again, US median is slightly highest one.

Average betas show that US stocks are significantly more sensitive to systematic nondiversifiable risk than EU stocks (.89 against .63). With this respect our evidence shows that US companies seem to have a riskier product mix and, consistently with it, a higher expected rates of earnings growth.

The number of forecasts per stock (F1NE) is slightly but significantly higher in the US, while their variability (F1SD) is much higher in the EU.

The average number of firm employees is higher in the EU sample, both in mean and median values, while the dividend payout is far smaller in the US than in EU also because more than 15 percent of US firms do not distribute dividends.

The depreciation-investment ratio is much higher in mean in the US than in the EU but this difference is affected by outliers. The difference in median between the two groups of stocks is much smaller.

5.2. Econometric tests of the three hypotheses

Tables II.A (US) and II.B (EU) illustrate results of the test on hypothesis 1. The model fits better the US sample, where the average estimated coefficient of the fundamental (E/P*) is between .60 and .61 reaching the highest value with a risk premium between 7 and 9 percent[25] and with a terminal rate of growth at 2.5 percent (table II.A). Since the intercept is significantly different from zero in all the US cross-sectional estimates, the joint hypothesis ($a_0=0,\ a_1=1$) is always rejected confirming our alternative (hypothesis 2) according to which other factors matter and affect the quality of the signal of the fundamental in a framework of asymmetric information.

Results from the EU sample are quite different (table II.B). First of all, we cannot reject the null that the coefficient of the fundamental is equal to one and the coefficient of the intercept is equal to zero (hypothesis 1) for a large range of values of the two calibration parameters (risk premium and terminal rate of growth). In addition, the coefficient of the fundamental is on average smaller than in the US sample (between .49 and .51) and with much higher standard deviation (namely, in mean group estimators, high variability of the coefficient itself in different cross-sectional estimates), reaching the highest value when (E/P)* is calculated with a 7 percent risk premium and a 2.5 percent terminal rate of growth.

A comparison between the US and EU findings therefore seems to show that the fundamental is a benchmark in the determination of the observed E/P more in the US than in EU markets. We will test more specifically this conclusion in the rest of the paper.

To test hyp. 2 we introduce additional variables in the model selecting for each subsample the combination of risk premium and terminal rate of growth yielding the highest (E/P)* coefficient in the calibration tables (tables III.A, III.B).

First of all, it is interesting to note that, if we look in these tables at the cross-sectional significance of the coefficient of the fundamental and of the intercept, we find results which are consistent with those presented in the calibration estimates (tables II.A, II.B). The coefficient of the US fundamental is again around .6 and is significant in all cross-sectional estimates in which we introduce additional regressors. The intercept is significant more than 80 percent of times. For European stocks the coefficient of the fundamental is around .5 and not significantly different from zero in 30 percent of estimates, while the intercept is generally significant more than 60 percent of times.

When we evaluate the significance of additional regressors in cross-sectional estimates, we find that some of them are significant, even though not in all time spells.

The negative coefficient of BETA in both the US and EU regressions, with the significance of the variable for the US case being higher (more than half of times against 30 percent of times in EU markets), reflects a negative surprise in the market log E/P (see equation 3.10, footnote 18) and supports the hypothesis that, in the considered sample period, earning price ratios were affected by

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[25] Damodaran (1996), for example estimates that the risk premium for the period 1926-99 is

upward revisions of the expected market E/P and, therefore, by increasing optimism over market perspectives. Hence, omitting beta in the regression yields biased estimates unless the market earnings-price ratio is correctly forecasted. [26] The influence of the DPO, in both the US and EU samples is consistent with the dividend discounted fundamental model (the variable is negatively related to the E/P) and its significance is relatively higher in the US sample. Looking at other comparative differences, the number of estimates (F1NE) has negative effects on the dependent variable only in the US sample, while F1SD, as expected, has positive and significant effects on the E/P ratio in both samples but relatively more in the US sample. The D/I variable is negative, consistently with the hypothesis that firms with conservative accounting methods (techniques of accelerated depreciation) have higher P/Es (Craig et.al., 1987), but the variable is seldom significant in both samples. The negative effect of the variable BULL and the positive effect of the variable BEAR in both samples (even if the significance of this variables is very low) shows that traders adopting trend-following strategies exist, even though they have a mild overall effect on our sample period.

Results from tables IIIA and IIIB commented above appear robust to changes in specification as far as new regressors are introduced. Moreover, the VIF test shows that correlations across regressors are quite limited and do not give rise to multicollinearity problems.

With regard to hypothesis 2, we also aim to verify whether the fundamental DCF has added explanatory power with respect to simpler models in which the dependent variable is directly regressed on short and long run forecasted earning growth. Econometric results reported in tables IV.A (US) and IV.B (EU) show that

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9.41% or 8.14% if we take respectively arithmetic or geometric averages of the stocks-Tbill spread.

both 1-year ahead IBES forecasts (g1) and long term IBES forecasts (glt) are significant in the expected direction, consistently with previous literature. [27]

In the weak version of the DCF model, the goodness of fit is far reduced with respect to the strong version tested in tables IIA-IIB including our measure of DCF fundamental. This is true especially in the US case and when we consider only 1-year ahead forecasts, where it looses at least 11 percent points. The superiority of the strong version against the weak version of the DCF model is successfully tested one-by-one Davidson-MacKinnon (1981, 1993) J-test for non-nested model[28]. In the 172 monthly cross-sectional estimates of the sample period, the fitted dependent variable from the strong specification has more significant t-values when considered as an additional regressor in the weak version (tables V.A, V.B, V.C, V.D) than the opposite case, when the estimated dependent variable from the weak version is considered as additional regressor in the strong version. This result confirms that the DCF fundamental brings additional valuable information for predicting E/P with respect to simple earning growth forecasts.

To test whether the two observed differences between the US and EU stock markets are significant when stocks of the two samples are jointly considered we

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[26] Those two effects cannot be separated when we estimate the unrestricted version of the model.

[27] Pari, Carvell and Sullivan (1989) use in their analysis estimate of 1200 analysts and a model of two stage-growth (the first is the geometric mean of the first two year growth and the second is the mean estimate of long run growth). They propose the following relation: $P/E = \gamma_0 + \gamma_1 g_1 + \gamma_2 g_2 + \gamma_3 \beta$. More specifically, growth variables explain 50% of the variation of the multiple. Beaver and Morse (1978) verify the importance of earnings growth in the determination of the value of the P/E. Analysing the correlation between the median P/E and g, they find that only the rate of growth of the first and second year influence on the multiple significantly and that thus the stock prices are determined from short- earnings forecasts, while for the following years the correlation between the two variables disappears.

[28] According to the Davidson-MacKinnon (1981, 1993) approach, given two non-nested specifications A1 and A2, specification A1 is the correct one if fitted values of the dependent variable from A2 do not have explanatory power when estimating A1, while fitted values of the dependent variable from A1 have explanatory power when estimating A2. The test is not conclusive if fitted values from A1 and A2 are not significant when added as regressors in the alternative specification.

reestimate the model presented in tables III.A and III.B on the pooled (US and EU) sample. In this regression we calculate the fundamental (*E/P**) according to the best US calibration values, add a slope dummy variable, *EUF,* which is the product of E/P* and a dummy taking value of one for EU stocks and zero otherwise. We also add six other variables which are the product of a US dummy for DPO, F1NE, F1SD, D/I, BULL and BEAR (see legend of table VI).

From the econometric regression we obtain a negative (expected) coefficient of the dummy measuring the difference in the impact of the European fundamental on the observed E/P. This result evidences that the EU effect on the total observed E/P is comparatively lower confirming that the hypothesis on the differences in the role of fundamentals between the two markets holds (table VI).

Results on the impact of the dummy variables confirm that most of coefficient differences in the two separate estimates are significant. First, investors in US stocks give more weight to information from dividend payout (higher positive effect on the earning price ratio). Second, the dispersion of business forecasts has more negative effects in US financial markets. This implies that, in that case, investors penalize more stocks on which analysts' opinions are more heterogeneous. The hypothesis of differences in the impact of the number of forecasts and on the reaction to bull and bear signals are rejected .

Results on hypothesis 3 are presented in tables VII.A (US) and VII.B (EU). The specification adopted for testing this hypothesis is the following:

$$\varepsilon_t = b_0 + \sum_{i=1}^{n} b_i \Delta g_{1i,t+1-t} + \eta_t \qquad (5.1)$$

where ε_t is the distance of the observed E/P from the fundamental value, according to equation (3.6) and $\Delta g1_{i,t+1-t}$ is the one period change in earnings growth forecasts affecting the fundamen A negative and significant, b_i coefficient implies that delays in the adjustment of publicly available information to news contribute to explain the distance between E/P and E/P*. This result is obtained in the EU case even though it is significant for limited time spells (around 30 percent of times). In the US sample we have much lower significance and an opposite sign. This result, when related to the evidence on the relatively higher impact of the fundamental in the US sample, appears consistent with the *Market Integrity Hypothesis*. It seems that in the US sample more transparent information and absence of delays in the adjustment to publicly available information increase reliance on fundamentals obtained from publicly available information.

6. Conclusions

The analysis on the adequacy of the traditional discounted cash flow model (DCF) explaining movements in stock prices, tested on two samples of US and EU stocks, shows that the fundamental earning price ratio (E/P) - evaluated with a "two-stage growth" DCF model - plays a crucial role to explain the cross-section variability of the observed E/P, when the model is calibrated on the risk premium and on the terminal rate of growth.

The fundamental E/P is also shown to have superior explanatory power with respect to simpler measures of expected earnings growth (1-year ahead and long term expected rate of earnings growth) usually adopted in the literature and this for both samples.

In spite of the strong significance of the DCF variable, the relevance of the "non-fundamental components" (proxing for the firm actual and future capacity of being profitable in a framework of asymmetric information) implies that something is missing in the traditional DCF evaluation. For example the negative and significant coefficient of beta in both the US and EU regressions, supports the hypothesis that, in the considered sample period, E/Ps were affected by upward revisions of the expected market E/P and therefore by increasing optimism over market perspectives.

However, for US stocks (supposedly because there is more diffusion and transparency of information and more pervasive presence of pension funds, that may be expected to increase the share of long term investors adopting a fundamentalist perspective) the relationship between DCF fundamental and observed E/P is stronger than in the EU case.

Among significant differences between the US and European sample we find that the variance of forecasts has, as expected, positive and significant effects on the E/P ratio in both samples but relatively more in the US one, while only for the EU case ex post adjustment of publicly available information to news contributes to explain the current distance between E/P and E/P*.

If we associate this last finding with that on the relatively different impact of fundamental values we find two pieces of evidence consistent with the *Market Integrity Hypothesis*: reduced "insider trading" effects are generally related to higher reliance on fundamentals extracted from publicly available information.

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Table I.A Descriptive statistics on the most relevant financial variables for US stocks

						percentiles							
	Mean	*St.dev.*	*95% Conf. Interval*		*Median*	1%	5%	10%	25%	75%	90%	95%	99%
E/Pobs	0.0658	0.0002	0.0654	0.0662	0.0593	0.0062	0.0203	0.0287	0.0427	0.0798	0.1056	0.1259	0.1916
P/Eobs	25.9791	0.4871	25.0243	26.9339	16.8750	5.2186	7.9403	9.4662	12.5237	23.4375	34.8684	49.2585	162.500
E/Pfund	0.0953	0.0003	0.0947	0.0959	0.0858	0.0092	0.0297	0.0462	0.0670	0.1077	0.1455	0.1834	0.3503
P/Efund	17.6293	0.3884	16.8681	18.3905	11.6561	2.8057	5.4383	6.8705	9.2816	14.9103	21.6343	33.5209	106.407
G1	0.5581	0.0347	0.4901	0.6261	0.0698	-0.8671	-0.5217	-0.3907	-0.0265	0.2222	0.7806	1.9615	8.6000
G2	0.1800	0.0080	0.1643	0.1958	0.1370	-1.5000	0.0000	0.0377	0.0990	0.1930	0.3421	0.5714	1.8824
GLT	0.1177	0.0002	0.1173	0.1181	0.1169	0.0200	0.0400	0.0700	0.0950	0.1400	0.1700	0.2000	0.2500
G1trunc	0.0926	0.0013	0.0901	0.0951	0.0664	-0.4632	-0.3680	-0.2030	-0.0102	0.1714	0.4125	0.6071	0.9231
G2trunc	0.1488	0.0004	0.1480	0.1496	0.1353	-0.0256	0.0255	0.0526	0.1004	0.1800	0.2583	0.3333	0.4600
GLTtrunc	0.1217	0.0002	0.1213	0.1220	0.1200	0.0500	0.0700	0.0800	0.1000	0.1450	0.1700	0.2000	0.2350
BETA	0.8950	0.0018	0.8916	0.8985	0.8925	0.0084	0.2391	0.3960	0.6226	1.1395	1.3955	1.5865	1.9720
F1NE	19.0228	0.0376	18.9492	19.0965	18.0000	3.0000	6.0000	8.0000	12.0000	25.0000	31.0000	34.0000	41.0000
F1SD	0.0902	0.0008	0.0887	0.0917	0.0400	0.0100	0.0100	0.0100	0.0200	0.0900	0.2000	0.3200	0.8100
NUMIMP	42.0952	0.3894	41.3321	42.8583	19.6190	1.0700	2.6240	4.2730	8.8960	45.300	97.500	144.000	366.600
DPO	0.6987	0.0159	0.6676	0.7299	0.3706	0.0000	0.0000	0.0065	0.1846	0.5829	0.9545	1.6316	6.6207
DI	757.346	76.1283	608.130	906.562	1.0313	0.0052	0.0849	0.1928	0.4371	2.2080	5.0681	10.1219	12575.00

Variables legend:

E/Pobs: earning per share divided for the stock price; P/Eobs: stock price divided for the earning per share; E/Pfund: the earning price ratio predicted by the DCF model (see equation 3.3); P/Efund: price earning ratio predicted by the DCF model; G1: average 1-year ahead IBES forecast of the rate of growth of earnings per share; G1trunc: average 1-year ahead IBES forecast of the rate of growth of earnings per share with lower and upper extreme values truncated respectively at the 5th and 95th percentile value of the variable distribution; G2: average 2-year ahead IBES forecast of the rate of growth of earnings per share; G2trunc: average 2-year ahead IBES forecast of the rate of growth of earnings per share with lower and upper extreme values truncated respectively at the 5th and 95th percentile value of the variable distribution; GLT: average long term IBES forecast of the rate of growth of earnings per share; GLTtrunc: average long term IBES forecast of the rate of growth of earnings per share with lower and upper extreme values truncated respectively at the 5th and 95th percentile value of the variable distribution; BETA: slope of the return of the stock on the return of the market index estimated over the last two year on weekly data; F1NE: number of IBES forecasts in the last three months; F1SD: standard deviation of 1-year ahead IBES forecasts; NUMIMP: number of firm employees; DPO: dividend payout; D/I: depreciation-investment ratio.

Table I.B Descriptive statistics on the most relevant financial variables for EU stocks

	Mean	St.dev.	95% Conf. Interval		Median	Percentiles							
						1%	5%	10%	25%	75%	90%	95%	99%
E/Pobs	0.1255	0.0024	0.1208	0.1301	0.0594	0.0000	0.0034	0.0140	0.0382	0.0847	0.1305	0.2000	1.8240
P/Eobs	38.6740	0.6632	37.3741	39.9739	16.4211	0.2603	5.1727	7.7835	11.7006	24.2345	44.9923	91.9426	515.000
E/Pfund	0.0723	0.0010	0.0703	0.0743	0.0630	0.0104	0.0292	0.0361	0.0474	0.0833	0.1095	0.1256	0.2519
P/Efund	26.8070	1.2697	24.3182	29.2957	15.8381	3.4997	7.9068	9.0962	11.9707	21.0384	27.5541	33.7731	75.7460
G1	0.6962	0.0580	0.5826	0.8099	0.0310	-1.2143	-0.5055	-0.3152	-0.1216	0.1896	0.5717	1.0914	11.9150
G2	0.5626	0.2026	0.1656	0.9597	0.1206	-1.5556	-0.1132	-0.0169	0.0659	0.1890	0.3333	0.5591	3.2339
GLT	0.1269	0.0008	0.1254	0.1284	0.1100	-0.0100	0.0400	0.0540	0.0800	0.1500	0.2000	0.2500	0.4330
G1trunc	0.0612	0.0013	0.0587	0.0638	0.0313	-0.4516	-0.3274	-0.2419	-0.1008	0.1667	0.3917	0.6154	0.9789
G2trunc	0.1339	0.0005	0.1329	0.1349	0.1205	-0.0844	-0.0222	0.0104	0.0732	0.1792	0.2660	0.3404	0.5000
GLTtrunc	0.1191	0.0003	0.1186	0.1196	0.1100	0.0450	0.0520	0.0650	0.0850	0.1500	0.1800	0.2010	0.2500
BETA	0.6320	0.0016	0.6289	0.6350	0.6325	-0.0598	0.0898	0.1700	0.3758	0.8669	1.0881	1.2154	1.4368
F1NE	18.2532	0.0415	18.1720	18.3345	18.0000	1.0000	4.0000	6.0000	12.0000	24.0000	32.0000	36.0000	41.0000
F1SD	3.4143	0.1597	3.1014	3.7273	0.3100	0.0100	0.0100	0.0200	0.0700	1.0400	2.4500	4.0100	13.0100
NUMIMP	49.6833	0.3202	49.0557	50.3109	27.1870	0.3510	1.4750	3.6830	10.3430	63.657	122.025	191.830	307.864
DPO	1.6630	0.1224	1.4231	1.9030	0.4539	0.0313	0.1149	0.1817	0.3077	0.6497	1.0340	1.7054	20.2020
DI	54.6517	5.7988	43.2859	66.0175	0.9185	0.0002	0.0037	0.0110	0.2067	2.8081	10.8333	27.7853	390.400

Variables legend:

E/Pobs: earning per share divided for the stock price; P/Eobs: stock price divided for the earning per share; E/Pfund: the earning price ratio predicted by the DCF model (see equation 3.3); P/Efund: price earning ratio predicted by the DCF model; G1: average 1-year ahead IBES forecast of the rate of growth of earnings per share; G1trunc: average 1-year ahead IBES forecast of the rate of growth of earnings per share with lower and upper extreme values truncated respectively at the 5th and 95th percentile value of the variable distribution; G2: average 2-year ahead IBES forecast of the rate of growth of earnings per share; G2trunc: average 2-year ahead IBES forecast of the rate of growth of earnings per share with lower and upper extreme values truncated respectively at the 5th and 95th percentile value of the variable distribution; GLT: average long term IBES forecast of the rate of growth of earnings per share; GLTtrunc: average long term IBES forecast of the rate of growth of earnings per share with lower and upper extreme values truncated respectively at the 5th and 95th percentile value of the variable distribution; BETA: slope of the return of the stock on the return of the market index estimated over the last two year on weekly data; F1NE: number of IBES forecasts in the last three months; F1SD: standard deviation of 1-year ahead IBES forecasts; NUMIMP: number of firm employees; DPO: dividend payout; D/I: depreciation-investment ratio.

Table II.A The effect of theoretical on observed price earning under calibration of the risk premia and the terminal rate of growth – US sample

Term. rate of growth		Risk Premium								
		0.055	***0.06***	***0.065***	***0.07***	***0.075***	***0.08***	***0.085***	***0.09***	***0.095***
0.025	**E/P***	0.6116	0.6126	0.6134	0.6140	0.6145	0.6148	0.6150	0.6150	0.6150
	s.e.	0.0465	0.0467	0.0470	0.0472	0.0474	0.0476	0.0478	0.0480	0.0482
	cross-sect.sign	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	constant	-1.0334	-1.0679	-1.1008	-1.1323	-1.1624	-1.1914	-1.2192	-1.2460	-1.2719
	s.e.	0.1437	0.1416	0.1396	0.1378	0.1360	0.1344	0.1328	0.1313	0.1299
	cross-sect.sign	*98.8*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Average R^2	0.389	0.388	0.387	0.385	0.384	0.382	0.381	0.379	0.377
	Joint hyp.	*1.74*	*2.91*	*1.16*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
0.03	**E/P***	0.6095	0.6106	0.6115	0.6122	0.6127	0.6131	0.6133	0.6134	0.6134
	s.e.	0.0464	0.0466	0.0468	0.0471	0.0473	0.0475	0.0477	0.0479	0.0481
	cross-sect.sign	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Constant	-1.0117	-1.0482	-1.0828	-1.1158	-1.1474	-1.1776	-1.2065	-1.2343	-1.2611
	s.e.	0.1454	0.1431	0.1410	0.1391	0.1372	0.1355	0.1338	0.1323	0.1308
	cross-sect.sign	*98.3*	*99.4*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Average R^2	0.389	0.388	0.387	0.385	0.384	0.382	0.380	0.379	0.377
	Joint hyp.	*0.8*	*0.74*	*2.91*	*1.16*	*0.58*	*0.00*	*0.00*	*0.00*	*0.00*
0.035	**E/P***	0.6073	0.6086	0.6095	0.6103	0.6109	0.6113	0.6116	0.6117	0.6117
	s.e.	0.0462	0.0465	0.0467	0.0469	0.0472	0.0474	0.0476	0.0478	0.0480
	cross-sect.sign	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Constant	-0.9879	-1.0266	-1.0632	-1.0980	-1.1311	-1.1627	-1.1929	-1.2218	-1.2496
	s.e.	0.1472	0.1448	0.1426	0.1404	0.1385	0.1366	0.1349	0.1333	0.1317
	cross-sect.sign	*97.7*	*98.8*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Average R^2	0.389	0.388	0.386	0.385	0.383	0.382	0.380	0.378	0.377
	Joint hyp.	*0.00*	*1.16*	*1.74*	*2.33*	*0.58*	*0.00*	*0.00*	*0.00*	*0.00*
0.04	**E/P***	0.6049	0.6064	0.6074	0.6083	0.6089	0.6094	0.6097	0.6099	0.6100
	s.e.	0.0461	0.0463	0.0466	0.0468	0.0470	0.0473	0.0475	0.0477	0.0479
	cross-sect.sign	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Constant	-0.9622	-1.0030	-1.0419	-1.0787	-1.1135	-1.1467	-1.1783	-1.2084	-1.2373
	s.e.	0.1493	0.1467	0.1442	0.1420	0.1399	0.1379	0.1361	0.1343	0.1327
	cross-sect.sign	*97.1*	*98.3*	*98.8*	*100*	*100*	*100*	*100*	*100*	*100*
	Average R^2	0.388	0.387	0.386	0.385	0.383	0.382	0.380	0.378	0.376
	Joint hyp.	*0.00*	*0.00*	*1.16*	*1.74*	*1.16*	*0.58*	*0.00*	*0.00*	*0.00*
0.045	**E/P***	0.6041	0.6039	0.6052	0.6062	0.6069	0.6074	0.6078	0.6080	0.6081
	s.e.	0.0460	0.0462	0.0464	0.0467	0.0469	0.0471	0.0473	0.0476	0.0478
	cross-sect.sign	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	Constant	-0.9253	-0.9774	-1.0186	-1.0576	-1.0944	-1.1293	-1.1625	-1.1940	-1.2241
	s.e.	0.1516	0.1487	0.1461	0.1436	0.1414	0.1393	0.1373	0.1355	0.1338
	cross-sect.sign	*93.0*	*97.7*	*98.8*	*100*	*100*	*100*	*100*	*100*	*100*
	Average R^2	0.389	0.387	0.386	0.384	0.383	0.381	0.380	0.378	0.376
	Joint hyp.	*0.00*	*0.00*	*0.00*	*1.16*	*1.16*	*1.16*	*0.58*	*0.00*	*0.00*

The model tested is $\ln(E/P) = \alpha_0 + \alpha_1 \ln(E/P)^* + \varepsilon$ where *(E/P)** is the "DCF earning price" calculated as in equation (3.3) of the paper.
Cross-sect. Sign.: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the t.statistic.
F-Test on the Joint hypothesis ($H_0: \alpha_0 = 0, \alpha_1 = 1$): number of times (in percent values) the null hypothesis that the coefficient of the fundamental is equal to one and the coefficient of the intercept is equal to zero (hyp. 1) is not rejected at 99 percent in the 172 monthly cross-sectional estimates of the sample period.

Table II.B The effect of theoretical on observed price earning under calibration of the risk premia and the terminal rate of growth – EU sample

Term. rate of growth		Risk Premium								
		0.055	***0.06***	***0.065***	***0.07***	***0.075***	***0.08***	***0.085***	***0.09***	***0.095***
0.025	**E/P***	0.5140	0.5154	0.5152	*0.5157*	0.5152	0.5142	0.5122	0.5118	0.5109
	s.e.	0.1556	0.1573	0.1588	0.1603	0.1616	0.1628	0.1638	0.1652	0.1663
	cross-sect.sign	*90.1*	*89.5*	*89.5*	*89.5*	*88.4*	*87.2*	*86.0*	*85.5*	*86.0*
	constant	-1.3435	-1.3653	-1.3903	-1.4116	-1.4342	-1.4574	-1.4820	-1.5017	-1.5219
	s.e.	0.4414	0.4389	0.4359	0.4332	0.4303	0.4272	0.4238	0.4216	0.4188
	cross-sect.sign	*81.4*	*82.0*	*83.1*	*83.7*	*84.3*	*85.5*	*86.6*	*87.2*	*87.8*
	Average R^2	0.088	0.087	0.086	0.085	0.084	0.083	0.081	0.080	0.079
	Joint hyp.	*21.51*	*21.51*	*20.93*	*18.02*	*16.28*	*17.44*	*15.12*	*11.63*	*8.14*
0.03	**E/P***	0.5095	0.5115	0.5125	0.5130	0.5131	0.5124	0.5107	0.5084	0.5083
	s.e.	0.1536	0.1555	0.1573	0.1588	0.1603	0.1616	0.1626	0.1635	0.1650
	cross-sect.sign.	*90.1*	*89.5*	*89.5*	*89.5*	*89.0*	*87.2*	*87.2*	*86.0*	*85.5*
	constant	-1.3370	-1.3582	-1.3808	-1.4035	-1.4257	-1.4487	-1.4735	-1.4981	-1.5171
	s.e.	0.4414	0.4391	0.4365	0.4337	0.4309	0.4279	0.4246	0.4210	0.4190
	cross-sect.sign.	*80.2*	*81.4*	*82.6*	*83.7*	*84.3*	*84.9*	*86.6*	*87.2*	*87.8*
	Average R^2	0.088	0.087	0.086	0.085	0.084	0.083	0.082	0.081	0.079
	Joint hyp.	*20.93*	*20.35*	*20.93*	*19.77*	*16.86*	*17.44*	*17.44*	*12.21*	*9.88*
0.035	**E/P***	0.5040	0.5075	0.5094	0.5103	0.5105	0.5103	0.5094	0.5076	0.5073
	s.e.	0.1514	0.1536	0.1555	0.1572	0.1588	0.1602	0.1614	0.1625	0.1640
	cross-sect.sign.	*90.1*	*89.5*	*89.5*	*89.5*	*89.5*	*89.0*	*87.2*	*87.2*	*85.5*
	Constant	-1.3320	-1.3503	-1.3715	-1.3943	-1.4174	-1.4401	-1.4634	-1.4881	-1.5083
	s.e.	0.4411	0.4393	0.4369	0.4343	0.4314	0.4285	0.4255	0.4221	0.4199
	cross-sect.sign.	*80.2*	*80.2*	*81.4*	*83.7*	*83.7*	*84.3*	*85.5*	*87.2*	*87.8*
	Average R^2	0.089	0.088	0.087	0.086	0.084	0.083	0.082	0.081	0.080
	Joint hyp.	*19.19*	*20.93*	*20.93*	*18.60*	*18.02*	*15.70*	*15.70*	*15.70*	*11.63*
0.04	**E/P***	0.4973	0.5021	0.5053	0.5071	0.5073	0.5078	0.5074	0.5059	0.5041
	s.e.	0.1490	0.1514	0.1536	0.1555	0.1571	0.1587	0.1601	0.1612	0.1622
	cross-sect.sign.	*8.95*	*89.5*	*89.5*	*89.5*	*89.5*	*89.0*	*87.8*	*87.2*	*86.6*
	Constant	-1.3294	-1.3452	-1.3639	-1.3853	-1.4098	-1.4317	-1.4547	-1.4796	-1.5037
	s.e.	0.4405	0.4390	0.4371	0.4347	0.4318	0.4291	0.4261	0.4229	0.4195
	cross-sect.sign.	*80.2*	*80.2*	*81.4*	*82.6*	*83.7*	*84.3*	*84.3*	*86.6*	*87.2*
	Average R^2	0.089	0.088	0.087	0.086	0.085	0.084	0.083	0.081	0.080
	Joint hyp.	*18.02*	*19.19*	*19.77*	*19.77*	*16.28*	*15.70*	*15.70*	*15.70*	*12.79*
0.045	**E/P***	0.4871	0.4954	0.4999	0.5026	0.5041	0.5047	0.5050	0.5044	0.5028
	s.e.	0.1458	0.1490	0.1514	0.1535	0.1554	0.1570	0.1586	0.1599	0.1611
	cross-sect.sign.	*89.0*	*89.0*	*89.0*	*89.5*	*89.5*	*89.5*	*89.0*	*87.8*	*87.2*
	Constant	-1.3349	-1.3424	-1.3586	-1.3789	-1.4010	-1.4238	-1.4462	-1.4696	-1.4944
	s.e.	0.4381	0.4384	0.4369	0.4347	0.4322	0.4295	0.4267	0.4237	0.4204
	cross-sect.sign.	*80.2*	*80.2*	*80.2*	*81.4*	*83.7*	*83.7*	*84.3*	*86.0*	*87.2*
	Average R^2	0.089	0.088	0.087	0.086	0.085	0.084	0.083	0.082	0.081
	Joint hyp.	*18.02*	*19.19*	*19.19*	*19.77*	*19.19*	*15.70*	*16.86*	*14.53*	*15.12*

The model tested is $\ln(E/P) = \alpha_0 + \alpha_1 \ln(E/P)^* + \varepsilon$ where *(E/P)** is the "DCF earning price" calculated as in equation (3.3) of the paper.

Cross-sect. Sign.: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the t.statistic.

F-Test on the Joint hypothesis (H_0: $\alpha_0 = 0, \alpha_1 = 1$): number of times (in percent values) the null hypothesis that the coefficient of the fundamental is equal to one and the coefficient of the intercept is equal to zero (hyp. 1) is not rejected at 99 percent in the 172 monthly cross-sectional estimates of the sample period.

Table III.A Empirical test of the strong version of the DCF model (hypotheses 1 and 2) in the US stock market

	MEAN GROUP ESTIMATORS								
const	-1.246	-1.308	-1.046	-1.219	-1.147	-1.115	-0.969	-0.986	-0.955
s.e.	0.131	0.140	0.161	0.165	0.173	0.175	0.248	0.257	0.270
cross-sect. sign.	100.0	100.0	93.6	95.3	90.7	96.5	84.9	84.3	82.6
E/P*	0.615	0.601	0.620	0.538	0.540	0.563	0.601	0.602	0.603
s.e.	0.048	0.050	0.050	0.053	0.053	0.054	0.075	0.075	0.076
cross-sect. sign.	100.0	97.7	97.7	97.7	97.7	98.3	97.7	97.7	97.1
NUMIMP		0.00031	0.00036	0.00036	0.00037	0.00035	0.00045	0.00045	0.00046
s.e.		0.00036	0.00035	0.00034	0.00034	0.00033	0.00045	0.00045	0.00045
cross-sect. sign.		6.4	7.6	12.8	3.5	3.5	9.9	10.5	9.9
BETA			-0.257	-0.254	-0.243	-0.222	-0.270	-0.271	-0.270
s.e.			0.080	0.078	0.078	0.077	0.114	0.115	0.117
cross-sect. sign.			69.8	68.0	68.0	62.8	55.8	56.4	55.8
DPO				-0.090	-0.088	-0.109	-0.154	-0.155	-0.156
s.e.				0.031	0.030	0.035	0.075	0.076	0.080
cross-sect. sign.				87.2	87.8	85.5	91.3	91.9	90.1
F1NE					-0.005	-0.005	-0.006	-0.005	-0.005
s.e.					0.003	0.003	0.005	0.006	0.006
cross-sect. sign.					34.9	30.2	31.4	31.4	31.4
F1SD						0.708	0.695	0.700	0.705
s.e.						0.272	0.465	0.480	0.510
cross-sect. sign.						72.7	50.6	50.6	47.7
DI							-0.004	-0.004	-0.004
s.e.							0.006	0.006	0.007
cross-sect. sign.							4.1	3.5	2.9
BEAR								0.027	0.007
s.e.								0.176	0.187
cross-sect. sign.								6.9	5.6
BULL									-0.080
s.e.									0.168
cross-sect. sign.									9.4
R²	**0.379**	**0.375**	**0.407**	**0.447**	**0.461**	**0.506**	**0.654**	**0.658**	**0.661**
variable	***E/P****	***NUMIMP***	***BETA***	***DPO***	***F1NE***	***F1SD***	***DI***	***BEAR***	***BULL***
VIF	*1.18*	*1.02*	*1.08*	*1.16*	*1.05*	*1.01*	*1.01*	*1.2*	*1.22*
1/VIF	*0.85*	*0.98*	*0.93*	*0.87*	*0.95*	*0.99*	*0.99*	*0.84*	*0.82*
mean VIF	*1.1*								

The table shows the time series averages of cross-sectional slopes of equation (3.6) of the paper:

$$\ln(E/P)_{jt} = \alpha_0 + \alpha_1 \ln(E/P)^*_{jt} + \alpha_2 NUMIMP_{jt} + \alpha_3 \beta_{jt} + \alpha_4 DPO_{jt} + \alpha_5 F1NE_{jt} +$$

$$+ \alpha_6 F1SD_{jt} + \alpha_7 BULL_{jt} + \alpha_8 BEAR_{jt} + \alpha_9 D/I_{jt} + \varepsilon_t$$

with their time series standard deviation for the overall sample period (January 1988 to March 2002).

Variables legend:

*E/P** is the log of the DCF earning price ratio computed as in (3.3). *NUMIMP* is the number of firm employees, *BETA* is the slope of the return of the stock on the return of the market index estimated over the last two year on weekly data, *DPO* is the dividend payout, *F1NE* is a measure of the number of IBES forecasts in the last three months, *F1SD* is the dispersion of analysts forecasts proxied by the standard deviation of 1-year ahead IBES forecasts, *DI* is the depreciation-investment ratio, *BEAR* and *BULL* are two chartist dummy variables proxy for the particular market trend.

Cross-sect. Sign.: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the t.statistic.

VIF (variance inflation factor): 1/1-R(x) where R(x) is the R squared when the independent variable is regressed on all other independent variables (Marquardt, 1970).

Table III.B Empirical test of the strong version of the DCF model (hypotheses 1 and 2) in the EU stock market

	MEAN GROUP ESTIMATORS								
const	-1.416	-1.488	-1.547	-1.554	-1.384	-1.488	-1.684	-1.694	-1.699
s.e.	0.433	0.565	0.700	0.793	0.856	0.817	1.063	1.070	0.757
cross-sect. sign.	83.7	76.7	64.5	64.5	65.	72.	63.	62.8	62.2
E/P*	0.514	0.515	0.476	0.486	0.591	0.583	0.510	0.512	0.496
s.e.	0.160	0.209	0.223	0.266	0.268	0.261	0.334	0.336	0.236
cross-sect. sign.	89.5	75.0	74.4	66.9	65.7	74.4	73.3	73.3	71.5
NUMIMP		0.00095	0.00101	0.00113	0.00119	0.00119	0.00094	0.00096	0.00094
s.e.		0.00128	0.00128	0.00130	0.00132	0.00126	0.00131	0.00129	0.00120
cross-sect. sign.		7.0	6.4	4.7	2.3	4.7	2.9	2.9	2.9
BETA			-0.148	-0.081	-0.160	-0.279	-0.264	-0.289	-0.268
s.e.			0.324	0.338	0.337	0.322	0.359	0.360	0.286
cross-sect. sign.			35.5	27.9	33.1	30.2	29.1	29.1	27.9
DPO				-0.006	0.007	-0.026	-0.021	-0.024	-0.023
s.e.				0.089	0.086	0.085	0.081	0.080	0.078
cross-sect. sign.				7.0	8.7	7.6	8.7	9.3	10.5
F1NE					0.006	0.010	0.011	0.010	0.010
s.e.					0.015	0.015	0.016	0.016	0.014
cross-sect. sign.					1.2	11.6	20.3	20.9	20.3
F1SD						0.387	0.337	0.331	0.352
s.e.						0.238	0.214	0.217	0.173
cross-sect. sign.						60.5	59.3	58.7	58.1
DI							0.002	0.001	-0.001
s.e.							0.005	0.005	0.004
cross-sect. sign.							4.7	4.7	4.1
BEAR								0.046	0.006
s.e.								0.207	0.234
cross-sect. sign.								1.2	0.6
BULL									-0.073
s.e.									0.194
cross-sect. sign.									0.6
R²	**0.083**	**0.099**	**0.127**	**0.140**	**0.161**	**0.209**	**0.233**	**0.236**	**0.239**
Variable	***E/P****	***NUMIMP***	***BETA***	***DPO***	***F1NE***	***F1SD***	***DI***	***BEAR***	***BULL***
VIF	*1.17*	*1.09*	*1.14*	*1.08*	*1.14*	*1.13*	*1*	*1.34*	*1.33*
1/VIF	*0.85*	*0.92*	*0.87*	*0.93*	*0.87*	*0.89*	*1.00*	*0.74*	*0.75*
mean VIF	*1.16*								

The table shows the time series averages of cross-sectional slopes of equation (3.6) of the paper:

$$\ln(E/P)_{jt} = \alpha_0 + \alpha_1 \ln(E/P)^*_{jt} + \alpha_2 NUMIMP_{jt} + \alpha_3 \beta_{jt} + \alpha_4 DPO_{jt} + \alpha_5 F1NE_{jt} +$$

$$+ \alpha_6 F1SD_{jt} + \alpha_7 BULL_{jt} + \alpha_8 BEAR_{jt} + \alpha_9 D/I_{jt} + \varepsilon_t$$

with their time series standard deviation for the overall sample period (January 1988 to March 2002).

Variables legend:

*E/P** is the log of the DCF earning price ratio computed as in (3.3). *NUMIMP* is the number of firm employees, *BETA* is the slope of the return of the stock on the return of the market index estimated over the last two year on weekly data, *DPO* is the dividend payout, *F1NE* is a measure of the number of IBES forecasts in the last three months, *F1SD* is the dispersion of analysts forecasts proxied by the standard deviation of 1-year ahead IBES forecasts, *DI* is the depreciation-investment ratio, *BEAR* and *BULL* are two chartist dummy variables proxy for the particular market trend.

Cross-sect. Sign.: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the t.statistic.

VIF (variance inflation factor): 1/1-R(x) where R(x) is the R squared when the independent variable is regressed on all other independent variables (Marquardt, 1970).

Table IV.A Empirical test of the weak version of the DCF model in the US stock market.

	MEAN GROUP ESTIMATORS							
Const	-2.839	-2.442	-2.457	-2.452	-2.265	-2.189	-2.225	-2.204
s.e.	0.031	0.085	0.092	0.105	0.110	0.125	0.135	0.202
cross-sect. sign.	100.0	99.4	99.4	99.4	99.4	99.4	100.0	100.0
G1	-0.128	-0.129	-0.131	-0.131	-0.082	-0.082	-0.080	-0.101
s.e.	0.014	0.014	0.016	0.016	0.021	0.021	0.022	0.036
cross-sect. sign.	100.0	99.4	97.7	97.7	80.2	80.2	79.1	71.5
GLT		-3.338	-3.318	-3.260	-4.333	-4.262	-4.039	-3.948
s.e.		0.665	0.697	0.742	0.748	0.750	0.799	1.163
cross-sect. sign.		99.4	96.5	94.8	96.5	95.9	96.5	84.9
NUMIMP			0.00027	0.00027	0.00023	0.00030	0.00027	0.00032
s.e.			0.00037	0.00037	0.00035	0.00036	0.00036	0.00049
cross-sect. sign.			8.1	8.1	5.8	5.2	3.5	5.2
BETA				-0.021	0.000	0.009	0.014	-0.019
s.e.				0.089	0.085	0.085	0.087	0.131
cross-sect. sign.				25.6	30.8	30.2	33.1	30.8
DPO					-0.180	-0.177	-0.199	-0.279
s.e.					0.040	0.040	0.047	0.086
cross-sect. sign.					89.0	89.0	87.2	80.8
F1NE						-0.005	-0.005	-0.005
s.e.						0.004	0.004	0.006
cross-sect. sign.						27.3	27.9	26.7
F1SD							0.338	0.528
s.e.							0.300	0.492
cross-sect. sign.							37.2	23.8
DI								-0.001
s.e.								0.006
cross-sect. sign.								3.5
R^2	0.269	0.332	0.335	0.343	0.408	0.418	0.440	0.602
Variable	***G1***	***GLT***	***NUMIMP***	***BETA***	***DPO***	***F1NE***	***F1SD***	***DI***
VIF	*1.75*	*1.13*	*1.02*	*1.11*	*1.76*	*1.04*	*1.02*	*1.01*
1/VIF	*0.57*	*0.89*	*0.98*	*0.90*	*0.57*	*0.96*	*0.98*	*0.99*
mean VIF	*1.23*							

The table shows the time series averages of cross-sectional slopes of equation (3.8) of the paper:

$$\ln(E/P)_{jt} = a_0 + a_1 g_{1\,jt} + a_2 glt_{jt} + \sum_{j=1}^{n} \gamma_j X_{jt} + \varepsilon_t$$

with their time series standard deviation for the overall sample period (January 1988 to March 2002).

Variables legend:

G1: 1-year ahead average IBES forecasts of the rate of growth earnings. *GLT*: long term average IBES forecasts of the rate of growth earnings, *NUMIMP* is the number of firm employees, *BETA* is the slope of the return of the stock on the return of the market index estimated over the last two year on weekly data, *DPO* is the dividend payout, *F1NE* is a measure of the number of IBES forecasts in the last three months, *F1SD* is the dispersion of analysts forecasts proxied by the standard deviation of 1-year ahead IBES forecasts, *DI* is the depreciation-investment ratio.

Cross-sect. Sign.: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the t.statistic.

VIF (variance inflation factor): 1/1-R(x) where R(x) is the R squared when the independent variable is regressed on all other independent variables (Marquardt, 1970).

Table IV.B Empirical test of the weak version of the DCF model in the EU stock market.

	MEAN GROUP ESTIMATORS							
const	-2.800	-2.594	-2.732	-2.725	-2.702	-2.824	-3.001	-2.855
s.e.	0.059	0.151	0.230	0.277	0.302	0.417	0.441	0.397
cross-sect. sign.	99.4	99.4	99.4	99.4	99.4	98.3	97.1	94.8
G1	-0.088	-0.104	-0.099	-0.072	-0.084	-0.214	-0.170	-0.180
s.e.	0.042	0.081	0.136	0.141	0.169	0.278	0.289	0.126
cross-sect. sign.	70.9	64.0	51.7	48.8	35.5	37.8	44.2	45.9
GLT		-1.563	-0.903	-0.823	-1.251	-0.875	-0.879	-1.117
s.e.		1.091	1.570	1.439	1.566	1.570	1.544	1.396
cross-sect. sign.		28.5	19.2	09.9	11.0	0.76	09.9	12.8
NUMIMP			0.00105	0.00117	0.00175	0.00123	0.00115	0.00099
s.e.			0.0014	0.00130	0.00132	0.00134	0.00131	0.00124
cross-sect. sign.			3.5	5.8	5.2	7.6	8.1	7.6
BETA				-0.097	-0.028	-0.043	-0.064	-0.135
s.e.				0.295	0.312	0.314	0.306	0.283
cross-sect. sign.				23.3	14.0	17.4	17.4	16.3
DPO					-0.020	-0.008	-0.022	-0.040
s.e.					0.105	0.108	0.104	0.087
cross-sect. sign.					01.2	01.2	02.3	03.5
F1NE						0.003	0.007	0.006
s.e.						0.015	0.015	0.014
cross-sect. sign.						02.9	07.0	09.9
F1SD							0.285	0.242
s.e.							0.179	0.145
cross-sect. sign.							54.1	54.1
DI								-0.004
s.e.								0.005
cross-sect. sign.								02.9
R^2	0.078	0.092	0.099	0.120	0.129	0.145	0.196	0.224
variable	***G1***	***GLT***	***NUMIMP***	***BETA***	***DPO***	***F1NE***	***F1SD***	***DI***
VIF	*1.23*	*1.01*	*1.08*	*1.07*	*1.23*	*1.13*	*1.09*	*1.00*
1/VIF	*0.82*	*0.99*	*0.93*	*0.94*	*0.82*	*0.88*	*0.92*	*1.00*
mean VIF	*1.10*							

The table shows the time series averages of cross-sectional slopes of equation (3.8) of the paper:

$$\ln(E/P)_{jt} = a_0 + a_1 g_{1jt} + a_2 glt_{jt} + \sum_{j=1}^{n} \gamma_j X_{jt} + \varepsilon_t$$

with their time series standard deviation for the overall sample period (January 1988 to March 2002).

Variables legend:

G1: 1-year ahead average IBES forecasts of the rate of growth earnings. *GLT*: long term average IBES forecasts of the rate of growth earnings, *NUMIMP* is the number of firm employees, *BETA* is the slope of the return of the stock on the return of the market index estimated over the last two year on weekly data, *DPO* is the dividend payout, *F1NE* is a measure of the number of IBES forecasts in the last three months, *F1SD* is the dispersion of analysts forecasts proxied by the standard deviation of 1-year ahead IBES forecasts, *DI* is the depreciation-investment ratio.

Cross-sect. significance: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the statistic t, that is distributed as a t with n-1 degree of freedom.

VIF (variance inflation factor): 1/1-R(x) where R(x) is the R squared when the independent variable is regressed on all other independent variables (Marquardt, 1970).

Tables V.A-V.D Davidson-MacKinnon J-test on non-nested hypotheses for the weak and strong version of the DCF model

Table V.A

Strong version (A1) vs weak version with G1 only (A2)	
US	
Both not significant	0
Both significant	117
A1 sign-A2 not sign	55
A2 sign-A1 not sign	0

Table V.C

Strong version (A1) vs weak version with G1 and GLT (A2)	
US	
Both not significant	0
Both significant	164
A1 sign-A2 not sign	8
A2 sign-A1 not sign	0

Table V.B

Strong version (A1)vs weak version with G1 only (A2)	
EU	
Both not significant	49
Both significant	25
A1 sign-A2 not sign	88
A2 sign-A1 not sign	10

Table V.D

Strong version (A1) vs weak version with G1 and GLT (A2)	
EU	
Both not significant	60
Both significant	22
A1 sign-A2 not sign	60
A2 sign-A1 not sign	30

According to the Davidson-MacKinnon (1981, 1993) approach, given two non-nested specifications A1 and A2, specification A1 is the correct one if fitted values of the dependent variable from A2 do not have explanatory power when estimating A1, while fitted values of the dependent variable from A1 have explanatory power when estimating A2. The test is not conclusive if fitted values from A1 and A2 are not significant when added as regressors in the alternative specification. The test is performed for any of the 172 monthly cross-sectional estimates of the sample period.
A1: strong version of the DCF model (see Tables IIIA-IIIB); A2 weak version of the DCF model (see Tables IVA-IVB)
Table legend:
Both not significant: fitted values of the dependent variable from A2 do not have explanatory power when estimating A1 and viceversa.
Both significant: fitted values of the dependent variable from A2 do have explanatory power when estimating A1 and viceversa.
A1 sign-A2 not sign: fitted values of the dependent variable from A2 do not have explanatory power when estimating A1, while fitted values of the dependent variable from A1 have explanatory power when estimating A2
A2 sign-A1 not sign: fitted values of the dependent variable from A2 do have explanatory power when estimating A1, while fitted values of the dependent variable from A1 do not have explanatory power when estimating A2

Table VI The determinants of the observed price earning ratios in the pooled US and EU sample

	MEAN GROUP ESTIMATORS													
Const	-2.699	-1.918	-1.815	-1.732	-1.903	-1.996	-2.059	-2.051	-2.037	-2.056	-2.267	-2.278	-2.256	-2.345
s.e.	0.058	0.211	0.211	0.235	0.265	0.278	0.281	0.287	0.296	0.296	0.463	0.471	0.484	0.497
cross-sect.S.	99.419	99.419	99.419	99.419	99.419	99.419	99.419	99.419	100.000	100.000	91.860	92.353	89.535	89.535
E/P*	0.133	0.412	0.442	0.443	0.358	0.309	0.310	0.328	0.327	0.340	0.305	0.310	0.311	0.330
s.e.	0.031	0.081	0.083	0.083	0.099	0.107	0.105	0.105	0.109	0.110	0.179	0.182	0.185	0.187
cross-sect.S.	87.209	94.186	94.767	95.349	91.279	76.744	76.744	79.070	78.488	79.651	47.674	47.059	45.349	46.512
EUF		-0.921	-1.076	-1.120	-0.885	-0.747	-0.778	-0.706	-0.779	-0.749	-0.448	-0.429	-0.445	-0.252
s.e.		0.239	0.247	0.250	0.288	0.300	0.294	0.350	0.361	0.361	0.535	0.542	0.546	0.579
cross-sect.S.		83.140	91.860	91.860	76.744	69.186	73.837	55.814	62.791	59.884	24.419	23.529	22.674	16.860
NUMIMP			0.00043	0.00049	0.00080	0.00091	0.00075	0.00078	0.00080	0.00079	0.00065	0.00066	0.00066	0.00063
s.e.			0.00099	0.00099	0.00099	0.00099	0.00099	0.00103	0.00103	0.00103	0.00118	0.00118	0.00120	0.00120
cross-sect.S.			21.512	22.093	24.419	27.326	27.326	27.907	27.326	27.326	24.419	24.118	23.256	23.837
BETA				-0.103	-0.106	-0.111	-0.128	-0.136	-0.131	-0.125	-0.186	-0.190	-0.197	-0.198
s.e.				0.109	0.116	0.116	0.115	0.115	0.116	0.116	0.167	0.168	0.169	0.171
cross-sect.S.				23.837	22.093	26.163	27.326	30.233	27.907	27.907	29.651	30.000	29.070	30.233
DPO					-0.070	-0.122	-0.121	-0.119	-0.138	-0.136	-0.123	-0.123	-0.123	-0.121
s.e.					0.020	0.036	0.035	0.035	0.037	0.037	0.045	0.045	0.046	0.047
cross-sect.S.					81.395	55.233	56.395	55.814	56.395	56.395	52.326	52.941	50.581	50.581
usdpo						-0.010	-0.012	-0.011	-0.016	-0.018	-0.097	-0.097	-0.100	-0.088
s.e.						0.074	0.073	0.073	0.078	0.079	0.143	0.144	0.146	0.150
cross-sect.S.						56.977	60.465	60.465	46.512	46.512	43.023	42.941	40.116	37.791
F1NE							0.004	0.000	0.001	0.001	0.002	0.002	0.001	0.002
s.e.							0.005	0.008	0.009	0.009	0.010	0.011	0.011	0.011
cross-sect.S.							24.419	22.093	26.163	26.163	20.349	20.588	22.674	23.837
usf1ne								0.005	0.004	0.004	0.009	0.009	0.009	0.008
s.e.								0.010	0.011	0.011	0.015	0.015	0.015	0.015
cross-sect.S.								15.116	16.279	16.279	13.372	14.118	13.953	12.791
F1SD									0.057	0.051	0.033	0.033	0.034	0.038
s.e.									0.045	0.046	0.058	0.058	0.059	0.059
cross-sect.S.									40.698	34.302	20.930	20.588	20.930	25.000

Table VI (follows) The determinants of the observed price earning ratios in the pooled US and EU sample

	MEAN GROUP ESTIMATORS													
usf1sd										0.838	0.877	0.983	0.980	0.921
s.e.										0.533	0.856	0.878	0.894	0.918
cross-sect.S.										31.395	14.535	15.294	15.116	15.116
DI											0.000	0.000	0.000	0.000
s.e.											0.001	0.001	0.001	0.001
cross-sect.S.											3.488	3.529	2.907	2.907
usdi												0.008	0.008	0.007
s.e.												0.012	0.012	0.012
cross-sect.S.												1.765	2.326	1.744
BEAR													0.014	0.110
s.e.													0.220	0.263
cross-sect.S.													0.041	0.145
BULL													-0.009	-0.094
s.e.													0.159	0.189
cross-sect.S.													5.233	11.628
usbear														0.394
s.e.														0.457
cross-sect.S.														7.558
usbull														0.261
s.e.														0.394
cross-sect.S.														17.442
R^2	*0.031*	*0.070*	*0.089*	*0.095*	*0.123*	*0.137*	*0.145*	*0.151*	*0.169*	*0.176*	*0.185*	*0.187*	*0.195*	*0.203*

The table shows the time series averages of cross-sectional slopes of equation (3.9) of the paper:

$$\ln(E/P)_{jt} = \alpha_0 + \alpha_1 \ln(E/P^*)_{jt} + \alpha_2 EUF_{jt} + a_3 NUMIMP_{jt} + a_4 \beta_{jt} + a_5 DPO_{jt} +$$
$$+ a_6 USDPO_{jt} + a_7 F1NE_{jt} + a_8 USF1NE_{jt} + \alpha_9 FISD_{jt} + a_{10} USF1SD_{jt} + a_{11} D/I_{jt} +$$
$$+ a_{12} USD/I + a_{13} BULL_{jt} + + a_{14} BEAR_{jt} + a_{15} USBULL_{jt} + a_{16} USBEAR_{jt} + \varepsilon_t$$

with their time series standard deviation for the overall sample period (January 1988 to March 2002). Variables legend: *E/P** is the "optimal" US log of the DCF earning price ratio calculated according to the best US calibration values, *EUF* is the product of E/P* and a dummy taking value of one for EUstocks and zero otherwise, *NUMIMP* is the number of firm employees, *BETA* is the slope of the return of the stock on the return of the market index estimated over the last two year on weekly data, *DPO* is the dividend payout, *F1NE* is a measure of the number of IBES forecasts in the last three months, *F1SD* is the dispersion of analysts forecasts proxied by the standard deviation of 1-year ahead IBES forecasts, *DI* is the depreciation-investment ratio, *BEAR* and *BULL* are two chartist dummy variables proxy for the particular market trend We also add other six variables which are the product of a US dummy for DPO, F1NE, F1SD, D/I, BULL and BEAR.

Table VII.A The effect of delays in the adjustment of publicly available information to news (hypothesis 3) in the US stock market
(Dependent variable: E/P-E/P*)

	MEAN GROUP ESTIMATOR
Const	-2.308
s.e.	2.244
cross-sect. sign.	*50.6*
dg1	***0.065***
s.e.	1.468
cross-sect. sign.	*11.6*
R^2	*0.068*

Table VII.B The effect of delays in the adjustment of publicly available information to news (hypothesis 3) in the EU stock market
(Dependent variable: E/P-E/P*)

	MEAN GROUP ESTIMATOR
Const	-0.006
s.e.	0.117
cross-sect. sign.	*42.4*
dg1	***-0.138***
s.e.	0.267
cross-sect. sign.	*27.9*
R^2	*0.088*

The tables show the time series averages of cross-sectional slopes of equation (5.1) of the paper:

$$\varepsilon_t = b_0 + \sum_{i=1}^{n} b_i \Delta g_{1i,t+1-t} + \eta_t$$

with their time series standard deviation for the overall sample period (January 1988 to March 2002).

Variables legend:

the dependent variable is the distance of the observed E/P from the fundamental value according to equation (3.6), thus the residual: (E/P-E/P*) where E/P is the log of the earning per share divided for the stock price and E/P* is the log of the DCF earning price ratio computed as in (3.3); dg1 is the one period change in earnings growth forecasts affecting the fundamental.

Cross-sect. significance: number of times (in percent values) the coefficient is significant at 99 percent in the 172 monthly cross-sectional estimates of the sample period. The significance is measured with the statistic t, that is distributed as a t with n-1 degree of freedom.

Taking ICT seriously. Two dimensions of time varying, country specific contribution of ICT to levels and growth of per capita GDP.

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Abstract

The effect of Information and Communication Technology on economic growth may be analysed in two different ways: i) by treating ICT as a specific type of physical capital; ii) by considering that telephone lines, personal computers and internet hosts are "bottleneck-reducing" factors which increase the productivity of labour by making easier the diffusion of (non rivalrous and almost non excludable) knowledge on the web.
In this paper we compare the relative significance of the two hypotheses in level and growth estimates and find that, when separately taken, both hypotheses improve upon the classical Mankiw et al.-Islam framework. We finally demonstrate that a mixed hypothesis which incorporates both dimensions of the ICT contribution to growth at the same time is preferred to the focus on only one dimension. The consistent improvement of within country significance in panel estimates documents that our approach captures two dimensions of time varying country specific technological progress that previous standard approaches in the literature could not take into account.

Key words: ICT capital stock, "bottleneck-reducing" ICT factors, economic growth.

JEL classification codes: O30, O47.

1. Introduction

One of the main limits in the current growth literature is the difficulty in modeling and testing the effects of technological progress, often considered as constant across countries (Mankiw, Romer and Weil, 1992) (from now on MRW) or country specific but time invariant (Islam, 1995). Furthermore, the vast literature evaluating the role of different variables affecting growth does neglect the role of the new vintage of ICT technology as a factor of endogenous growth or, alternatively, conditional convergence in the transitional dynamics toward the steady stade output in exogenous growth models.[1] The theoretical justification for this omission is that technology embodies expansible and infinitely reproducible *knowledge products* which are public goods, freely available to individuals in all countries (Temple, 1999).

The issue which is not always properly considered in the investigation is that the diffusion and availability of knowledge products is not the same across countries and may be crucially prevented by limits in technology transfers and by several "*bottlenecks*". As an example of these bottlenecks we observe that knowledge diffusion in the internet era may depend on: i) the capacity of telecommunication networks to carry the largest amount of knowledge products in the shortest time, ii) the access of individuals to the web in which knowledge products are immaterially transported and iii) the power and availability of

[1] Durlauf and Quah (1998) survey the empirical literature on growth and list around 87 different proxies adopted to test the significance of additional factors in standard growth models. Among them the most recurrent appear to be human capital (Mankiw-Romer-Weil, 1992), the role of government sector (Hall-Jones, 1997), social and political stability (Alesina-Perotti, 1994), corruption (Mauro, 1995), social capital (Knack-Keefer, 1997), financial institutions (Pagano, 1977; King-Levine, 1992; Wachtel 2000) and income inequality (Persson-Tabellini, 1994; Perotti, 1996). None of them resembles proxies adopted in this paper to measure factors crucially affecting ICT diffusion.

"peripherals" which process, implement and exchange knowledge products on the internet.

In this perspective, we argue that Information and Communication Technology can enhance economic growth in the following two ways. First, it may generate new vintages of capital goods which add value to traditional physical products. Second, it may gradually remove the above described bottlenecks which limit access to knowledge by augmenting the power of telephone lines, personal computers and internet hosts in downloading and vehiculating images, data and voice across different parts of the world, with the effect of increasing the diffusion of knowledge and the productivity of labour.

Our hypothesis on the dual effect of ICT is consistent with the approach recently followed by Sanidas (2004) who divides technology in two types: i) embodied in capital goods, such as machinery, and other physical equipment; ii) disembodied in industrial property rights, unpatented know-how, management and organization. The author finds that embodied innovations are only part of the whole impact of innovations on economic growth.

Jalava and Pohjola (2002) evaluate the diffusion of three ICT assets (IT hardware, software and telecommunications equipment) in the perspective of the first approach (ICT as a new vintage of capital goods). In their analysis on Finland, they find that in 1999 about 9% of the total productive capital stock was under the form of ICT assets and that the ICT capital contribution to output doubled in the period 1995-1999.[2]

In the perspective of the second approach (reduction of bottlenecks reducing access to knowledge which increases the productivity of labour), Quah

[2] The same result is found in Colecchia and Schreyer (2001) and in Daveri (2001).

(1999) explains how information technology reduces “distance” between consumers and knowledge production and how the weightless economy is knowledge-intensive because of the quantity of knowledge products consumed. In an economic system with these features limits in the access to knowledge, usually referred to as “digital divides”, have significant effects on differences in productivity across areas.

In this paper we show that the consideration of these two roles for ICT technology (quality improvement of physical capital and reduction of bottlenecks to the diffusion of knowledge) generates a sharp increase in the explanatory power of cross-section and panel estimates of the determinants of levels and growth of real per capita GDP.

More specifically, we demonstrate that each of the two dimensions of ICT contribution to GDP, when individually taken, significantly improve upon the standard Mankiw, Romer and Weil (from now on MRW) (1992)- Islam (1995) empirical framework and that a mixed hypothesis which combines the physical capital quality adjustment with the bottleneck reducing contribution of ICT gives results which are superior to those obtained when only one of the two dimensions is considered.

The robustness of paper results is accurately tested. With boostrap estimates we find that they are not affected by departures from the normality assumption on the distribution of the dependent variable. Generalised 2-Stage Least Squares (G2SLS) dynamic panel estimates evidence that the ICT-growth relationship is not affected by endogeneity.

The paper documents all these findings and is divided into five sections (including introduction and conclusions). In the second section we formally sketch our argument on the two dimensions of the impact of ICT on levels and growth of per capita GDP. The third section illustrates our choice of variables and the estimation approach. In the fourth section we present and comment our empirical findings.

2. The econometric specification

2.1 The determinants of differences in levels of per capita growth

The considerations developed in the introduction on the role of ICT on levels and growth of per capita GDP lead us to formulate the following two hypotheses:

Hypothesis 1: ICT is a specific type of capital good which can provide a significant contribution to economic growth if combined with all other types of physical capital

versus

Hypothesis 2: factors affecting ICT diffusion are good proxies for measuring the amount of technological progress which augments labour productivity

To evaluate these hypotheses consider the standard MRW (1992) production function taking into account the role of human capital:

$$Y_t = F(K_t, H_t, A_t L_t) = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \quad \text{with } \alpha + \beta < 1 \qquad (1)$$

where H is the stock of human capital, L and K are the two traditional labour and physical capital inputs and A is the stock of labour augmenting technology.

Under the first hypothesis, the aggregate capital stock in (1) consists of ICT capital services (*Kict*) and other physical capital goods (*Ko*).

As a consequence:

$$Y_t = (K'_t)^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \quad [3] \quad \text{con} \quad \alpha + \beta < 1 \qquad (1')$$

Where K'_t is a stock of capital weighted for the quality of ICT capital goods included in the overall capital stock.

By rewriting the production function in terms of output per efficiency units we get $y = k'^{\alpha} h^{\beta}$, where $k' = K'/AL$.

The law of motion of physical capital turns into:

$$\dot{k}_t = (s_{k'}) y_t - (n + g + \delta) k'_t \qquad (2')$$

where δ is the rate of depreciation of the aggregate physical capital.

Equation (2') yields the following steady state solution:

$$(s_{k'}) k'^{*\alpha} h^{*\beta} = (n + g + \delta) k'^{*} \qquad (3')$$

By combining (3') with the steady state solution for human capital and by taking logs we obtain:

$$\ln\left(\frac{Y_t}{L_t}\right) = \ln A_0 + gt + \frac{\alpha}{1-\alpha-\beta}\ln(s_{k'}) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) \qquad (4')$$

The difference with MRW here is that, in this modified framework, the marginal contribution of the stock of ICT to the level of real per capita GDP matters and is equivalent to the marginal contribution of the income invested in the aggregate physical capital, in which ICT factors represent an important part of its quality (i.e. computer power, internet access, etc.).

To formulate the second hypothesis, we enter into the blackbox of the labour augmenting technological progress by assuming that most of it may be proxied by weightless, infinitely reproducible knowledge products (software, databases) (see Adriani-Becchetti, 2001). These products are conveyed to labour

[3] Differently from Jalava and Pohjola (2002), here the physical capital share of the real GDP is not distinguished between ICT and other traditional physical capital components.

through crucial factors such as the access to the network, the capacity of the network and the availability of “peripherals” which process and exchange knowledge products[4].

We accordingly specify its dynamics as:

$A_{(t)} = A_{KP(t)}\, A_{ICT(t)}$ with $A_{ICT(t)} = [A_{ICT(0)}\, e^{gICT(t)t}]$ and $A_{KP(t)} = A_{KP(0)}\, e^{gKP(t)t}$.

A_{ICT} is a measure of the stock of ICT factors reducing the above mentioned “bottlenecks” and g_{ICT} its rate of growth, while $A_{KP(t)}$ is the contribution to technological progress of weightless, infinitely reproducible knowledge products and g_{KP} is their rate of growth.

The two standard growth equations become:

$$\dot{k}_t = s_k y_t - (n + g' + \delta) k_t \qquad (2")$$

$$\dot{h}_t = s_h y_t - (n + g' + \delta) h_t$$

where $g' = g_{ICT} + g_{KP}$.

If we set the growth of physical and human capital equal to zero in the steady state and substitute h^* *and* k^* into the production function, by taking logs, we obtain:

$$\ln\left(\frac{Y_t}{L_t}\right) = c + \ln\left(A_{ICT(0)}\right) + g_{ICT}t + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n + g' + \delta) \qquad (4")$$

where $c = ln(A_{KP(0)}) + g_{KP(t)t}$ is the quasi-public good component of knowledge products and is therefore assumed constant across countries.

The difference with the traditional MRW (1992) specification is that we reinterpret the intercept and, as in Adriani and Becchetti (2001), we add to it two additional terms respectively accounting for the log of the stock of ICT at the

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[4] Of course other factors unrelated to technological progress will also be picked up by the residual, such as for instance changes in efficiency, scale and cyclical

initial period and its rate of growth per time unit. Hence, the possibility that all countries have the same steady state level of real per capita GDP does not depend only on the levelling of their population growth and broad capital investment rates since it is also affected by both initial stock and growth rate of ICT. A second important difference in this equation is that the country specific rate of growth of technology plus depreciation ($g+\delta$ in all previous models) is no more treated as fixed and equal to 0.05 for all countries[5] with an heroic assumption. In our specification it varies being crucially influenced by the measured country specific growth rates of ICT.

2.2 The determinants of differences in convergence of per capita growth

To obtain growth equations from the two hypotheses, following MRW, we examine transition dynamics on the balanced growth pact toward the steady state level of output. We start from the differential equation

$$d\ln(y_t)/dt=-\lambda[\ln(y_t)-\ln(y^*)], \qquad (5)$$

where $\lambda=(n+g+\delta)(1-\alpha-\beta)$ is the convergence rate and y^* is the steady state level of output per effective worker.

Equation (5) has the following solution:

$$\ln(y_t)-\ln(y^*)=e^{-\lambda t}[\ln(y_0)-\ln(y^*)] \qquad (6)$$

where y_0 is the output per effective worker at some initial date.

If we add $\ln(y^*)-\ln(y_0)$ to both sides and substitute for y^*, we get:

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factors, quality of institutions and measurement errors (Jalava and Pohjola 2002).

[5] This is the approach followed by Solow (1956), Mankiw-Romer-Weil (1992) and Islam (1995) among many others.

$$\ln\left(\frac{Y_t}{L_t}\right)-\ln\left(\frac{Y_0}{L_0}\right)=c+(1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln(s_k)+(1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln(s_h)+ -(1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta)-(1-e^{-\lambda t})\ln\left(\frac{Y_0}{L_0}\right) \quad (7)$$

Under hypothesis 1 both (6) and (7) still hold, with $s_k = s_{K'}$, while, under hypothesis 2, it is possible to show that, in the proximity of the balanced growth path, y converges to y^* at the rate $\lambda'' = (n+g'+\delta)(1-\alpha-\beta)$ [6].

Hence:

$$\ln\left(\frac{Y_t}{L_t}\right)-\ln\left(\frac{Y_o}{L_o}\right)=c'+g_{ICT}t+(1-e^{-\lambda t})\ln(A_{ICT(0)})+(1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln(s_k)+ (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln(s_h)-(1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g'+\delta)-(1-e^{-\lambda t})\ln\left(\frac{Y_o}{L_0}\right) \quad (7")$$

where $c' = g_{KP(t)}t + (1-e^{-\lambda t})\ln A_{KP(0)}$.

The difference with the traditional MRW approach (and with our first hypothesis) is in the interpretation of the common intercept (which now incorporates the worldwide diffusion of quasi-public knowledge products) and in the fact that convergence may be prevented by differences both in the initial stocks of ICT and/or in their rates of growth.

3 Empirical analysis

3.1 The choice of variables

We extract our variables by combining information from the following databases: i) World Bank development indicators, ii) Penn World Tables, iii) indicators of institutional quality collected by the Frazer Institute and iv)

[6] This obviously implies that the speed of convergence differs across countries and is crucially influenced by the pace of ICT growth.

UNESCO data on school enrollment and quality adjusted schooling years of the working population. The dependent variable ln(*Y/L)* is the logarithm of real gross domestic product (real GDP) per total labor force, s_K (or $s_{K'}$ under hyp. 1) is the gross domestic investment over GDP and is calculated using values taken from WB or, alternatively, PWT data [7].

Three different types of proxies for human capital investment are considered in our estimates.

We first consider measures of secondary school enrollment ratio. These variables, commonly used in most applied empirical works, have been strongly criticised since current enrollment ratios represent human capital investment of future and not of current workers. A direct measure of the schooling years of the working population is then generally preferred (Wossmann, 2003).

As a second proxy of human capital investment we therefore consider average schooling years of the working population calculated by Barro and Lee (2001). Even this measure is an imperfect proxy for human capital investment. This is because specifying human capital by average years of schooling implicitly gives the same weight to any year of schooling acquired by a person, regardless of the efficiency of the educational system, of the quality of teaching, of the educational infrastructure, or of the curriculum. Average schooling years should therefore be weighted for the quality of the educational system.

To encompass this problem we use as a third proxy of human capital, the Hanushek and Kimko's (2000) educational quality index, conveniently normalized

[7] Penn World Tables are the result of a United Nation International Comparison Project whose aim is to create information for consistent cross-country comparisons in time and space starting from price surveys of identical sets of good and services in different countries. To find a detailed discussion of the methodology and of the critical issues of PWTs see Heston-Summers (1991) .

by Wossmann (2003) for each country relative to the measure for the United States.

In order to measure technological factor we consider two different proxies: i) *ICT1 index,* which is composed by data on telephone mainlines, on personal computers users and on internet users scaled for the number of inhabitants.[8] Data on internet users are based on estimates derived from reported counts of internet service subscribers or calculated by multiplying the number of internet hosts by an estimated multiplier; ii) *ICT2 index,* which is composed by data on telephone mainlines, personal computer, internet users and by two different prices for internet access. These are internet provider access ($ per 30 off-peak hours) and internet telephone access ($ per 30 off-peak hours).

Data on individual components of our ICT indexes are more complete in recent than in earlier years. As a result, changes in the ICT index over time may reflect the fact that some indicators are missing in some years, but not in others. The problem of missing values reduces the comparability of ICT indexes over time. In order to correct for this problem, we calculate a chain weighted index of ICT diffusion.[9]

Our *ICT1 index* is built in two steps. In the first, missing data of personal computers are chained with telephone mainlines data (measured almost every

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[8] Telephone mainlines are defined as telephone lines connecting a costumer's equipment to the public switched telephone network. Personal computers as self-contained computers designed to be used by a single individual. Internet users indicate people with access to the worldwide network.

[9] Chain indexes are typically used to reconstruct series with incomplete or missing past information. Among the wide range of applications see Whelan (2002) for a comment on the use of chain indexes for reconstruction of the National Income and Product Accounts (NIPA) on behalf of the US Department of Commerce, Nordhaus (2001) for an application to productivity indexes and the Frazer Institute for the definition of indicators of economic freedom which we will use as control variables in our estimates.

year and in almost all sample countries from 1960). What we assume here is that unobserved changes in PC diffusion are proxied by changes in the observed diffusion of telephone mainlines. After the construction of the series of PCs, we normalise cross-sectionally absolute values in each year using the formula (Vti-Vtmin)/(Vtmax-Vtmin) obtaining values in the range 0-1 for all the sample countries (0 being the minimum and 1 the maximum value of personal computers for 1,000 people in the same year and in the different countries). In a second step, missing data of internet users are obtained with the same approach adopted for previously built personal computer data using for chains the composite telephone-PC indicator. The series of internet users is normalised cross-sectionally as well. Finally, we calculate the *Chain-Weighted ICT1 Index* giving the weight of 2 to internet users, the weight of 2 to personal computers and the weight of 1 to telephone mainlines normalised data.[10] We prefer this approach to the simple use of telephone mainlines indicator which we consider a too poor proxy of ICT diffusion.

ICT2 index is built following the same approach. We assume that unobserved changes in the two internet access prices are proxied by changes in the simple average of telephone mainlines and personal computers.[11] We normalise cross-sectionally the absolute values of the prices series using the formula (Vtmax-Vti)/(Vtmax-Vtmin) obtaining values in the 0-1 range in each

[10] PCs and internet accession are given higher weight under the assumption that they are a sharper proxy of ICT advancement and fruition than telephone mainlines. Sensitivity on changes of these weights provides results that are substantially unchanged with respect to those illustrated in the paper and available from the authors upon request.

[11] We are fully aware that any of these procedures will inevitably retain some degree of arbitrariness. We do not have the ambition of finding the right values but that of showing how weighting for some, albeit imperfect, indicator of ICT diffusion enhances the significance of level and growth estimates.

year for all sample countries. Finally, we calculated the *Chain-Weighted ICT2 Index* giving the weight of 1 to the telephone mainlines data, the weight of 1 to the personal computers data, the weight of 1 to the internet users data, the weight of 2 to the internet provider access charge data and the weight of 2 to the internet telephone access charge data.[12]

3.2 The estimation approach

The use of cross-sectional regressions for estimating the determinants of levels of per capita income has been strongly criticised by Islam (1995). His argument is that, since the labour augmenting A-factor in the aggregate production function represents country specific preferences and technological factors, it is not possible to assume that it is absorbed in the intercept and is therefore constant across countries (*cross-sectional constant critique).* Our estimate overcomes the problem by specifying the technological variable, but what if some additional country specific variables (deep fundamentals such as *ethos* or governance parameters such as economic freedom) are omitted? The solution here is to adopt a panel estimate in which fixed effects capture all additional country specific variables. [13] Our panel dataset consists of data for 156 countries, averaged over six non-overlapping 5-year periods between 1970 and 2001.

Even though they are preferable, panel estimates may also have some disadvantages with respect to cross-sectional estimates. First, the contribution of

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[12]Sensitivity of these weights produces results that are substantially unchanged with respect to those illustrated in the paper and available from the authors upon request.

ICT is no more split into the two components of initial levels and rates of growth and is therefore not completely lagged with respect to the dependent variable (*endogeneity critique*)[14]. Second, the five-year periods may be too short to generate the predicted convergence effects. We therefore need to test whether the significance of the ICT variable in panel estimates is robust to methodological changes which take into account these issues. To rule out *endogeneity problems* of estimates in levels we use the G2SLS methodology[15] which combines fixed effect panel estimates with instrumental variables. We use one to three periods lagged values of ICT indicators as instruments.

Because of the short time intervals such as those considered in our panel estimates it is difficult that all hypotheses of conditional convergence be respected. Thus for growth estimates we report only cross-sectional estimates which cover a longer time horizon.

Moreover, since the dependent variable is clearly nonnormal,[16] to test if our results are affected by the normality assumption, we provide confidence intervals calculated by using bootstrap standard errors[17].

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[13] The fixed effect is preferred to the random effect approach as the second retains the strong assumption of independence between regressors and the disturbance term.

[14] In the panel estimate the log of stock of ICT at the initial period and its rate of growth per time units (which compared in the equation (4”)) are incorporated in one variable that is the log of value of ICT for each period. This is because $g_{ICT} = \ln(A_{ICT}(t)) - \ln(A_{ICT}(0))$

[15] Our decision to use generalized 2-stage least squares instead of GMM hinges on a recent result of Erickson (2001) showing that “The main advantage of GMM is its well known covariance matrix formula rather than its efficiency with respect to TSLS…the difference between GMM and TSLS estimates is likely to be small.” Therefore, the difference between the two approaches is only in the computational simplicity of the variance-covariance matrix.

[16] The Shapiro-Wilks test rejects the null hypothesis of normal distribution for GDP per capita income in levels.

[17] Bootstrapping provides an alternative way of estimating standard errors which does not rely on any a priori given distributional form (Efron, 1979, Efron and

To compare the two hypotheses we use the Davidson-MacKinnon (1981, 1993) J-test for non-nested models. [18]

4. Results

4.1 Econometric findings: ICT as a special vintage of physical capital

ICT diffusion data, measured through our chain indexes, illustrate the uneven spread of this technology around the world.[19] To illustrate this point just consider that 79% of the Internet users lives in the OECD countries which account only for the 14% of the world population. While in the United States, Sweden, Iceland and Norway half of the population has access to Internet, in countries like India, in which one of the most important districts of ICT innovation is located, only the 0.4% of the population used Internet in 1999.

Tables 1-6 at the end of paper provide results on various tests of our general argument that consideration of ICT contribution in levels and growth estimates significantly improves the standard MRW-Islam model. Our

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Stein, 1981; Efron and Tibshirani, 1986). More specifically, in each trial of the bootstrapping procedure we draw with replacement N observations from the N observation dataset (therefore in each trials some countries may have higher weight and other countries may not be included in the sample). We perform two thousands of trials and for each of them we calculated the coefficient magnitude. The estimate of the standard error of that statistics then depends on the variability of the estimate in the different trials. In this sense, and given that in each trial of the bootstrapping procedure we draw with replacement N observations from the N observation dataset, bootstrapping measures the sensitivity of the result to changes in the number of observations.

[18] According to the Davidson-MacKinnon (1981, 1993) approach, given two non-nested specifications, A1 and A2, specification A1 is the correct one if fitted values of the dependent variable from A2 do not have explanatory power when estimating A1, while fitted values of the dependent variable from A1 have explanatory power when estimating A2. The test is not conclusive if fitted values from A1 and A2 are not significant when added as regressors in the alternative specification.

[19] Results are reported in appendix for reasons of space.

econometric analysis tries also to discriminate the relative contribution of the two different hypotheses on how the ICT operates.

We repeat the experiment six times by considering two different measures of physical capital investment before ICT weighting (Summers-Heston and World Bank physical capital) and three different proxies of human capital investment (secondary school net enrolment rates, simple and quality adjusted schooling years of the working population). We also test the robustness of the different versions of the model to the inclusion of variables controlling for the role of institutional factors[20] and evaluate whether the impact of ICT persists when we instrument it in order to reduce the risk of endogeneity in our results.

Our main finding is that the ICT-weighted measure of physical capital significantly improves the goodness of fit of the MRW specification in levels. For instance, the comparison between first and second column in Table 1 shows that, with a constant number of observations, the overall R^2 passes from 55 to 79 percent in our specification just by replacing MRW physical capital with our ICT-adjusted measure without the inclusion of any additional variable. The strong reduction of the significance of fixed effects in panel estimates when introducing

[20] As a measure of institutional factors we use the Economic Freedom Index (published in the *Economic Freedom of the World: 2001 Annual Report* and currently available for 123 countries). The index provides a tentative measure of cross-country differences in economic freedom and, indirectly, of quality of institutions and economic policies. Its key ingredients are personal choice, voluntary exchange, freedom to compete, protection of person and property. The index is an average of economic freedom in five major areas: size of government, legal structure and security of property rights, access to sound money, freedom to exchange with foreigners and regulation of credit, labour and business (see table A7 in Appendix).
The index for many countries is calculated back to 1970. As in the case of our ICT, also for the Economic Freedom Index the problem of missing data reduces the comparability of the index ratings over time. In order to correct for this problem, the Frazer Institute has constructed a *Chain-Weighted Summary Index*

the ICT-weighted physical capital suggests that part of them incorporates differences in technology across countries. This result is an implementation of the Islam (1995) interpretation in its panel estimates of country specific fixed effects which he finds significantly and positively correlated with growth rates and human capital and interpret as country specific technology effects. Some of these technology effects, though, are necessarily time varying and therefore require time varying indicators to be captured. Our estimates demonstrate that the time varying component matters since the improvement in goodness of fit is in the between, but also, and for a substantial part, in the within R squared (from .25 to .48).

In the same estimates we find that the human capital factor share is below the boundaries indicated by MRW for the US case (except for the specifications with ICT2 and average schooling year), while the magnitude of the physical capital factor share is higher than that found in MRW, but it cannot be interpreted in the usual way after the ICT weighting.

The improvement obtained under our first hypothesis is robust to changes in the measures of physical, (for WB physical capital compare columns 1-2, 4-5, 7-8 while for PWT physical capital, compare columns 10-11, 13-14 and 16-17 in Table 1) and human capital (secondary school net enrolment rates in columns 1-2 and 10-11, average schooling years in columns 4-5 and 13-14 and average schooling years corrected for quality in columns 7-8 and 16-17 of Table 1) and remains substantial when we control for institutional quality and estimate the model with instrumental variables.[21]

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that is based on the 2000 rating as a base year. Results are reported in tables A2-A5 in appendix for reasons of space.

[21] Results are reported in appendix for reasons of space (Table A2 in Appendix)

In all considered specifications coefficients pass several tests on restrictions imposed by the MRW-Islam model, such as those on i) diminishing returns on physical and human capital, ii) nonzero physical and human capital shares and iii) equality between the sum of the physical and human capital coefficients and the coefficient on the variable which adds up rates of change in population and in technological progress plus depreciation. Note that restriction iii) is almost always rejected in the MRW-Islam base specification, while accepted in our modified specification.

The most interesting feature of our results is that the improvement in goodness of fit is larger when we apply the ICT1 weighting to the WB than to the PWT measure of investment in physical capital (compare changes in goodness of fit between columns 1 and 2, 4 and 5, 7 and 8 against columns 10 and 11, 13 and 14, 16 and 17 respectively in Table 1). We interpret this result by arguing that PWT correction takes into account the quality of physical capital and therefore partially reduces the benefit of the ICT1-weighted correction. On the other hand, since our ICT1-weighted nonetheless significantly improves upon PWT physical capital as well, we are led to conclude that it may represent a more efficient and easier way to correct raw figures of physical capital investment for quality and domestic market structure adjustment.

If we look at Table 2 in the same perspective, we find that the adoption of the ICT indicator which includes access prices dramatically reduces the improvement in goodness of fit of hypothesis one with respect to the MRW-Islam specification, consistently with the idea that access pricing factors are more suitable for describing the bottleneck than the quality improvement hypothesis

4.3 Econometric findings: ICT as a bottleneck reducing labour augmenting technology

The specification in which the ICT1 index is introduced as a proxy of the labour augmenting technological factor (consistently with our second hypothesis) further improves the goodness of fit of the model (even though in this case we must consider that we are introducing an additional regressor) with respect to the MRW-Islam specification, but not always with respect to our hypothesis 1 (see Table 1). The significance of the ICT variable is robust to changes in our measures of physical (WB in columns 1 to 9, PWT in columns 10 to 18 in Table 1) and human capital (secondary school net enrolment rates in columns 1-3 and 10-12, average schooling years in columns 4-6 and 13-15 and average schooling years corrected for quality in columns 7-9 and 16-18) and robust to the use of lagged values as instruments or to the inclusion of controls on institutional quality.[22]

In terms of the magnitude of the effect of the additional ICT regressor we find that a doubling of ICT1 generates a change from 17 to 20 percent in levels of real per capita GDP (Table 1), while the output elasticity of ICT2 is much higher and around 100 percent (Table 2).

Thus an important result is that our ICT2 indicator under the second hypothesis appears to be not significantly different from one, or slightly above that value, consistently with what assumed in (4”). This means that the ICT2 factors almost contribute to explain the overall labour augmenting component.

[22] Results are omitted for reasons of space and are available upon request (Table A2 in Appendix)

Consider also that the inclusion of the ICT component reduces the output elasticities of physical and human capital. The reasonable interpretation for this finding is that part of the contribution of physical and human capital to output depends on ICT technology. The former are overstated if the latter is not accounted for.

4.4 Econometric findings: a direct comparison of the two hypotheses and the mixed hypothesis

Results commented in the previous sections induce us to evaluate the relative superiority of one ICT dimension (quality improvement of physical capital) over the other (bottleneck reducing factor). The Davidson-MacKinnon (1981, 1993) J-test for non-nested models shows the superiority of hypothesis 1 against hypothesis 2 when we use the ICT1 index and the superiority of hypothesis 2 against hypothesis 1 when we use the ICT2 index. The result is confirmed for both specifications of physical capital investment and for the three proxies of human capital investment (Table 3).

Our findings are reasonable given the composition of the two indexes. ICT1 is more fit for hypothesis 1, since it includes ICT components which represent high-tech vintages of physical capital. ICT2 is more related to the bottleneck hypothesis, since it includes indicators of access prices.

Given that we found that both hypotheses bring different but important improvement in our estimates we wonder whether a mixed hypothesis, which incorporates both of them and tries to take into account both dimensions of ICT (quality improvement of physical capital and reduction of bottlenecks which limit access to knowledge), may be superior to the two different ones when separately tested. For this reason we test the following hypothesis:

Mixed Hypothesis: ICT has two functions. It is both a special vintage of physical capital and a bottleneck reducing labour augmenting technology

The specification adopted for our regression in levels will therefore be

$$\ln\left(\frac{Y_t}{L_t}\right) = c + \ln\left(A_{ICT2(0)}\right) + g_{ICT2}t + \frac{\alpha}{1-\alpha-\beta}\ln\left(s_{k'}\right) + \frac{\beta}{1-\alpha-\beta}\ln\left(s_h\right) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln\left(n+g'+\delta\right) \quad (4''')$$

which is the same as (4”) with the replacement of a raw measure of physical capital investment with our ICT1 corrected measure and with ICT2 used for measuring the bottleneck reducing effect of ICT.

Table 4 presents results of the mixed hypothesis documenting an improvement in the overall R^2 and a reduction in the significance of fixed effects with respect to hypothesis 2. This result holds for all combinations of the two specifications of physical capital and the three proxies of human capital investment and is robust to the inclusion of institutional quality indicators[23].

Consider that, if we compare results from the mixed hypothesis with the base MRW estimate (Table 1), we find that the overall goodness of fit jumps from .55 to .72 with WB physical capital investment and secondary school enrolment ratios, and from .65 to .76 with WB physical capital investment and average schooling years. The most important result, though, is that within group significance <u>is almost doubled</u> in all of these comparisons.

[23] Results about the inclusion of institutional quality indicators are reported in appendix for reasons of space (table A4 in appendix).

These results show that inclusion of the two ICT dimensions mainly helps to capture the two facets of the time varying (country specific) component of technological progress which fixed effects cannot account for.

The Davidson-MacKinnon (1981, 1993) J-test confirms the superiority of the mixed hypothesis showing that it dominates hypothesis 2 for all the six different combinations of physical and human capital investment (table 5). Since the mixed hypothesis and hypothesis 1 are nested and the introduction in the specification under hypothesis 1 of the bottleneck reducing ICT component is significant, the mixed hypothesis improves upon hypothesis 1 as well.

4.5 Econometric finding: growth estimates

Results on cross-sectional convergence estimates are roughly in line with the existing literature. Table 6 provides mainly tests of hypothesis 1 (and only one test of hypothesis 2). It shows that our ICT-growth model performs better than the MRW model and that the physical capital (not significant in the MRW case with the WB variable), corrected for ICT1, becomes significant. In our modified specification a 100 percent increase of ICT adjusted physical capital investment generates an effect on rates of growth in the range of 16-27 percent. Again, the ICT-corrected investment in physical capital proves to be much sharper than the WB investment, as the ICT weighting incorporates corrections for the already mentioned quality and market structure components, not measured by WB data.

If we arbitrary set $(n+g+\delta)$ equal to 0.05 for all countries our implied λ is larger that in MRW and lower than in Solow (1956) and in Islam (1995). It is also larger when we introduce ICT variables. One possible interpretation of this result is that in our sample period convergence looks faster because it is conditioned to variables relevant in our model.

Our results are confirmed (with some exceptions) when we use bootstrap standard errors and are therefore robust to changes in sample composition and independent from the assumption of a specific functional form for the dependent variable.

We explain the limited number of growth estimates in the first place from paucity of observations and degrees of freedom in cross-sectional estimates. On the other hand, if we test the growth equation with panel estimates, given the short time intervals considered, it is plausible that hypotheses of conditional convergence are not met and that estimates in repeated five year intervals are weaker than those performed in the larger thirty year sample period of cross-sectional specifications[24].

[24] This evidence is available from the authors upon request.

5. Conclusions

The MRW empirical framework of the augmented Solow-Swann model explains only a limited part of the differences in levels and growth of per capita GDP across countries. Part of its limits are in the too arbitrary restrictions on the effects of technological progress, which is assumed to be a residual component constant in time and across countries. Islam fixed effect panel approach provides an important improvement on this point by modeling technological progress as different across countries but invariant in time, successfully rejecting the MRW original hypothesis.

In this paper we aim to go one step beyond by providing a richer description of the role of technological progress which takes into account also the recent ICT advancements. We argue that ICT is, on the one side, a high quality component of the latest vintages of physical capital stock and, on the other side, a bottleneck reducing factor easing access of individuals to public knowledge available in the internet. We therefore device a chain index of ICT diffusion which we use i) to adjust for quality traditional measures of physical capital investment and ii) as an independent variable proxying an important component of the Solow residual augmenting the productivity of labour.

We show that the specification which includes both dimensions of ICT is superior to the Islam's and to our two specifications in which each of the two ICT dimensions is separately considered. Our conclusion is supported by proper diagnostics and mainly driven by the fact that within group significance is doubled with respect to the MRW-Islam estimates. These results show that i) our simple ICT adjusted measure of physical capital investment seems to solve in a easier way problems in comparability of raw physical capital investment across countries which PWTs try to solve with international survey data and that ii) the inclusion of the two ICT dimensions captures the two facets of the time varying (country specific) components of technological progress which fixed effects cannot account for.

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Table 1 The determinants of levels of real per capita GDP in panel regressions with fixed effects

ICT1																		
Variables	Sk=World Bank investment to GDP ratio									Sk=Penn World Tables' investment to GDP ratio								
	Sh=Schoolsecnet			Sh=Averschool			Sh=Averschoolqua			Sh=Schoolsecnet			Sh=Averschool			Sh=Averschoolqua		
	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2
ln(s_k) (1)	.185**	.182**	.147**	.182**	.192**	.151**	.147**	.181**	.132**	.181**	.170**	.126**	.219**	.182**	.157**	.217**	.174**	.164**
	[4.49]	[14.83]	[4.27]	[4.03]	[13.27]	[3.92]	[3.17]	[11.77]	[3.26]	[5.27]	[14.63]	[4.32]	[5.76]	[13.46]	[4.71]	[5.61]	[12.31]	[4.77]
ln(s_h) (2)	.348**	.131**	.122**	.559**	.151**	.133**	.525**	.160**	.139**	.363**	.158**	.139**	.583**	.191**	.171**	.552**	.193**	.185**
	[10.65]	[4.28]	[3.87]	[11.90]	[3.00]	[2.52]	[11.07]	[3.12]	[2.60]	[11.13]	[5.23]	[4.31]	[12.56]	[3.98]	[3.21]	[11.85]	[4.00]	[3.43]
ln(n+g+δ) (3)	-.287**	-.153	-.135	-.517**	-.270**	-.242**	-.444**	-.247**	-.214**	-.304**	-.196**	-.190**	-.449**	-.215**	-.204**	-.375**	-.178**	-.175**
	[-2.84]	[-1.83]	[-1.59]	[-4.66]	[-2.87]	[-2.49]	[-3.95]	[-2.55]	[-2.14]	[-2.82]	[-2.16]	[-2.10]	[-4.08]	[-2.23]	[-2.09]	[-3.40]	[-1.81]	[-1.76]
ln(ICT1)			.189**			.200**			.190**			.183**			.189**			.177**
			[13.86]			[12.46]			[11.28]			[13.36]			[11.72]			[10.53]
constant	8.536**	9.398**	9.408**	6.987**	8.989**	9.058**	7.252**	9.021**	9.098**	8.536**	9.279**	9.240**	7.238**	9.063**	9.105**	7.545**	9.158**	9.172**
	[31.51]	[40.17]	[40.20]	[23.63]	[30.36]	[29.99]	[24.27]	[29.89]	[29.62]	[28.50]	[36.18]	[35.96]	[23.94]	[30.00]	[29.71]	[24.81]	[29.91]	[29.60]
H_0: Joint insignificance of fixed effects	165.88 (0.00)	106.94 (0.00)	102.62 (0.00)	145.05 (0.00	96.24 (0.00)	93.56 (0.00)	141.96 (0.00)	93.54 (0.00)	90.51 (0.00)	124.90 (0.00)	88.22 (0.00)	88.63 (0.00)	111.63 (0.00)	80.95 (0.00)	80.86 (0.00)	114.44 (0.00)	80.07 (0.00)	79.82 (0.00)
F-test	48.18(0.00)	133.13(0.00)	100.21(0.00	60.10(0.00)	133.82(0.00)	100.77(0.00)	49.12(0.00)	106.52(0.00)	80.47(0.00)	54.28(0.00)	134.96(0.00)	102.37(0.00)	65.58(0.00)	133.16(0.00)	99.96(0.00)	56.47(0.00)	109.57(0.00)	82.01(0.00)
R^2 overall	0.55	0.79	0.80	0.60	0.80	0.81	0.63	0.81	0.82	0.66	0.83	0.83	0.70	0.84	0.84	0.71	0.84	0.84
R^2 between	0.53	0.77	0.77	0.57	0.80	0.81	0.57	0.81	0.82	0.65	0.81	0.81	0.70	0.85	0.85	0.69	0.85	0.85
R^2 within	0.25	0.48	0.48	0.30	0.49	0.50	0.27	0.45	0.45	0.28	0.49	0.49	0.32	0.49	0.49	0.30	0.46	0.46
α	0.121	0.139	0.116	0.105	0.143	0.118	0.088	0.135	0.104	0.117	0.128	0.100	0.122	0.133		0.123	0.127	0.122
β	0.227	0.100	0.096	0.321	0.112	0.104	0.314	0.119	0.109	0.235	0.119	0.110	0.324	0.139	0.129	0.312	0.141	0.137
H_0: β=0	171.05(0.00)	21.68(0.00)	18.39(0.00)	259.40(0.00)	10.89(0.001)	7.91(0.005)	223.75(0.00)	11.96(0.00)	8.57(0.004)	204.49(0.00)	33.69(0.00)	24.04(0.00)	327.33(0.00)	20.27(0.00)	14.00(0.00)	289.52(0.00)	20.59(0.00)	16.38(0.00)
H_0: 1+2= -3	4.69(0.031)	3.09(0.080)	2.01(0.157)	3.20(0.074)	0.49(0.485)	0.15(0.699)	3.26(0.072)	0.77(0.382)	0.27(0.606)	3.76(0.053)	1.77(0.184)	0.50(0.481)	7.61(0.006)	2.24(0.135)	1.23(0.269)	9.31(0.002)	3.09(0.079)	2.29(0.131)
Countries	104	104	104	88	88	88	82	82	82	101	101	101	86	86	86	80	80	80
Obs	538	538	538	503	503	503	478	478	478	528	528	528	498	498	498	473	473	473

Legend: the proxies used for *sk* and *sh* are indicated in the column header (under hyp.1 sk is the product of physical capital investment and ICT1) (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality) ; *g* is $g_{ICT}+g_{KP}$ where g_{ICT} is the growth rate of ICT1 and g_{KP} is assumed constant across countries; *ICT1* is the technological chain index constructed using data on telephone mainlines, on personal computers and on internet users (for details see section 3.1). All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications). See table A6 in appendix for the list of countries included in each regression.

Table 2 The determinants of levels of real per capita GDP in panel regressions with fixed effects

	ICT2																	
	Sk=World Bank investment to GDP ratio									Sk=Penn World Tables' investment to GDP ratio								
	Sh=Schoolsecnet			Sh=Averschool			Sh=Averschoolqua			Sh=Schoolsecnet			Sh=Averschool			Sh=Averschoolqua		
Variables	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2	MRW-Islam	Hp1	Hp2
$\ln(s_k)$ (1)	.171**	.275**	.145**	.149**	.287**	.137**	.097	.247**	.094	.204**	.267**	.133**	.242**	.314**	.162**	.240**	.310**	.159**
	[3.61]	[6.56]	[3.58]	[2.87]	[6.24]	[3.19]	[1.80]	[5.14]	[2.10]	[4.79]	[7.28]	[3.54]	[5.26]	[8.12]	[4.10]	[5.11]	[7.92]	[3.9
$\ln(s_h)$ (2)	.425**	.407**	.325**	.611**	.584**	.470**	.558**	.543**	.436**	.442**	.427**	.340**	.637**	.616**	.498**	.594**	.580**	.469**
	[10.29]	[10.35]	[8.91]	[10.74]	[10.81]	[9.70]	[9.70]	[9.87]	[8.93]	[10.71]	[10.91]	[9.10]	[11.55]	[11.97]	[10.26]	[10.69]	[11.24]	[9.61]
$\ln(n+g+\delta)$ (3)	-.397**	-.432**	-.369**	-.529**	-.580**	-.464**	-.412**	-.484**	-.383**	-.331**	-.324**	-.324**	-.495**	-.500**	-.444**	-.388**	-.399**	-.369**
	[-3.06]	[-3.50]	[-3.33]	[-3.96]	[-4.60]	[-4.21]	[-3.03]	[-3.74]	[-3.41]	[-2.59]	[-2.66]	[-2.92]	[-3.85]	[-4.14]	[-4.09]	[-3.00]	[-3.30]	[-3.37]
ln(ICT2)			1.205**			1.306**			1.237**			1.150**			1.208**			1.130**
			[10.33]			[11.33]			[10.83]			[9.64]			[10.36]			[9.85]
constant	8.086**	8.307**	8.794**	6.651**	6.935**	7.823**	7.039**	7.244**	8.054**	8.400**	8.696**	8.920**	6.914**	7.256**	7.860**	7.341**	7.650**	8.125**
	[23.14]	[24.76]	[28.75]	[18.39]	[20.01]	[24.84]	[19.14]	[20.45]	[25.36]	[23.39]	[25.12]	[28.20]	[19.37]	[21.30]	[24.94]	[20.42]	[22.38]	[25.78]
H_0: Joint insignificance of fixed effects	169.09 (0.00)	181.82 (0.00)	226.68 (0.00)	153.75 (0.00)	164.75 (0.00)	218.12 (0.00)	152.29 (0.00)	159.50 (0.00)	209.68 (0.00)	130.96 (0.00)	140.84 (0.00)	170.86 (0.00)	125.95 (0.00)	136.15 (0.00)	169.67 (0.00)	134.77 (0.00)	143.13 (0.00)	175.21 (0.00)
F-test	43.34(0.00)	57.31(0.00)	71.34(0.00)	45.47(0.00)	60.48(0.00)	82.50(0.00)	34.57(0.00)	45.41(0.00)	67.40(0.00)	47.89(0.00)	61.89(0.00)	70.93(0.00)	53.53(0.00)	72.00(0.00)	83.02(0.00)	43.86(0.00)	60.79(0.00)	69.97(0.00)
R^2 overall	0.59	0.60	0.53	0.65	0.67	0.59	0.69	0.70	0.67	0.68	0.70	0.60	0.72	0.74	0.67	0.74	0.76	0.73
R^2 between	0.55	0.56	0.50	0.62	0.64	0.60	0.64	0.66	0.66	0.65	0.67	0.58	0.70	0.73	0.68	0.70	0.73	0.72
R^2 within	0.32	0.38	0.50	0.34	0.40	0.55	0.29	0.35	0.52	0.34	0.40	0.50	0.38	0.45	0.56	0.35	0.42	0.53
α	0.107	0.163	0.099	0.085	0.153	0.085	0.059	0.138	0.061	0.124	0.158	0.090	0.129	0.163	0.098	0.131	0.164	0.098
β	0.266	0.242	0.221	0.347	0.312	0.292	0.337	0.303	0.285	0.269	0.252	0.231	0.339	0.319	0.300	0.324	0.307	0.288
H_0: β=0	173.68(0.00)	163.01(0.00)	123.64(0.00)	223.37(0.00)	205.72(0.00)	169.46(0.00)	187.27(0.00)	171.24(0.00)	142.94(0.00)	202.76(0.00)	196.56(0.00)	140.77(0.00)	286.53(0.00)	282.93(0.0)	215.81(0.0)	245.18(0.0)	249.38(0.0)	188.95(0.00)
H_0: 1+2= -3	1.94(0.165)	3.41(0.066)	0.69(0.407)	2.46(0.118)	4.37(0.037)	1.38(0.241)	2.68(0.103)	4.69(0.031)	1.43(0.233)	4.56(0.034)	7.13(0.008)	1.34(0.248)	6.83(0.009)	9.97(0.002)	2.97(0.086)	9.11(0.003)	12.91(0.00)	4.19(0.042)
Countries	72	72	72	59	59	59	53	53	53	71	71	71	59	59	59	53	53	53
Obs	357	357	357	329	329	329	304	304	304	354	354	354	328	328	328	303	303	303

Legend: the proxies used for *sk* and *sh* are indicated in the column header (under hyp.1 sk is the product of physical capital investment and ICT2) (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality); *g* is $g_{ICT}+g_{KP}$ where g_{ICT} is the growth rate of ICT2 and g_{KP} is assumed constant across countries; *ICT2* is the technological index constructed using data on telephone mainlines, on personal computers and on internet users (for details see section 3.1). All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications). See table A6 in appendix for the list of countries included in each regression.

Table 3 Davidson-MacKinnon J-test on non-nested hypotheses

Ict improving physical capital (Hp1) vs Ict removing bottlenecks which limit access to public knowledge (Hp2)				
Variables	ICT1		ICT2	
	Hp2 fitted in Hp1 model	Hp1 fitted in Hp2 model	Hp2 fitted in Hp1 model	Hp1 fitted in Hp2 model
Sk: PWT physical capital Sh: average schooling years of the working population	0.378	0.000	0.000	0.554
Sk: PWT physical capital Sh: average schooling years corrected for quality	0.704	0.000	0.000	0.692
Sk: PWT physical capital Sh: secondary school net enrolment ratio	0.114	0.000	0.000	0.202
Sk: WB physical capital Sh: average schooling years of the working population	0.254	0.000	0.000	0.478
Sk: WB physical capital Sh: average schooling years corrected for quality	0.188	0.000	0.000	0.799
Sk: WB physical capital Sh: secondary school net enrolment ratio	0.330	0.000	0.000	0.168

According to the Davidson-MacKinnon (2002) approach, given two non-nested specifications A1 and A2, specification A1 is the correct one if fitted values of the dependent variable from A2 do not have explanatory power when estimating A1, while fitted values of the dependent variable from A1 have explanatory power when estimating A2. The test is not conclusive if fitted values from A1 and A2 are not significant when added as regressors in the alternative specification. The test is performed for different proxies of physical (sk) and human capital (sh) in an eight (interval) 5-years panel estimate.

Table legend:

ICT1, *Hp2 fitted in Hp1 model.* H_0: fitted values of the dependent variable from Hp2 specification do not have explanatory power when estimating Hp1 specification.

Hp1 fitted in Hp2 model. H_0: fitted values of the dependent variable from Hp1 specification do not explanatory power when estimating Hp2 specification.

ICT2, *Hp2 fitted in Hp1 model.* H_0: fitted values of the dependent variable from Hp2 specification do not explanatory power when estimating Hp1 specification.

Hp1 fitted in Hp2 model. H_0: fitted values of the dependent variable from Hp1 specification do not have explanatory power when estimating Hp2 specification.

Table 4 The determinants of levels of real per capita GDP in panel regression with fixed effects: the mixed hypothesis

Variables		Sk=World Bank investment to GDP ratio			Sk=Penn World Tables' investment to GDP ratio		
		Schoolsecnet	Averschool	Averschoolqua	Schoolsecnet	Averschool	Averschoolqua
$\ln(s_{k''})$	(1)	.135**	.118**	.093**	.137**	.126**	.110**
		[8.74]	[6.36]	[4.68]	[8.84]	[6.91]	[5.66]
$\ln(s_h)$	(2)	.183**	.274**	.291**	.197**	.281**	.284**
		[5.02]	[5.00]	[5.23]	[5.48]	[5.37]	[5.43]
$\ln(n+g+\delta)$	(3)	-.329**	-.365**	-.325**	-.295**	-.341**	-.294**
		[-3.31]	[3.55]	[-3.06]	[-2.95]	[-3.30]	[-2.77]
ln(ICT2)		.655**	.813**	.861**	.591	.700*	.715*
		[5.26]	[6.02]	[6.29]	[4.61]	[5.03]	[5.08]
constant		8.957**	8.493**	8.535**	9.071**	8.558**	8.658**
		[31.21]	[26.71]	[26.36]	[32.11]	[26.79]	[26.71]
H_0: Joint insignificance		122.16	119.90	110.47	97.96	95.08	96.38
of fixed effects		(0.00)	(0.00)	(0.0)	(0.00)	(0.00)	(0.00)
F-test		101.99(0.00)	98.82(0.00)	76.40(0.00)	102.57(0.00)	99.41(0.00)	78.33(0.00)
R^2 overall		0.72	0.76	0.78	0.80	0.81	0.82
R^2 between		0.71	0.77	0.78	0.76	0.81	0.82
R^2 within		0.59	0.60	0.55	0.60	0.60	0.56
α		0.102	0.085	0.067	0.103	0.090	0.079
β		0.139	0.197	0.210	0.148	0.200	0.204
H_0:β=0		31.92(0.00)	35.26(0.00)	39.40(0.00)	38.88(0.00)	41.13(0.00)	42.29(0.00)
H_0:1+2= -3		0.01(0.911)	0.05(0.815)	0.26(0.613)	0.12(0.725)	0.34(0.563)	0.76(0.383)
Countries		72	59	53	71	59	53
Obs		357	329	304	354	328	303

Legend: the proxied used for *sh* and *sk''* are indicated in the column header (in the mixed hyp. sk'' is the product of physical capital investment and *ICT1*) (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality); *g* is $g_{ICT}+g_{KP}$ where g_{ICT} is the growth rate of ICT2 and g_{KP} is assumed constant across countries; *ICT1* is the technological chain index constructed using data on telephone mainlines, on personal computers and on internet users; *ICT2* is the technological index constructed on telephone mainlines, on personal computers, on internet users, on internet service provider access charges and on internet telephone access charges (for details see section 3.1). All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications).

Table 5 Davidson-MacKinnon J-test on non-nested hypotheses

	Ict mixed hypothesis (HpM) Vs Ict2 removing bottlenecks which limit access to public knowledge (Hp2)		Ict mixed hypothesis (HpM) Vs Ict1 improving physical capital (Hp1)	
Variables	Hp2 fitted in Hp mixed model	Hp mixed fitted in Hp2 model	Hp1 fitted in Hp mixed model	Hp mixed fitted in Hp1 model
Sk: PWT physical capital Sh: average schooling of the working population	0.330	0.000	(the hypothesis is nested)	0.000
Sk: PWT physical capital Sh: average schooling corrected for quality	0.130	0.000	-	0.000
Sk: PWT physical capital Sh: secondary school net enrolment ratio	0.954	0.000	-	0.000
Sk: WB physical capital Sh: average schooling of the working population	0.825	0.000	-	0.000
Sk: WB physical capital Sh: average schooling corrected for quality	0.972	0.001	-	0.001
Sk: WB physical capital Sh: secondary school net enrolment ratio	0.991	0.000	-	0.000

According to the Davidson-MacKinnon (1989) approach, given two non-nested specifications A1 and A2, specification A1 is the correct one if fitted values of the dependent variable from A2 do not have explanatory power when estimating A1, while fitted values of the dependent variable from A1 have explanatory power when estimating A2. The test is not conclusive if fitted values from A1 and A2 are not significant when added as regressors in the alternative specification. The test is performed for different proxies of physical (sk) and human capital (sh) in an eight (interval) 5-years panel estimate.

Table legend: *Hp2 fitted in HpM model. H_0:* fitted values of the dependent variable from Hp2 specification do not have explanatory power when estimating HpM specification.

HpM fitted in Hp2 model. H_0: fitted values of the dependent variable from HpM specification do not have explanatory power when estimating Hp2 specification

Hp1 fitted in HpM model. H_0: fitted values of the dependent variable from Hp1 specification do not have explanatory power when estimating HpM specification.

HpM fitted in Hp1 model. H_0: fitted values of the dependent variable from HpM specification do not have explanatory power when estimating Hp1 specification

Table 6 The determinants of rates of growth of real per capita GDP in cross-section regression

Variables	Sk=World Bank investment to GDP ratio						Sk=Penn World Tables' investment to GDP ratio					
	Sh=Schoolsecnet		Sh=Averschool		Sh=Averschoolqua		Sh=Schoolsecnet		Sh=Averschoolqua			
	MRW	HP1	MRW	HP1	MRW	HP1	MRW	HP1 - ICT2	MRW	HP1 - ICT1	MRW	HP2 - ICT1
ln(gdpwr0)	-.169**	-.377**	-.230**	-.426**	-.274**	-.440**	-.148	-.203**	-.136**	-.327**	-.171**	-.235**
	[-2.37]	[-3.70]	[-2.99]	[-3.59]	[-4.59]	[-4.00]	[-1.83]	[-3.32]	[-2.97]	[-3.97]	[-2.70]	[-3.60]
ln(sk) (1)	-1.395	.238**	-1.216	.270**	-1.682	.218**	.480**	.208	.385**	.174**	.206**	.160
	[-1.77]	[2.55]	[-1.23]	[2.42]	[-1.80]	[2.30]	[3.30]	[1.96]	[3.36]	[2.83]	[2.01]	[1.65]
ln(sh) (2)	.457**	.244	.746**	.380*	.694**	.444**	.152	.255**	.183	.185	.394**	.146
	[4.65]	[2.08]	[3.90]	[2.00]	[5.79]	[4.81]	[1.39]	[2.48]	[1.95]	[1.77]	[3.00]	[1.63]
ln(n+g+d) (3)	-.753	-.653*	-.991**	-.703**	-1.037**	-.778**	-.845	-1.080**	-.324	-.722**	-.306	-.371
	[-1.82]	[-2.16]	[-2.70]	[-2.25]	[-3.06]	[-2.64]	[-3.51]	[-2.45]	[-1.50]	[-2.21]	[-1.16]	[-1.39]
gICT1												.192**
												[3.33]
ln($ICT1_{(0)}$)												.311**
												[6.31]
constant	2.357	1.007	2.253	1.644	4.056	1.485	.290	-.710	.957	1.298	.625	1.720
	[1.04]	[0.89]	[0.87]	[1.36]	[1.59]	[1.50]	[0.22]	[-0.67]	[1.33]	[1.08]	[0.86]	[1.90]
F-test	12.15(0.00)	9.58(0.00)	5.75(0.00)	5.60(0.00)	10.54(0.00)	10.68(0.00)	9.02(0.00)	9.43(0.00)	7.27(0.00)	7.88(0.00)	5.20(0.010)	16.79(0.00)
R^2	0.34	0.36	0.32	0.33	0.41	0.40	0.44	0.40	0.26	0.42	0.55	0.55
α	-	0.161	-	0.164	-	0.131	0.294	0.142	0.246	0.128	0.129	0.123
β	-	0.165	-	0.230	-	0.267	0.093	0.174	0.117	0.136	0.246	0.112
λ	-	0.034	-	0.030	-	0.030	0.031	0.034	0.032	0.037	0.031	0.038
H_0:β=0	0.01(0.939)	5.17(0.026)	0.29(0.549)	5.58(0.021)	0.00(0.989)	30.79(0.00)	2.65(0.116)	7.27(0.009)	4.42(0.039)	3.88(0.053)	13.97(0.00)	2.95(0.091)
H_0:1+2 = -3	3.01(0.082)	0.27(0.606)	1.51(0.223)	0.03(0.869)	3.41(0.070)	0.17(0.683)	0.35(0.557)	1.74(0.192)	0.85(0.359)	1.09(0.300)	0.98(0.326)	0.06(0.813)
Countries	85	78	70	67	66	63	98	60	74	71	76	68

Legend: *gdpwr0* is the real per capita GDP in the first year of the sample period; the proxies used for *sk* and *sh* are indicated in the column header (under hyp.1 sk is the product between physical capital investment and ICT) (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality); *g* is g_{ICT}+g_{KP} where g_{ICT} is the growth rate of ICT and g_{KP} is assumed constant across countries; *ICT1* is the technological index constructed using data on telephone mainlines, on personal computers and on internet users; *ICT2* is the technological index constructed on telephone mainlines, on personal computers, on internet users, on internet service provider access charges and on internet telephone access charges (for details see section 3.1). All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications).

APPENDIX

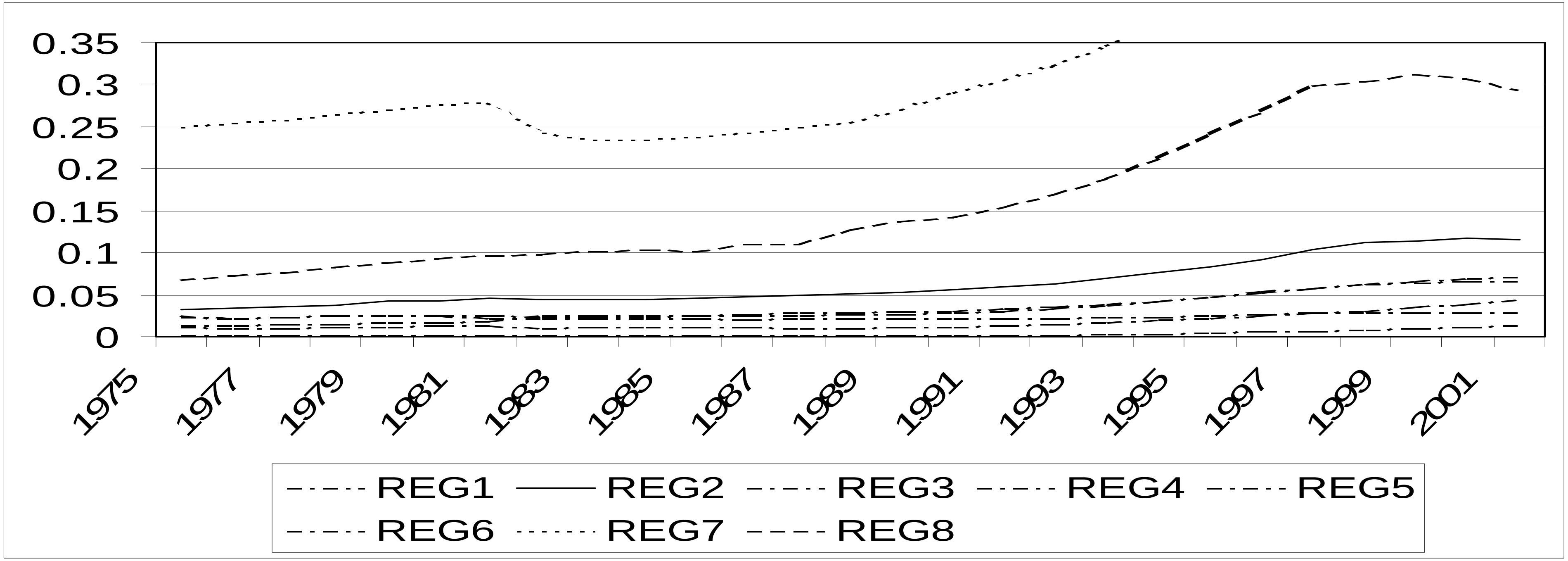
Table A1 Distribution of the dependent variable and regressors used in the econometric analysis

Centile	GDP	Capfor	Skict1	Skict2	Capfis	Skict1H	Skict2H	Schsec net	Aver sch	Aver schQ	ICT1	ICT2	Index free
5	388.308	.105	.0001	.052	.032	.00005	.018	.076	1.6	.968	.0008	.382	3.510
10	515.137	.126	.0002	.067	.048	.00008	.026	.121	2.2	1.696	.0013	.454	3.771
20	808.350	.155	.0005	.083	.072	.00025	.038	.199	3	2.318	.0028	.502	4.339
30	1302.650	.178	.001	.097	.098	.00068	.051	.282	3.859	3.361	.006	.525	4.709
40	2297.398	.198	.002	.109	.117	.00154	.063	.399	4.7	4.219	.012	.540	4.995
50	4091.272	.216	.005	.120	.140	.00307	.072	.508	5.3	4.959	.022	.550	5.324
60	6415.076	.234	.010	.131	.174	.00602	.089	.615	6.145	5.643	.039	.557	5.690
70	10441.160	.252	.018	.142	.207	.01353	.118	.735	7.212	7.141	.067	.569	6.122
80	26412.270	.276	.038	.158	.235	.03509	.138	.853	8.38	8.185	.130	.587	6.576
90	44641.720	.315	.071	.183	.280	.07854	.174	.959	9.4	9.250	.285	.619	7.212
95	56308.300	.349	.101	.207	.314	.10506	.196	1.053	10.2	9.755	.403	.672	7.526
99	82431.630	.435	.138	.253	.404	.14319	.268	1.248	11.7	12.300	.565	.801	8.457
S-WILKS	13.024	7.434	11.386	6.175	7.693	11.595	6.909	7.725	5.721	9.376	12.428	8.627	1.875
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.03040

Legend: *GDP*: real gross domestic product per working-age person; C*apfor*: gross capital formation/GDP ratio (WB data); *Capfis*: Summers-Heston corrected investment/GDP ratio (PWT data); *ICT1:* technological index constructed using data on telephone mainlines (for 1000 people), on personal computers (for 1000 people) and on internet users; *ICT2:* technological index constructed on telephone mainlines (for 1000 people), on personal computers (for 1000 people), on internet users, on internet service provider access charges ($ per 30 off-peak hours) and on internet telephone access charges ($ per 30 off-peak hours); *Skict1*: product between Capfor and the ICT1; *Skict2*: product between Capfor and ICT2; *Skict1H*: product between Capfis and ICT1; *Skict2H*: product between Capfis and ICT2; *Schsecnet:* net secondary school enrolment ratio; *Aversch:* average schooling of the working population; *AverSchQ:* average schooling of the working population corrected for quality; *Index free:* index of the quality of institutions and of economic policies.

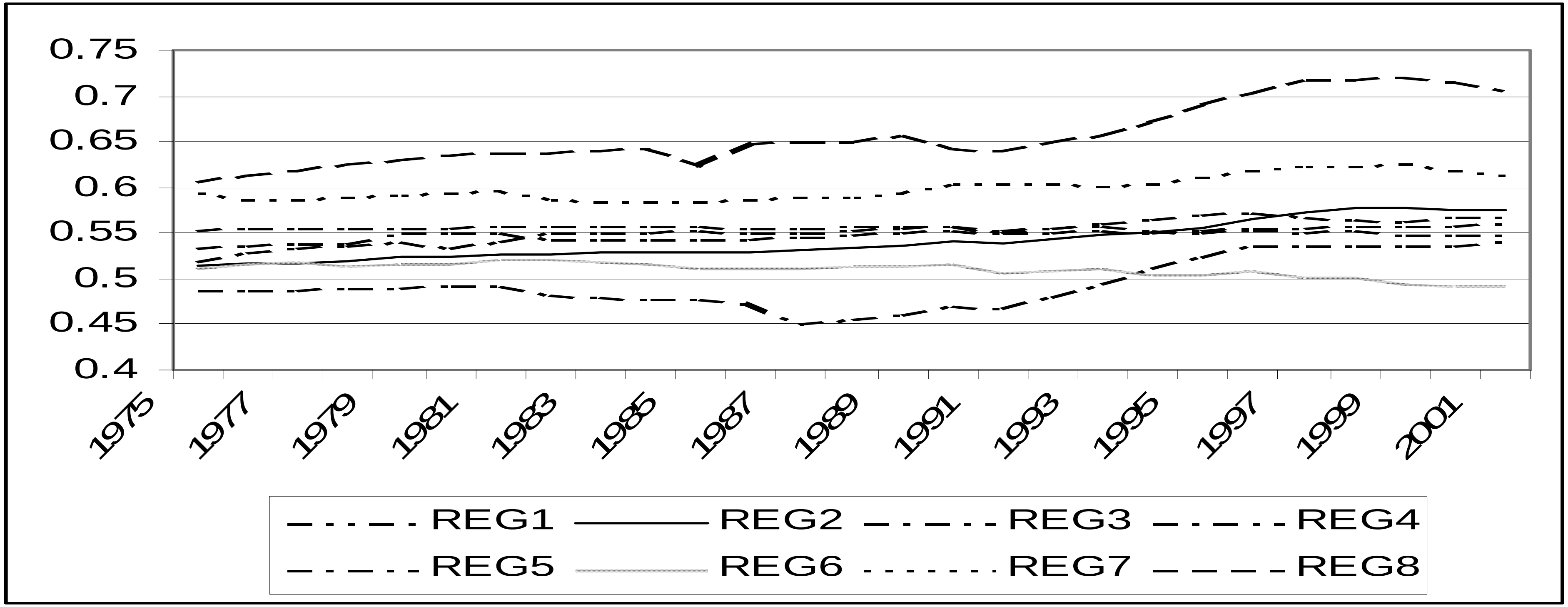
The last two lines show the Shapiro-Wilks normality tests on dependent variable and selected regressors

Figure A1 Dynamic of ICT1 indicators in the eight macroareas



Legend: *ICT1:* technological index constructed using data on telephone mainlines (for 1000 people), on personal computers (for 1000 people) and on internet users; *REG1:* EastAsia&Pacific*; REG2:* Europe&CentralAsia; *REG3:* LatinAmerica&Carribean*; REG4:* MiddleEast&NorthAfrica; REG5: South Asia*; REG6*: Sub-SaharanAfrica*; REG7:* High income OECD*; REG8:* Other high income.

Figure A2 Dynamic of ICT2 indicators in the eight macroareas



Legend: *ICT2:* technological index constructed on telephone mainlines (for 1000 people), on personal computers (for 1000 people), on internet users, on internet service provider access charges ($ per 30 off-peak hours) and on internet telephone access charges ($ per 30 off-peak hours); *REG1:* EastAsia&Pacific*; REG2:* Europe&CentralAsia; *REG3:* LatinAmerica&Carribean*; REG4:* MiddleEast&NorthAfrica; REG5: South Asia*; REG6*: Sub-SaharanAfrica*; REG7:* High income OECD*; REG8:* Other high income.

Table A2 Robustness of the ICT1 indicator to endogeneity and to the inclusion of institutional variables

Variables	ICT1																							
	Sk=World Bank investment to GDP ratio												Sk=Penn World Tables' investment to GDP ratio											
	Sh=Schoolsecnet				Sh=Averschool				Sh=Averschoolqua				Sh=Schoolsecnet				Sh=Averschool				Sh=Averschoolqua			
	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRV + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree
ln(sk) (1)	.147	.157**	.170**	.139**	.149	.152**	.182**	.141**	.126	.114**	.168**	.119**	.133	.147**	.158**	.116**	.163	.183**	.172**	.145**	.180	.177**	.162**	.150**
	[4.84]	[3.96]	[12.97]	[4.05]	[3.55]	[3.45]	[11.94]	[3.65]	[2.88]	[2.52]	[10.31]	[2.93]	[4.62]	[4.42]	[12.66]	[3.99]	[4.62]	[4.80]	[12.02]	[4.30]	[4.98]	[4.59]	[10.74]	[4.31]
ln(sh) (2)	.088	.259**	.112**	.104**	.149	.446**	.128**	.110**	.190	.408**	.136**	.116**	.082	.273**	.136**	.119**	.162	.474**	.168**	.147**	.194	.441**	.169**	.160**
	[2.62]	[7.56]	[3.56]	[3.24]	[2.31]	[8.75]	[2.50]	[2.06]	[2.84]	[7.99]	[2.63]	[2.14]	[2.40]	[7.92]	[4.40]	[3.62]	[2.71]	[9.28]	[3.44]	[2.71]	[3.21]	[8.62]	[3.44]	[2.91]
ln(n+g+d) (3)	-.217	-.248**	-.146	-.131	-.227	-.454**	-.259**	-.232**	-.190	-.372**	-.232**	-.199**	-.214	-.285**	-.197**	-.191**	-.175	-.394**	-.206**	-.194**	-.155	-.314**	-.166**	-.161**
	[-2.48]	[-2.56]	[-1.76]	[-1.55]	[-2.05]	[-4.19]	[-2.77]	[-2.40]	[-1.64]	[-3.39]	[-2.40]	[-2.00]	[-2.18]	[-2.76]	[-2.18]	[-2.12]	[-1.68]	[-3.65]	[-2.14]	[-1.99]	[-1.32]	[-2.91]	[-1.69]	[-1.62]
ln(ICT1)	.137			.175**	.146			.189**	.136			.177**	.134			.169**	.136			.180**	.123			.166**
	[8.46]			[12.17]	[8.37]			[11.33]	[7.50]			[10.02]	[8.34]			[11.73]	[7.66]			[10.75]	[6.75]			[9.45]
ln(indexfree)		.357**	.139	.137		.297**	.119	.118		.306**	.133	.133		.350**	.145	.142		.272**	.109	.111		.276**	.121	.121
		[6.32]	[2.68]	[2.63]		[5.03]	[2.20]	[2.20]		[5.23]	[2.41]	[2.41]		[6.21]	[2.79]	[2.72]		[4.60]	[2.02]	[2.04]		[4.74]	[2.19]	[2.20]
constant	8.771	7.929**	9.100**	9.114**	8.836	6.791**	8.800**	8.869**	8.857	7.062**	8.809**	8.886**	8.808	7.868**	8.946**	8.917**	9.005	7.036**	8.887**	8.930**	9.055	7.347**	8.964**	8.980**
	[35.25]	[28.66]	[35.35]	[35.34]	[25.66]	[23.42]	[28.68]	[28.36]	[25.30]	[24.22]	[28.18]	[27.97]	[31.32]	[25.66]	[31.82]	[31.71]	[27.56]	[23.58]	[28.36]	[28.16]	[25.88]	[24.57]	[28.24]	[28.01]
H_0: Joint insignif. of fixed effects	107.48 (0.00)	150.86 (0.00)	105.06 (0.00)	100.83 (0.00)	93.56 (0.00)	140.06 (0.00)	96.92 (0.00)	94.16 (0.00)	91.41 (0.00)	139.54 (0.00)	94.62 (0.00)	91.57 (0.00)	94.46 (0.00)	122.14 (0.00)	88.29 (0.00)	88.62 (0.00)	85.07 (0.00)	112.54 (0.00)	81.61 (0.00)	81.54 (0.00)	86.68 (0.00)	115.83 (0.00)	80.91 (0.00)	80.67 (0.00)
F-test	45.21(0.00)	49.38(0.00)	103.09(0.00)	82.65(0.00)	45.40(0.00)	54.05(0.00)	102.52(0.00)	82.33(0.00)	37.60(0.00)	46.14(0.00)	82.33(0.00)	66.33(0.00)	43.54(0.00)	53.98(0.00)	104.77(0.00)	84.62(0.00)	44.58(0.00)	56.91(0.00)	101.64(0.00)	81.42(0.00)	39.04(0.00)	50.29(0.00)	84.19(0.00)	67.23(0.00)
R^2 overall	0.77	0.62	0.80	0.80	0.80	0.64	0.80	0.81	0.82	0.66	0.81	0.82	0.83	0.70	0.83	0.83	0.83	0.71	0.84	0.84	0.84	0.73	0.84	0.84
R^2 between	0.75	0.65	0.79	0.79	0.79	0.64	0.81	0.82	0.81	0.63	0.82	0.83	0.81	0.72	0.82	0.82	0.83	0.73	0.85	0.85	0.85	0.72	0.86	0.86
R^2 within	0.39	0.31	0.49	0.49	0.40	0.34	0.50	0.50	0.37	0.32	0.46	0.46	0.38	0.34	0.50	0.50	0.40	0.36	0.50	0.50	0.38	0.34	0.46	0.46
α	0.119	0.111	0.133	0.112	0.115	0.095	0.139	0.113	0.096	0.075	0.129	0.096	0.109	0.104	0.122	0.094	0.123	0.110	0.128	0.112	0.131	0.109	0.122	0.115
β	0.071	0.183	0.087	0.084	0.115	0.279	0.098	0.088	0.144	0.268	0.104	0.094	0.067	0.192	0.105	0.096	0.122	0.286	0.125	0.114	0.141	0.273	0.127	0.122
H_0:β=0	7.95(0.005)	83.44(0.00)	14.82(0.00)	12.60(0.00)	6.80(0.010)	139.19(0.00)	7.46(0.007)	5.16(0.024)	10.88(0.001)	114.39(0.00)	8.29(0.004)	5.62(0.018)	6.63(0.010)	98.42(0.00)	23.45(0.00)	16.49(0.00)	9.74(0.002)	175.06(0.00)	14.89(0.00)	9.65(0.002)	14.29(0.00)	148.09(0.00)	14.99(0.00)	11.42(0.00)
H_0:1+2= -3	0.03(0.857)	2.35(0.126)	2.18(0.140)	1.41(0.236)	0.30(0.586)	1.27(0.243)	0.23(0.631)	0.03(0.858)	0.85(0.357)	1.49(0.222)	0.45(0.501)	0.10(0.748)	0.00(0.99)	1.28(0.259)	0.96(0.328)	0.17(0.676)	1.48(0.224)	4.31(0.039)	1.63(0.202)	0.77(0.381)	2.49(0.116)	5.68(0.018)	2.39(0.123)	1.66(0.198)
Countries	119	104	104	104	93	88	88	88	84	82	82	82	111	101	101	101	91	86	86	86	82	80	80	80
Obs	473	538	538	538	392	503	503	503	365	478	478	478	444	528	528	528	382	498	498	498	358	473	473	473

Legend: the proxies used for *sk* and *sh* are indicated in the column header (under hyp.1 sk is the product between physical capital investment and ICT1); *g* is $g_{ICT}+g_{KP}$ where g_{ICT} is the growth rate of ICT1 and g_{KP} is assumed constant across countries (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality); *ICT1* is the technological index constructed using data on telephone mainlines, on personal computers and on internet users (for details see section 3.1). All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications). See Table A6 for the list of countries included in each regression. In the IV regressions ICT is instrumented with $ln(A_{ICT\ t-1})$, $ln(A_{ICT\ t-2})$ and $ln(A_{ICT\ t-3})$.

Table A3 Robustness of the ICT2 indicator to endogeneity and to the inclusion of institutional variables

Variables	ICT2																							
	Sk=World Bank investment to GDP ratio												Sk=Penn World Tables' investment to GDP ratio											
	Sh=Schoolsecnet				Sh=Averschool				Sh=Averschoolqua				Sh=Schoolsecnet				Sh=Averschool				Sh=Averschoolqua			
	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRV + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree	Hp2-I.V.	MRW + Indexfree	Hp1 + Indexfree	Hp2 + Indexfree
ln(sk) (1)	.135	.146**	.246**	.127**	.155	.125**	.261**	.123**	.122	.068	.215**	.076	.120	.179**	.241**	.117**	.137	.215**	.290**	.148**	.155	.207**	.282**	.141**
	[3.41]	[3.19]	[6.04]	[3.23]	[3.26]	[2.44]	[5.68]	[2.88]	[2.49]	[1.29]	[4.50]	[1.71]	[3.06]	[4.35]	[6.76]	[3.21]	[3.00]	[4.70]	[7.45]	[3.73]	[3.32]	[4.45]	[7.16]	[3.48]
ln(sh) (2)	.233	.321**	.315**	.250**	.376	.486**	.484**	.402**	.403	.424**	.433**	.358**	.223	.338**	.334**	.262**	.374	.522**	.525**	.429**	.406	.472**	.482**	.393**
	[6.09]	[7.27]	[7.48]	[6.48]	[6.41]	[7.52]	[7.86]	[7.38]	[6.62]	[6.54]	[6.96]	[6.56]	[5.67]	[7.64]	[7.94]	[6.62]	[6.13]	[8.23]	[8.84]	[7.81]	[6.46]	[7.43]	[8.14]	[7.12]
ln(n+g+d)(3)	-.360	-.380**	-.415**	-.358**	-.420	-.479**	-.537**	-.437**	-.340	-.347**	-.427**	-.344**	-.419	-.326**	-.320**	-.320**	-.386	-.450**	-.464**	-.417**	-.326	-.332**	-.355**	-.333**
	[-3.24]	[-3.07]	[-3.51]	[-3.36]	[-3.31]	[-3.65]	[-4.31]	[-3.99]	[-2.56]	[-2.61]	[-3.34]	[-3.09]	[-3.41]	[-2.66]	[-2.74]	[-3.00]	[-2.95]	[-3.55]	[-3.88]	[-3.86]	[-2.46]	[-2.62]	[-2.96]	[-3.06]
ln(ICT2)	.951			1.132**	1.217			1.255**	1.161			1.177**	.861			1.084**	1.093			1.164**	1.026			1.082**
	[5.34]			[9.97]	[6.97]			[10.85]	[6.76]			[10.31]	[4.90]			[9.36]	[6.03]			[9.98]	[5.81]			[9.47]
ln(indexfree)		.362**	.328**	.282**		.282**	.232**	.166		.300**	.252**	.187		.351**	.321**	.284**		.251**	.203*	.160		.259**	.211	.174
		[5.29]	[4.99]	[4.74]		[3.77]	[3.23]	[2.63]		[4.08]	[3.52]	[2.99]		[5.17]	[4.92]	[4.75]		[3.46]	[2.94]	[2.56]		[3.66]	[3.12]	[2.83]
constant	8.360	7.406**	7.670**	8.222**	7.974	6.476**	6.766**	7.674**	8.149	6.875**	7.081**	7.903**	8.201	7.700**	8.033**	8.324**	8.040	6.748**	7.100**	7.720**	8.228	7.184**	7.500**	7.987**
	[26.76]	[20.70]	[22.13]	[25.81]	[21.85]	[18.19]	[19.64]	[24.23]	[22.08]	[19.15]	[20.26]	[24.96]	[23.44]	[20.84]	[22.38]	[25.26]	[21.60]	[19.12]	[20.88]	[24.38]	[22.20]	[20.33]	[22.11]	[25.39]
H_0: Joint insignif. of fixed effects	229.46 (0.00)	154.80 (0.00)	166.58 (0.00)	206.31 (0.00)	220.63 (0.00)	145.63 (0.00)	156.57 (0.00)	205.17 (0.00)	212.71 (0.00)	147.29 (0.00)	154.65 (0.00)	202.07 (0.00)	173.07 (0.00)	128.26 (0.00)	137.77 (0.00)	166.26 (0.00)	179.31 (0.00)	125.06 (0.00)	135.01 (0.00)	167.02 (0.00)	186.84 (0.00)	133.94 (0.00)	142.40 (0.00)	173.57 (0.00)
F-test	29.19(0.00)	42.63(0.00)	52.83(0.00)	65.94(0.00)	33.60(0.00)	39.34(0.00)	49.58(0.00)	68.85(0.00)	29.28(0.00)	31.73(0.00)	38.72(0.00)	57.44(0.00)	28.03(0.00)	45.92(0.00)	56.31(0.00)	65.65(0.00)	31.15(0.00)	44.79(0.00)	57.71(0.00)	69.12(0.00)	29.13(0.00)	37.90(0.00)	49.65(0.00)	59.17(0.00)
R^2 overall	0.52	0.65	0.65	0.57	0.58	0.68	0.69	0.60	0.68	0.72	0.72	0.67	0.62	0.72	0.73	0.63	0.64	0.74	0.76	0.67	0.72	0.76	0.78	0.73
R^2 between	0.48	0.65	0.64	0.56	0.56	0.68	0.69	0.62	0.68	0.69	0.70	0.68	0.59	0.72	0.73	0.63	0.65	0.74	0.75	0.69	0.72	0.73	0.75	0.74
R^2 within	0.34	0.38	0.43	0.54	0.44	0.37	0.43	0.56	0.43	0.34	0.39	0.54	0.34	0.40	0.45	0.54	0.42	0.40	0.47	0.57	0.42	0.38	0.45	0.55
α	0.099	0.100	0.158	0.092	0.101	0.078	0.150	0.081	0.080	0.046	0.130	0.053	0.089	0.118	0.153	0.085	0.091	0.124	0.160	0.094	0.099	0.123	0.160	0.092
β	0.170	0.219	0.202	0.182	0.246	0.302	0.277	0.264	0.264	0.284	0.263	0.250	0.166	0.223	0.212	0.190	0.248	0.301	0.289	0.272	0.260	0.281	0.273	0.256
H_0:β=0	52.02(0.00)	84.00(0.00)	83.84(0.00)	62.35(0.00)	68.97(0.00)	109.67(0.00)	111.34(0.00)	97.46(0.00)	75.49(0.00)	81.16(0.00)	85.63(0.00)	75.52(0.00)	45.24(0.00)	97.77(0.00)	100.36(0.00)	69.15(0.00)	64.67(0.00)	142.93(0.00)	155.69(0.00)	121.35(0.00)	74.66(0.00)	113.54(0.00)	129.59(0.00)	98.75(0.00)
H_0:1+2= -3	0.00(0.947)	0.39(0.535)	1.21(0.271)	0.03(0.872)	0.58(0.448)	0.82(0.366)	2.23(0.137)	0.52(0.472)	1.48(0.225)	0.98(0.323)	2.49(0.115)	0.54(0.463)	0.30(0.582)	1.78(0.183)	3.57(0.060)	0.22(0.640)	0.68(0.409)	3.83(0.051)	6.60(0.011)	1.62(0.205)	2.28(0.133)	5.60(0.019)	9.07(0.003)	2.53(0.114)
Countries	86	72	72	72	64	59	59	59	55	53	53	53	80	71	71	71	62	59	59	59	54	53	53	53
Obs	333	357	357	357	265	329	329	329	238	304	304	304	310	354	354	354	258	328	328	328	234	303	303	303

Legend: the proxies used for *sk* and *sh* are indicated in the column header (under hyp.1 sk is the product between the physical capital and ICT2); *g* is $g_{ICT}+g_{KP}$ where g_{ICT} is the growth rate of ICT2 and g_{KP} is assumed constant across countries (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality); *ICT2* is the technological index constructed using data on telephone mainlines, on personal computers and on internet users (for details see section 3.1). All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications). See Table A6 for the list of countries included in each regression. In the IV regressions ICT is instrumented with $ln(A_{ICT\ t-1})$, $ln(A_{ICT\ t-2})$ and $ln(A_{ICT\ t-3})$.

Table A4 Mixed hypothesis with the inclusion of institutional quality indicators

Variables	Sk=World Bank investment to GDP ratio			Sk=Penn World Tables' investment to GDP ratio		
	Schoolsecnet	Averschool	Averschoolqua	Schoolsecnet	Averschool	Averschoolqua
ln(sk) (1)	.121**	.110**	.081**	.122**	.118**	.099**
	[7.48]	[5.79]	[3.94]	[7.57]	[6.31]	[4.87]
ln(sh) (2)	.155**	.244**	.255**	.168**	.252**	.251**
	[4.14]	[4.25]	[4.40]	[4.51]	[4.57]	[4.55]
ln(n+g+d) (3)	-.325**	-.354**	-.306**	-.296**	-.331**	-.277**
	[-3.30]	[-3.45]	[-2.88]	[-2.99]	[-3.21]	[-2.61]
ln(ICT2)	.673**	.813**	.867**	.615	.704	.728**
	[5.46]	[6.04]	[6.38]	[4.84]	[5.07]	[5.19]
ln(indexfree)	.160	.103	.132	.159	.097	.119
	[2.76]	[1.66]	[2.09]	[2.73]	[1.58]	[1.91]
constant	8.612**	8.357**	8.366**	8.713**	8.432**	8.507**
	[28.52]	[25.54]	[25.23]	[28.23]	[25.68]	[25.61]
H_0: Joint insignificance of fixed effects	119.71 (0.00)	112.26 (0.00)	118.87 (0.00)	97.90 (0.00)	95.64 (0.00)	97.49 (0.00)
F-test	85.04(0.00)	80.13(0.00)	62.83(0.00)	85.45(0.00)	80.48(0.00)	64.07(0.00)
R^2 overall	0.76	0.76	0.77	0.80	0.80	0.82
R^2 between	0.72	0.78	0.79	0.77	0.81	0.83
R^2 within	0.60	0.60	0.56	0.61	0.60	0.57
α	0.095	0.081	0.061	0.095	0.086	0.073
β	0.121	0.180	0.191	0.130	0.184	0.186
H_0:β=0	21.38(0.00)	25.23(0.00)	27.54(0.00)	25.87(0.00)	29.45(0.00)	29.32(0.00)
H_0:1+2= -3	0.21(0.650)	0.00(0.999)	0.07(0.792)	0.00(0.953)	0.12(0.728)	0.40(0.528)
Countries	72	59	53	71	59	53
Obs	357	329	304	354	328	303

Legend: the proxied used for *sk* and *sh are* indicated in the column header (under the mixed hyp. sk is the product between the physical capital and *ICT1*); *g* is g_{ICT}+g_{KP} where g_{ICT} is the growth rate of ICT2 and g_{KP} is assumed constant across countries; (*schoolsecnet* is secondary school gross enrolment ratio, *averschool* is average schooling years; *averschoolqua* is average schooling years corrected for quality)*ICT1* is the technological index constructed using data on telephone mainlines, on personal computers and on internet users; *ICT2* is the technological index constructed on telephone mainlines, on personal computers, on internet users, on internet service provider access charges and on internet telephone access charges users (for details see section 3.1); *indexfree* is the index of economic freedom. All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications). See Table A6 for the list of countries included in each regression.

Table A5 Cross-sectional growth estimates with the inclusion of institutional quality indicators

Variables		Sh=Net Secondary School - ICT1 - Indexfreedom			
		Sk=World Bank investment to GDP ratio		Sk=Penn World Tables' investment to GDP ratio	
		MRW + Indexfree	Hp1 + Indexfree	MRW + Indexfree	Hp1 + Indexfree
ln(gdpwr0)		-.218**	-.345**	-.177**	-.357**
		[-2.85]	[-3.57]	[-4.22]	[-4.51]
ln(sk)	(1)	-.142	.194**	.465**	.210**
		[-0.19]	[2.12]	[5.04]	[3.31]
ln(sh)	(2)	.450**	.232**	.193**	.144
		[3.98]	[2.16]	[2.38]	[1.48]
ln(n+g+d)	(3)	-.387	-.408	-.305	-.382
		[-1.46]	[-1.72]	[-1.48]	[-1.63]
ln(indexfree)		.760**	.623**	.457**	.444**
		[3.32]	[3.15]	[2.48]	[2.30]
constant		.580	2.237	1.193	2.219**
		[0.28]	[1.81]	[1.71]	[2.42]
F-test		8.96(0.00)	8.86(0.00)	19.26(0.00)	10.13(0.00)
R^2		0.34	0.42	0.45	0.46
α		-0.109	0.136	0.280	0.155
β		0.344	0.163	0.116	0.106
λ		0.038	0.035	0.030	0.037
H_0:β=0		3.15(0.080)	5.43(0.023)	6.34(0.013)	2.49(0.119)
H_0:1+2= -3		0.01(0.929)	0.01(0.943)	2.31(0.133)	0.01(0.914)
Countries		77	74	82	81

Legend: *gdpwr0* is the real per capita GDP in the first year of the sample period; *sh* is the secondary school net enrolment ratio while the proxy used for *sk* is indicated in the column header (in the hyp.1 is the product between the physical capital and ICT1); *g* is $g_{ICT}+g_{KP}$ where g_{ICT} is the growth rate of ICT1 and g_{KP} is assumed constant across countries; *ICT1* is the technological index constructed using data on telephone mainlines, on personal computers and on internet users; *indexfree* is the index of economic freedom. All regressors are calculated as estimation period averages while the dependent variable has the end of period value. T-stats are in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors (percentile and bias corrected approach with 2000 replications).

Table A6 Individual countries included in the restricted regression with panel data fixed effects

	SEC WB1	SEC SH1	SEC WB2	SEC SH2	AV WB1	AV SH1	AV WB2	AV SH2	AVQ WB1	AVQ SH1	AVQ WB2	AVQ SH2
1	Albania	Albania	Albania	Albania	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria
2	Algeria	Algeria	Algeria	Algeria	Argentina	Argentina	Argentina	Argentina	Argentina	Argentina	Argentina	Argentina
3	Argentina	Argentina	Argentina	Argentina	Australia	Australia	Australia	Australia	Australia	Australia	Australia	Australia
4	Australia	Australia	Australia	Australia	Austria	Austria	Austria	Austria	Austria	Austria	Austria	Austria
5	Austria	Austria	Austria	Austria	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh
6	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Belgium	Belgium	Belgium	Belgium	Belgium	Belgium	Belgium	Belgium
7	Belgium	Belgium	Belgium	Belgium	Benin	Benin	Benin	Benin	Benin	Benin	Benin	Benin
8	Benin	Benin	Benin	Benin	Bolivia	Bolivia	Botswana	Botswana	Bolivia	Bolivia	Botswana	Botswana
9	Bolivia	Bolivia	Botswana	Botswana	Botswana	Botswana	Bulgaria	Bulgaria	Botswana	Botswana	Bulgaria	Bulgaria
10	Botswana	Botswana	Bulgaria	Bulgaria	Brazil	Brazil	Cameroon	Cameroon	Brazil	Brazil	Cameroon	Cameroon
11	Brazil	Brazil	Cameroon	Cameroon	Bulgaria	Bulgaria	China	China	Bulgaria	Bulgaria	China	China
12	Bulgaria	Bulgaria	Central African Republic	Central African Republic	Cameroon	Cameroon	Costa Rica	Costa Rica	Cameroon	Cameroon	Costa Rica	Costa Rica
13	Cameroon	Cameroon	China	China	Canada	Canada	Croatia	Croatia	Canada	Canada	Czech Republic	Czech Republic
14	Canada	Canada	Costa Rica	Costa Rica	Chile	Chile	Czech Republic	Czech Republic	Chile	Chile	Egypt, Arab Rep.	Egypt, Arab Rep.
15	Central African Republic	Central African Republic	Cote d'Ivoire	Cote d'Ivoire	China	China	Egypt, Arab Rep.	Egypt, Arab Rep.	China	China	El Salvador	El Salvador
16	Chad	Chad	Croatia	Croatia	Colombia	Colombia	El Salvador	El Salvador	Colombia	Colombia	Finland	Finland
17	Chile	Chile	Czech Republic	Czech Republic	Congo, Rep.	Congo, Rep.	Finland	Finland	Congo, Rep.	Congo, Rep.	Ghana	Ghana
18	China	China	Egypt, Arab Rep.	Egypt, Arab Rep.	Costa Rica	Costa Rica	Ghana	Ghana	Costa Rica	Costa Rica	Greece	Greece
19	Colombia	Colombia	El Salvador	El Salvador	Croatia	Croatia	Greece	Greece	Cyprus	Cyprus	Honduras	Honduras
20	Congo, Rep.	Congo, Rep.	Finland	Finland	Cyprus	Cyprus	Honduras	Honduras	Czech Republic	Czech Republic	Hungary	Hungary
21	Costa Rica	Costa Rica	Gabon	Gabon	Czech Republic	Czech Republic	Hungary	Hungary	Denmark	Denmark	Iceland	Iceland
22	Cote d'Ivoire	Cote d'Ivoire	Ghana	Ghana	Denmark	Denmark	Iceland	Iceland	Ecuador	Ecuador	India	India
23	Croatia	Croatia	Greece	Greece	Ecuador	Ecuador	India	India	Egypt, Arab Rep.	Egypt, Arab Rep.	Indonesia	Indonesia
24	Czech Republic	Czech Republic	Honduras	Honduras	Egypt, Arab Rep.	Egypt, Arab Rep.	Indonesia	Indonesia	El Salvador	El Salvador	Ireland	Ireland
25	Denmark	Denmark	Hungary	Hungary	El Salvador	El Salvador	Ireland	Ireland	Finland	Finland	Israel	Israel
26	Ecuador	Ecuador	India	India	Finland	Finland	Israel	Israel	France	France	Italy	Italy
27	Egypt, Arab Rep.	Egypt, Arab Rep.	Indonesia	Indonesia	France	France	Italy	Italy	Germany	Germany	Japan	Japan
28	El Salvador	El Salvador	Ireland	Ireland	Germany	Germany	Japan	Japan	Ghana	Ghana	Jordan	Jordan
29	Estonia	Estonia	Israel	Israel	Ghana	Ghana	Jordan	Jordan	Greece	Greece	Kenya	Kenya
30	Finland	Finland	Italy	Italy	Greece	Greece	Kenya	Kenya	Guatemala	Guatemala	Mauritius	Mauritius
31	France	France	Japan	Japan	Guatemala	Guatemala	Malaysia	Malaysia	Honduras	Honduras	Nepal	Nepal
32	Gabon	Gabon	Jordan	Jordan	Honduras	Honduras	Mauritius	Mauritius	Hong Kong, China	Hong Kong, China	Netherlands	Netherlands
33	Germany	Germany	Kenya	Kenya	Hong Kong,	Hong Kong,	Nepal	Nepal	Hungary	Hungary	Nicaragua	Nicaragua

					China	China						
34	Ghana	Ghana	Latvia	Latvia	Hungary	Hungary	Netherlands	Netherlands	Iceland	Iceland	Norway	Norway
35	Greece	Greece	Lithuania	Lithuania	Iceland	Iceland	Nicaragua	Nicaragua	India	India	Pakistan	Pakistan
36	Guatemala	Guatemala	Madagascar	Madagascar	India	India	Norway	Norway	Indonesia	Indonesia	Papua New Guinea	Papua New Guinea
37	Honduras	Honduras	Malaysia	Malaysia	Indonesia	Indonesia	Pakistan	Pakistan	Iran, Islamic Rep.	Iran, Islamic Rep.	Poland	Poland
38	Hong Kong, China	Hong Kong, China	Mali	Mali	Iran, Islamic Rep.	Iran, Islamic Rep.	Papua New Guinea	Papua New Guinea	Ireland	Ireland	Portugal	Portugal
39	Hungary	Hungary	Mauritius	Mauritius	Ireland	Ireland	Poland	Poland	Israel	Israel	Romania	Romania
40	India	India	Morocco	Morocco	Israel	Israel	Portugal	Portugal	Italy	Italy	Senegal	Senegal
41	Indonesia	Indonesia	Nepal	Nepal	Italy	Italy	Romania	Romania	Jamaica	Jamaica	Singapore	Singapore
42	Iran, Islamic Rep.	Iran, Islamic Rep.	Netherlands	Netherlands	Jamaica	Jamaica	Senegal	Senegal	Japan	Japan	South Africa	South Africa
43	Ireland	Ireland	Nicaragua	Nicaragua	Japan	Japan	Singapore	Singapore	Jordan	Jordan	Sri Lanka	Sri Lanka
44	Israel	Israel	Niger	Niger	Jordan	Jordan	Slovak Republic	Slovak Republic	Kenya	Kenya	Sweden	Sweden
45	Italy	Italy	Nigeria	Nigeria	Kenya	Kenya	Slovenia	Slovenia	Korea, Rep.	Korea, Rep.	Switzerland	Switzerland
46	Jamaica	Jamaica	Norway	Norway	Korea, Rep.	Korea, Rep.	South Africa	South Africa	Kuwait	Mauritius	Tanzania	Tanzania
47	Japan	Japan	Oman	Pakistan	Kuwait	Malaysia	Sri Lanka	Sri Lanka	Mauritius	Mexico	Trinidad and Tobago	Trinidad and Tobago
48	Jordan	Jordan	Pakistan	Papua New Guinea	Malaysia	Mauritius	Sweden	Sweden	Mexico	Nepal	Tunisia	Tunisia
49	Kenya	Kenya	Papua New Guinea	Poland	Mauritius	Mexico	Switzerland	Switzerland	Nepal	Netherlands	Turkey	Turkey
50	Korea, Rep.	Korea, Rep.	Poland	Portugal	Mexico	Nepal	Tanzania	Tanzania	Netherlands	New Zealand	Uganda	Uganda
51	Kuwait	Latvia	Portugal	Romania	Nepal	Netherlands	Thailand	Thailand	New Zealand	Nicaragua	United States	United States
52	Latvia	Lithuania	Romania	Russian Federation	Netherlands	New Zealand	Togo	Togo	Nicaragua	Norway	Zambia	Zambia
53	Lithuania	Madagascar	Russian Federation	Senegal	New Zealand	Nicaragua	Trinidad and Tobago	Trinidad and Tobago	Norway	Pakistan	Zimbabwe	Zimbabwe
54	Madagascar	Malawi	Senegal	Singapore	Nicaragua	Norway	Tunisia	Tunisia	Pakistan	Panama		
55	Malawi	Malaysia	Singapore	Slovak Republic	Norway	Pakistan	Turkey	Turkey	Panama	Papua New Guinea		
56	Malaysia	Mali	Slovak Republic	Slovenia	Pakistan	Panama	Uganda	Uganda	Papua New Guinea	Paraguay		
57	Mali	Mauritius	Slovenia	South Africa	Panama	Papua New Guinea	United States	United States	Paraguay	Peru		
58	Mauritius	Mexico	South Africa	Sri Lanka	Papua New Guinea	Paraguay	Zambia	Zambia	Peru	Philippines		
59	Mexico	Morocco	Sri Lanka	Sweden	Paraguay	Peru	Zimbabwe	Zimbabwe	Philippines	Poland		
60	Morocco	Namibia	Sweden	Switzerland	Peru	Philippines			Poland	Portugal		
61	Namibia	Nepal	Switzerland	Tanzania	Philippines	Poland			Portugal	Romania		
62	Nepal	Netherlands	Tanzania	Thailand	Poland	Portugal			Romania	Senegal		
63	Netherlands	New Zealand	Thailand	Togo	Portugal	Romania			Senegal	Singapore		
64	New Zealand	Nicaragua	Togo	Trinidad and Tobago	Romania	Senegal			Singapore	South Africa		
65	Nicaragua	Niger	Trinidad and Tobago	Tunisia	Senegal	Singapore			South Africa	Spain		
66	Niger	Nigeria	Tunisia	Turkey	Singapore	Slovak			Spain	Sri Lanka		

						Republic						
67	Nigeria	Norway	Turkey	Uganda	Slovak Republic	Slovenia			Sri Lanka	Sweden		
68	Norway	Pakistan	Uganda	Ukraine	Slovenia	South Africa			Sweden	Switzerland		
69	Oman	Panama	Ukraine	United States	South Africa	Spain			Switzerland	Syrian Arab Republic		
70	Pakistan	Papua New Guinea	United States	Zambia	Spain	Sri Lanka			Syrian Arab Republic	Tanzania		
71	Panama	Paraguay	Zambia	Zimbabwe	Sri Lanka	Sweden			Tanzania	Trinidad and Tobago		
72	Papua New Guinea	Peru	Zimbabwe		Sweden	Switzerland			Trinidad and Tobago	Tunisia		
73	Paraguay	Philippines			Switzerland	Syrian Arab Republic			Tunisia	Turkey		
74	Peru	Poland			Syrian Arab Republic	Tanzania			Turkey	Uganda		
75	Philippines	Portugal			Tanzania	Thailand			Uganda	United Kingdom		
76	Poland	Romania			Thailand	Togo			United Arab Emirates	United States		
77	Portugal	Russian Federation			Togo	Trinidad and Tobago			United Kingdom	Uruguay		
78	Romania	Senegal			Trinidad and Tobago	Tunisia			United States	Venezuela, RB		
79	Russian Federation	Singapore			Tunisia	Turkey			Uruguay	Zambia		
80	Senegal	Slovak Republic			Turkey	Uganda			Venezuela, RB	Zimbabwe		
81	Singapore	Slovenia			Uganda	United Kingdom			Zambia			
82	Slovak Republic	South Africa			United Arab Emirates	United States			Zimbabwe			
83	Slovenia	Spain			United Kingdom	Uruguay						
84	South Africa	Sri Lanka			United States	Venezuela, RB						
85	Spain	Sweden			Uruguay	Zambia						
86	Sri Lanka	Switzerland			Venezuela, RB	Zimbabwe						
87	Sweden	Syrian Arab Republic			Zambia							
88	Switzerland	Tanzania			Zimbabwe							
89	Syrian Arab Republic	Thailand										
90	Tanzania	Togo										
91	Thailand	Trinidad and Tobago										
92	Togo	Tunisia										
93	Trinidad and Tobago	Turkey										
94	Tunisia	Uganda										
95	Turkey	Ukraine										
96	Uganda	United										

		Kingdom					
97	Ukraine	United States					
98	United Arab Emirates	Uruguay					
99	United Kingdom	Venezuela, RB					
100	United States	Zambia					
101	Uruguay	Zimbabwe					
102	Venezuela, RB						
103	Zambia						
104	Zimbabwe						

Legend: *SEC WB1:* regression with the net secondary school enrolment ratio as proxy of the human capital, the gross capital formation/GDP ratio (WB data) as proxy of the physical capital and with ICT1 index; *SEC SH1*: regression with the net secondary school enrolment ratio as proxy of the human capital, the Summers-Heston corrected investment/GDP ratio (PWT data) as proxy of the physical capital and with ICT1 index; *SEC WB2:* regression with the net secondary school enrolment ratio as proxy of the human capital, the gross capital formation/GDP ratio (WB data) as proxy of the physical capital and with ICT2 index; ; *SEC SH2*: regression with the net secondary school enrolment ratio as proxy of the human capital, the Summers-Heston corrected investment/GDP ratio (PWT data) as proxy of the physical capital and with ICT2 index; *AV WB1:* regression with the average schooling of the working population as proxy of the human capital, the gross capital formation/GDP ratio (WB data) as proxy of the physical capital and with ICT1 index; *AV SH1*: regression with the average schooling of the working population as proxy of the human capital, the Summers-Heston corrected investment/GDP ratio (PWT data) as proxy of the physical capital and with ICT1 index; *AV WB2:* regression with the average schooling of the working population as proxy of the human capital, the gross capital formation/GDP ratio (WB data) as proxy of the physical capital and with ICT2 index; ; *AV SH2*: regression with the average schooling of the working population as proxy of the human capital, the Summers-Heston corrected investment/GDP ratio (PWT data) as proxy of the physical capital and with ICT2 index; *AVQ WB1:* regression with the average schooling of the working population corrected for quality as proxy of the human capital, the gross capital formation/GDP ratio (WB data) as proxy of the physical capital and with ICT1 index; *AVQ SH1:* regression with the average schooling of the working population corrected for quality as proxy of the human capital, the Summers-Heston corrected investment/GDP ratio (PWT data) as proxy of the physical capital and with ICT1 index; *AVQ WB2:* regression with the average schooling of the working population corrected for quality as proxy of the human capital, the gross capital formation/GDP ratio (WB data) as proxy of the physical capital and with ICT2 index; ; *AVQ SH2*: regression with the average schooling of the working population corrected for quality as proxy of the human capital, the Summers-Heston corrected investment/GDP ratio (PWT data) as proxy of the physical capital and with ICT2 index.

Table A7 Components of Index of Economic Freedom

The index published in the *Economic Freedom of the World: 2001 Annual Report* issued by the Frazer Institute is a weigthed average of the five following composed indicators designed to identify the consistency of institutional arrangements and policies with economic freedom:

1 Size of Government: Expenditures, Taxes, and Enterprises

A General government consumption spending as a percentage of total consumption; B Transfers and subsidies as a percentage of GDP; C Government enterprises and investment as a percentage of GDP; D Top marginal tax rate (and income threshold to which it applies); i Top marginal tax rate (excluding applicable payroll taxes); ii Top marginal tax rate (including applicable payroll taxes)

2 Legal Structure and Security of Property Rights

A Judicial independence. the judiciary is independent and not subject to interference by the government or parties in disputes; B Impartial court. a trusted legal framework exists for private businesses to challenge the legality of government actions or regulation; C Protection of intellectual property; D Military interference in rule of law and the political process; E Integrity of the legal syste*m*

3 Access to Sound Money

A Average annual growth of the money supply in the last five years minus average annual growth of real GDP in the last ten years; B Standard inflation variability in the last five years; C Recent inflation rate; D Freedom to own foreign currency bank accounts domestically and abroad

4 Freedom to Exchange with Foreigners

A Taxes on international trade i Revenue from taxes on international trade as a percentage of exports plus imports ii Mean tariff rate iii Standard deviation of tariff rates; B Regulatory trade barriers i Hidden import barriers. no barriers other than published tariffs and quotas ii Costs of importing. the combined effect of import tariffs, licence fees, bank fees, and the time required for administrative red-tape raises the costs of importing equipment; C Actual size of trade sector compared to expected size; D Difference between official exchange rate and black market rate E International capital market controls i Access of citizens to foreign capital markets and foreign access to domestic capital markets ii Restrictions on the freedom of citizens to engage in capital market exchange with foreigners index of capital controls among 13 IMF categories

5 Regulation of Credit, Labor, and Business

A Credit Market Regulations i Ownership of banks. percentage of deposits held in privately owned banks ii Competition. domestic banks face competition from foreign banks iii Extension of credit. percentage of credit extended to private sector iv Avoidance of interest rate controls and regulations that lead to negative real interest rates v Interest rate controls .interest rate controls on bank deposits and/or loans are freely determined by the market; B Labor Market Regulations i Impact of minimum wage. the minimum wage, set by law, has little impact on wages because it is too low or not obeyed ii Hiring and firing practices. hiring and firing practices of companies are determined by private contract iii Share of labor force whose wages are set by centralized collective bargaining iv Unemployment Benefits. the unemployment benefits system preserves the incentive to work; v Use of conscripts to obtain military personnel; C Business Regulations i Price controls. extent to which businesses are free to set their own prices ii Administrative conditions and new businesses. administrative procedures are an important obstacle to starting a new business iii Time with government bureaucracy. senior management spends a substantial amount of time dealing with government bureaucracy iv Starting a new business. starting a new business is generally easy v Irregular payments. irregular, additional payments connected with import and export permits, business licenses, exchange controls, tax assessments, police protection, or loan applications are very rare.

The effect of Information and Communication Technology on Fertility rates in a random coefficient model*

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Abstract

The paper analyzes the relationship between fertility and Information and Communication Technology (ICT) for a large sample of countries in the last thirty years. A random effect model is used to account for the presence of heterogeneity in the link between the two variables across different countries. The approach followed is based on the theory of the non-parametric maximum likelihood estimation of a discrete mixing distribution on a finite number of mass-points. Omitted variable bias is properly taken into account.

Our results show that: i) the transition matrix of fertility rates exhibits characteristics of persistence and bimodality which parallel those well known of the distribution of the real per capita GDP; ii) ICT diffusion has significant negative effects on fertility rates after controlling for human capital and institutional quality; iii) the significant effects of both ICT and education on fertility rates are highly heterogeneous across macroareas and cannot be detected with estimation approaches that assume homogeneous parameters. We interpret this heterogeneity as depending on initial conditions and on country fundamentals which may change the impact of the selected regressors on the dependent variable.

Keywords : ICT diffusion, fertility, random coefficient model, transition matrix

JEL classification codes: J13, O33

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1. Introduction

One of the most surprising aspects in the current fertility literature is the lack of consideration for the role of technology (and, in recent times, especially of ICT technology) as a factor which, by affecting women's empowerment and productivity, could have significant effects on fertility decisions.

Indeed, the existing literature on fertility dwells upon the role of a variety of socioeconomic variables, such as education, work status, employment, religion and age at marriage, as factors which are strongly related to family size.[1] *Female education* can be expected to reduce the desired family size for a large number of reasons. First, under the quantity-quality trade-off between the number of children and the time available for each child, educated women may have higher aspirations for their children and this may reduce their desired family size. Second, female education raises the opportunity cost of women's time and is positively related to the use of contraception and to the adoption of modern social norms. In a similar, but slightly different perspective, the higher initial stock of human capital may lead to lower fertility rates because people shift from saving in the form of children to saving in the form of physical and human capital (Barro and Becker, 1989; Becker, Murphy and Tamura, 1990).

Empirical findings seem strongly in support of this negative relationship. Drezè and Murthi (1999), examine the determinants of the decline of fertility rates in India and find that female education, even after controlling for fixed effects, is the most important factor explaining fertility differences across countries and over time. Riley

[1] Henceforth, desired family size is defined as the number of children that women are willing to have.

(1997) shows that an increase in women's education and labor force participation enhances their power to make decisions about demographic outcomes such as fertility.

Fertility patterns are also affected by various *regional and cultural factors* (Basu, 1992; Mary and Bhat, 1998). For instance, fertility rates tend to be somewhat higher among Muslims than in other communities.

In our search for the determinants of fertility rates we must not forget that reproduction is inextricably linked to *women's roles in family and society*. Using data from Brazil, Thomas (1990) finds that, if the mother, rather than the father, controls household resources, effects on fertility are totally different. In his analysis about Zimbabwe, Hindin (2000) shows that when men dominate all household decisions, women are less likely to approve the contraceptive use (Morgan and Nicaula 1995 and Cleland et al. 1996).

By a multivariate logistic regression model, Dharmalingam and Morgan (1996) argue that women's autonomy could directly affect fertility *as an intermediate factor that transmits or conditions the effects of other variables*. They focus on three measures of women's autonomy: i) perceived economic independence, i.e. whether a woman reports that she can support herself and her offspring without her husband help; ii) freedom to move within and between villages, and iii) spousal interaction, i.e. whether the spouses discuss family finances and desired family size.

The existing literature does not directly consider the effect of technology on fertility rates and limits herself to the description of how ICT affects women's empowerment. Indeed, some recent work indicates that ICT could be a tool for women's active participation. By accessing information and improving communications through ICT, women can improve their status because of the knowledge acquired and the information received. *ICT* is an important tool for women's empowerment because it can be a carrier of education for women and girls, within the context of what has been called "equitable and affordable access".[2]

In addition, as argued by Martinez and Reilly (2002), ICT plays an important role in enabling women and their organizations to access and manage information for the purposes of lobbying advocacy and in organizing for change. In this framework, they have identified many direct benefits to women, such as learning how to save money – resulting in the fact that some women decided to open up bank accounts on the web – and learning how to manage their resources more efficiently. In addition, Martinez and Reilly (2002) show that when women become trainers of other women in ICT, they experience improved reading skills and productivity and they develop ideas for new businesses.

Some of the above described effects of ICT technology on women necessarily imply that ICT is a fundamental driver of productivity gains. Hence, a second fundamental path for the effects of ICT on fertility is productivity itself, and, therefore, also productivity of women.[3] If we consider this link we are led to believe

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[2] Geographical location is still one of the main barriers which prevent women's access to ICT. Indeed, in developing countries women tend to live more than men in rural areas, where access to ICT is less easily available and travel to ICT centres is more difficult due to cost, time and cultural reasons.

[3] The relationship between ICT and productivity has long been debated over the past three decades. In the 1980s and in the early 1990s, empirical research generally did not find relevant productivity improvements associated with ICT investment (Bender, 1986; Loveman, 1988; Roach, 1991; Stokey, 1990). This research showed that there was no statistically significant, or even measurable, association between ICT investment and productivity at any level of analysis chosen. More recently, as new data were made available and new methodologies were applied, empirical investigations have found evidence that in the second part of the 90es ICT investment was associated with improvements in productivity, in intermediate measures, and in economic growth (Oliner and Sichel, 2002; Brynjolfsson and Hitt, 1996 and 2000; Sichel, 1997; Lehr and Lichtenberg, 1999; Jorgenson and Stiroh, 2000). The same authors find similar evidence in 2001 despite the 2001 downward revision of the US GDP and the recession beginning in March 2001 (Oliner and Sichel [2002]; Jorgenson et al. [2002]).

that ICT diffusion generates further increases of opportunity costs of women's time with negative effects on fertility rates.

The interplay of all these factors with initial conditions (ex ante fertility rates) and with deep country fundamentals (culture, religion and social norms) makes it hard to believe that proxies of the above mentioned determinants of fertility rates may have the same effect on the dependent variables in markedly different country environments. In other words, the restriction implicit in traditional estimates with homogeneous coefficients, which requires that human capital, institutions and ICT have the same effects on fertility rates in Sub-Saharan Africa and in OECD countries is clearly untenable. Durlauf et al. (2001) emphasize this point by arguing that being able to tackle the issue of heterogeneity is one of the main goals of current research in this field. This is why we explore the possibility of using an estimation approach (random coefficient model) which keeps into account the possibility of an heterogeneous impact of regressors in different macroareas.

Taking into account all these considerations, the purpose of our paper is to test whether ICT diffusion has negative and significant effects on fertility rates. To do so, we choose to apply a random coefficient approach which allows to consider the effects of ICT, after controlling for sources of variability arising from omitted environmental and socio-cultural factors.

The paper is divided into four sections (including introduction and conclusions). The second section illustrates the choice of variables for the empirical analysis and our random coefficient model. In the third section, we present and comment our descriptive and econometric findings. The most relevant results are: i) the characteristics of persistence and bimodality of fertility rates which parallel those well known of the distribution of the real per capita GDP; ii) the negative relationship between ICT diffusion and fertility after controlling for human capital and institutional quality; ii) the different impact of ICT on fertility across macroareas, which can be detected only with estimation approaches which remove the assumption of homogeneous coefficients.

2 Empirical analysis

2.1 The econometric model

We build for the empirical analysis a panel dataset consisting of data extracted from *WB Development indicators* for 156 countries, averaged over eight non-overlapping 5-year periods between 1970 and 2001. This choice is due to the fact that many variables, such as fertility rates and the proxy of human capital, are recorded only every five years in the database.

In the standard literature, fertility determinants are generally measured by a linear model in which

$$FERT_{it} = \alpha_i + \beta_{it} X_{it} + \varepsilon_{it} \tag{1}$$

where, for each country $i=1,\dots n$ and period $t=1,\dots T$, β_{it} is a vector of coefficients, X_{it} is a vector of explanatory variables and ε_{it} is a residual term assumed to be normally distributed with zero mean and variance σ_{ε}^2 .

To estimate (1) we use a random coefficient model which takes into account model misspecifications, like omitted variables, associating a set of random parameters to some elements of the adopted set of covariates. By this manipulation we explicitly adjust the estimate of model parameters for country specific omitted variables which affect the relationship between fertility and selected regressors with random components (i.e. religious culture, country specific education policies, etc.). In statistical terms, we insert inside our model these omitted variables by assuming that each country has its own regression

$$y_{it} = \gamma_{0i} + \gamma_{1i} X_{it} + \varepsilon_{it} \qquad (2)$$

where ε_{it} are independent and normally distributed with mean 0 and variance σ_i^2 . Conditionally upon the random parameters $\theta_i = [\gamma_{0i}, \gamma_{1i}]'$, the probability density function of y_{it} is

$$F(y_{it}/\theta_i) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2\sigma^2} (y_{it} - \gamma_{0i} - \gamma_{1i} x_{it})^2 \right] \qquad (3)$$

while that of $Y_i = [y_{1t}, \ldots. y_{nt}]'$ is

$$f(Y_i/\theta_i) = \prod_{t=1}^{T} f(y_{it}/\theta_i) \qquad (4)$$

By assuming that θ_i has a probability function p , the marginal (unconditional) distribution of Y_i is then given by the following integral

$$f(Y_i) = \int f(Y_i/\theta_i)\rho(\theta_i)d\theta_i \qquad (5)$$

By assuming independence between observations belonging to different countries, we can write the p.d.f. of the whole sample $Y = [Y'_1, \ldots., Y'_n]'$ as

$$f(Y) = \prod_{i=1}^{N} f(Y_i) \qquad (6)$$

Model parameters are estimated by adopting a non parametric maximum likelihood (NPML) approach (Laird, 1978). We do not assume a particular specification for the p.d.f. p , but estimate it together with the other parameters. Following this approach, the mixture (5) is estimated by a finite mixture of the form

$$f(Y_i) = \sum_{c=1}^{C} \pi_c \prod_{t=1}^{T} f(y_{it} / \theta_c) \quad (7)$$

where $0 < \pi_c < 1$ and $\sum_{c=1}^{C} \pi_c = 1$.

The likelihood of the sample is then

$$L(\theta / Y) = f(Y) \quad (8)$$

$$= \prod_{i=1}^{N} f(Y_i) \quad (9)$$

$$= \prod_{i=1}^{N} \left(\sum_{c=1}^{C} \pi_c f(Y / \theta_c) \right) \quad (10)$$

$$= \prod_{i=1}^{N} \left(\sum_{c=1}^{C} \prod_{t=1}^{T} f(y_{it} / \theta_c) \right) \quad (11)$$

The maximum likelihood estimates of model parameters are computed by using an EM algorithm (Dempster et al. 1977, McLachlan and Krishnan, 1997), which consists in two steps (E and M). In the M step we maximize the complete likelihood

$$L(\theta / Y) = \prod_{i=1}^{N} \prod_{c=1}^{C} \left(\pi_c \prod_{t=1}^{T} f(y_{it} / \theta_c) \right)^{z_{ic}} \quad (12)$$

where z_{ic} is 1 if the observation Y_i has been sampled from the c^{th} component of the mixture and 0 otherwise. In the E step the z's, which are not observed, are treated as missing data, i.e. they are estimated by their expectations

$$\hat{z}_{ic} = \frac{\pi_c f(Y_i / \theta_c)}{\sum_{c=1}^{C} \pi_c f(Y_i / \theta_c)} \quad (13)$$

It can be shown that, at each step, E or M, the likelihood (11) increases.

The sum up, our model allows to consider explicitly country specific components of fertility. Moreover, by applying a random coefficient approach, we do not need to specify other regressors which can affect the relationship between fertility and the ICT indicator, since we implement our model with random parameters which take into account the effects of these latent variables. The model, by introducing a random distribution of parameters, allows us to estimate an unbiased coefficient of the ICT, conditional to the effects of additional unobserved environmental variables, even though these variables are not specified in the model.

2.2 The choice of variables

The dependent variable, *TOTFERT*, as defined from World Bank (2003), is the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates. *TOTFERT* is based on data from registered successful births from vital registration systems, or, in absence of such systems, from censuses or sample surveys. As long as these surveys are fairly recent, the estimated rates can generally be considered reliable measures of fertility in the recent past. Where no empirical information on age specific fertility rates is available, a model is used to estimate the percentage of births to adolescents. For countries without vital registration systems, fertility rates are generally based on extrapolations from trends observed in censuses or surveys from earlier years.

When considering potential proxies of human capital we take into account that the use of school enrollment ratios (commonly used in most applied empirical works) has been subject to severe criticism since current enrollment ratios represent human capital investment of future and not of current workers. We therefore prefer to use average schooling years of the working population calculated by Barro and Lee (2001), who build their variable on attainment levels based on UNESCO's International

Standard Classification of Education (ISCED) (no schooling, incomplete first level, complete first level, entered the first cycle of second level, entered second cycle of second level and entered higher level).

Even this measure needs further refinement. The specification of human capital by average schooling years implicitly gives the same weight to any year of schooling acquired by a person, regardless of the efficiency of the educational system, of the quality of teaching, of the educational infrastructure, or of the curriculum.

To encompass this problem, we use the Hanushek and Kimko's (2000) educational quality index, conveniently normalized by Wößmann (2003) for each country with a measure of relative quality. To obtain a quality-adjusted human capital specification, Wößmann combines the quality and the quantity with world average rates of return on education at the different educational levels.

In order to measure the technological factor, we consider an ICT index which is composed by data on telephone mainlines (for 1000 inhabitants), on personal computers (for 1000 inhabitants), and on internet users[4]. Data on internet users are based on estimates derived from reported counts of internet service subscribers, or calculated by multiplying the number of internet hosts by an estimated multiplier.

Data on individual components of our ICT index are more complete in recent than in earlier years. As a result, changes in the ICT index over time may reflect the fact that some components are missing in some years, but not in others. The problem of missing values threatens the comparability of the index over time. In order to

[4] Telephone mainlines are defined as telephone lines connecting a costumer's equipment to the public switched telephone network. Personal computers as self-contained computers designed to be used by a single individual. Internet users indicate people with access to the worldwide network.

correct for this problem, we calculate a chain-weighted ICT Index[5]. Thus our *ICT index* has been constructed in two steps. In the first, missing data of personal computers are chained with telephone mainlines data (measured almost every year and in almost all sample countries from 1960). Our assumption here is that unobserved changes in PC diffusion are proxied by changes in the observed diffusion of telephone mainlines. After the construction of the series of PCs, we normalise cross-sectionally absolute values in each year using the formula $(V_{ti}-V_t\min)/(V_t\max-V_t\min)$, obtaining values in the range 0-1 for all sample countries (0 being the minimum and 1 the maximum value of personal computers for 1000 people in the same year and in the different countries). In the second step, missing data of internet are obtained with the same approach adopted for previously built personal computer data using for chains the composite telephone-PC indicator. The series of internet users is normalized cross-sectionally, as well. Finally, we calculate the Chain-Weighted ICT Index giving the weight of 2 to internet users normalized data, the weight of 2 to personal computers normalized data and the weight of 1 to telephone mainlines normalized data[6].

In order to measure the institutional quality of a country, we use the index on Regulation of Credit, Labor and Business. This index is one of the five major areas

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[5] Chain indexes are typically used to reconstruct series with incomplete or missing past information. Among the wide range of applications, see Whelan (2002) for a comment on the use of chain indexes for reconstruction of the National Income and Product Accounts (NIPA) on behalf of the US Department of commerce, Nordhaus (2001) for an application to productivity indexes and the Frazer Institute (2001) for the definition of indicators of economic freedom which we will use as control variables in our estimates.

[6] PCs and internet accession are given higher weight under the assumption that they are a sharper proxy of ICT advancement and fruition than telephone mainlines. Sensitivity on changes of these weights provides results (available from the authors upon request) that are substantially unchanged with respect to those illustrated in the paper.

which compose the Economic Freedom Index (2001).[7] Considering the individual component of this index which measures factors limiting freedom in these three aspects of economic activity we expect that: i) increased freedom in these fields enhances returns to talents; ii) higher flexibility in the labour market, generally correlated with reduced protection of women employment status in case of pregnancy, increases opportunity costs in the fertility choice.

3. Results

3.1 Descriptive analysis

In the last forty years we assisted to a rapid change in the reproductive behaviour with an aggregate decrease of 41% in fertility rates at the world level. Table 1 presents descriptive statistics of total fertility rates, calculated each five years

[7] The Regulation of Credit, Labor, and Business is an aggregate index which weights the following components: A) Credit Market Regulations i Ownership of banks. percentage of deposits held in privately owned banks ii Competition. domestic banks face competition from foreign banks iii Extension of credit. percentage of credit extended to private sector iv Avoidance of interest rate controls and regulations that lead to negative real interest rates v Interest rate controls .interest rate controls on bank deposits and/or loans are freely determined by the market; B) Labor Market Regulations i Impact of minimum wage. the minimum wage, set by law, has little impact on wages because it is too low or not obeyed ii Hiring and firing practices. hiring and firing practices of companies are determined by private contract iii Share of labor force whose wages are set by centralized collective bargaining iv Unemployment Benefits. the unemployment benefits system preserves the incentive to work; v Use of conscripts to obtain military personnel; C) Business Regulations i Price controls. extent to which businesses are free to set their own prices ii Administrative conditions and new businesses. administrative procedures are an important obstacle to starting a new business iii Time with government bureaucracy. senior management spends a substantial amount of time dealing with government bureaucracy iv Starting a new business. starting a new business is generally easy v Irregular payments. irregular, additional payments connected with import and export

between 1960 and 2001 and averaged across macroareas. In the 1960, Middle East and North Africa (region 4) and Sub-Saharan Africa (region 6) had the highest fertility rate (respectively 7.14 and 6.52). In 2001, the Sub-Saharan Africa rate fell to 5.15 (-21% with respect to 1960). All other regions exhibit much stronger reductions with the High Income non OECD (region 8), East Asia and Pacific (region 1) and Latin America (region 3) countries registering respectively a decrease of 61%, 55% and 53%. In this final year Europe and Central Asia (region 2) and High Income OECD countries (region 7) exhibit the lowest fertility rates, respectively 1.63 and 1.60.

Only four countries (Denmark, Finland, Norway, Sweden and the United Kingdom) had a total fertility rate already lower than the substitution level in 1975. Moreover, total fertility rates increased from 1975 to 2000 only in five countries: Cuba, Cyprus, Finland, Luxembourg and the United States. The highest increase was in the United States (17%), followed by Luxembourg (16%).

From the available evidence we can identify in 1960 two broad groups. The first is characterized by fertility rates varying from an average of 2.99 in High Income OECD countries to an average of 3.56 in Europe and Central Asian countries. The second one is characterized by fertility rates varying from an average of 5.15 in the High Income non OECD countries to an average of 7.14 in Middle East countries. In the year 2001 we observe a slightly modified pattern. Europe and Central Asia, High Income OECD and High Income non OECD countries seem to constitute a common block with fertility rates between 1.6 and 3. Latin America and East Asian countries seem to converge to this block. On the other side, Sub-Saharan Africa seems to follow

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permits, business licenses, exchange controls, tax assessments, police protection, or loan applications are very rare.

an independent and non converging path with Middle East and North Africa remaining in the middle.

Figure 2 shows the dynamics of the diffusion of ICT across macroareas. From this figure we find that the diffusion of ICT is much higher in the High Income OECD (region 7), High Income non OECD (region 8) and Europe and Central Asia (region 2) countries than in the remaining macroareas. These regions coincide with those that showed the lowest fertility rates in the observed period.

This evidence on the aggregate ICT index is well described by individual data on internet access. Nowaday 79% of the Internet users live in the OECD countries which accommodate only 14% of the world population. At the end of 2001 the macroareas where ICT is less diffused are South Asia (region 5) and Sub-Saharan Africa (region 6), where internet catches up only the 0.4% of the population[8].

When we finally look at the dynamics of the third relevant variable in our estimate, average schooling years of the working population, we find that Europe and Central Asia, High Income OECD and High Income non OECD countries, which presented already in 1975 higher levels of the above mentioned variable, keep on growing toward a possible point of convergence of 10 years, while East Asia, Latin America and Middle East countries seem to converge toward a lower convergence target of 6 years. Sub-Saharan Africa countries seem to follow an even lower trajectory (figure 3).

In order to explore further the convergence process of fertility rates from 1960 to 2001 we propose an analysis similar to that carried out by Quah (1993, 1995) on per-capita income levels. The distribution of fertility rates at the beginning and at the end

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[8] For instance, in India, which accommodates one of the main global poles of high-tech innovation, only the 0.4% of the population used Internet in 1999.

of the sample period has been divided into five states, delimited by distribution ventiles. State one (five) is that of countries whose fertility rate is within the lowest (highest) ventile of the cross-sectional fertility rate distribution.[9]

Table 2 shows the transition matrix from 1960 to 2001, obtained by calculating the transition probabilities across stages. Beginning of period states are in row, while end of period states are in column so that position in row j and column k measures the probability that a given country is in the state j at the beginning of the period and in state k at the end of the period. The cells in the main diagonal therefore show the probability of remaining in the same stage of fertility from 1960 to 2001.

From the matrix two important characteristics of fertility rates are evidenced: i) persistence (the probability of remaining in the same state is always much higher than the total probability of moving from that state, calculated by summing cells frequencies by rows with the exclusion of the diagonal value); ii) bimodality, or "twin-peakedness" (Quah, 1993) (the probability of remaining in the same state is higher in the first and last states than in the intermediate states. Moreover, the probability of moving from the fourth to the fifth state is much higher than the probability of moving from the fifth to the fourth state).

3.2 Empirical findings

The bimodality in the distribution of the dependent variable is quite evident just by looking at graph 1. This picture shows two peaks corresponding to values of 1.8 and

[9] The distribution of fertility rates, at the time t, is defined as F_t. The evolution of fertility rates is defined by the time series $F_{t+1} = M^*F_t$, where M is the transition matrix that maps F_t into F_{t+1}. The properties of M are described by a (5x5)

6.6 children per woman. This supports our hypothesis that fertility rates may be modeled with a mixing distribution, where the observed density of the dependent variable is a linear combination of C different densities. We assume this hypothesis, neglected by the existing literature, by estimating eq. (1) with a normal mixture using a semiparametric specification and comparing these results with those of more conventional OLS (fixed effects) and MLE estimates which assume that the dependent variable is the outcome of a unique density function.

The first step for a random coefficient model estimated by normal mixtures is the identification of locations and prior probabilities of the mixture. In our case we find that the Bayesian Information Criterion is maximized when considering the optimal number of five mass points. The locations of the five components of the mixture (mass-points) for the three random effects (intercept, ICT and schooling variables) are reported in table 3 with their correspondent probabilities.

Looking at these locations we find that, for each mass-point, ICT has different effects on fertility. The biggest negative effects on fertility characterize the first and the third component of mixture, while the other mass-points show a positive ICT effect on fertility. This is also confirmed by the π_c that shows the prior probability of belonging to that component (table 3).

Results of the random coefficient estimate which incorporate the assumption of coefficients heterogeneity are presented in table 4.

The within-country variance is estimated as .312 with a standard error of .021. The random intercept variance is 4.58 while the random slope of ICT variance is 100.164 with its standard error in parenthesis. From these numbers we can observe

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Markov chain in which the combination (j,k) indicates the probability that a country with fertility rate in 1960 in the stage j evolves in 2001 to the stage k.

that the null hypothesis of homogeneity in the coefficient measuring the impact of ICT on fertility rates is clearly rejected. On the contrary, the variance of the coefficient of the SCHOOL variable gives the impression that it is not significant at the 5% level. Instead a Likelihood Ratio Tests (LRT) shows that the effect of school varies significantly between countries with p-values equal to 0.000[10]. The hypothesis of heterogeneity in the impact on the dependent variable is therefore not rejected also for this variable.

After this first indication of the validity of the RC model we compare its results with those obtained from more standard OLS and MLE estimates.

The first comparison between the two approaches shows that the log-likelihood in the random coefficient model improves with respect to the MLE approach.

Second, mean response coefficients of the independent variables under the RC method are different for the coefficients obtained under the OLS method and in this last case the ICT regressor is not significant. This finding may lead to two different interpretations: the first is that ICT does not affect fertility rates, the second is that it does, but its impact is heterogeneous across different countries or macroareas and, when measured in the aggregate, vanishes.

We find support for this second hypothesis since considered regressors become significant once the possibility of their heterogeneous impact is taken into account. In table 4 we find that the ICT regressor has the expected sign and is statistically significant, also after the inclusion of schooling and economic freedom proxies.

The negative sign of *Averschoolqua* confirms the idea that women's education reduces the desired family size. We identified at least three rationales for this finding

[10] The p-values are obtained by comparing the maximum likelihood of the full and constrained model. The latter is obtained by estimating the model without the random

in our brief survey. First, education increases productivity and opportunity cost of time and offers in addition many working opportunities that are often in conflict with repeated maternity. This can carry better-educated women to desire a smaller number of children. Second, better-educated women can have greater aspirations for their own children. In the trade-off between quantity and quality of children, better-educated women generally choose for greater quality, in the sense of greater potentialities and opportunities offered to their children. Third, better-educated women can be more receptive to modern social norms and familiar planning campaigns. Women's education can therefore accept more easily principles of responsible procreation.

Another expected finding is the negative relationship between fertility and our indicator of freedom in credit, labour and business. This result confirms that easier access to credit and business, and also higher flexibility and easier access to the labour market, increases returns to talents and therefore augments women's opportunity costs in rasing children. More specifically, a more flexible and accessible labour market may increase labour participation of the group whose participation is more elastic to market conditions. All these rationales go in the same direction of postulating a negative effect of regulation on the fertility rate.

The expected negative sign of ICT does not reject our hypothesis on the positive influence of technology on women's empowerment and productivity with negative effects on fertility. Because of ICT, women can make progress toward economic independence and have better access to resources and education. ICT facilitates exchanges among different social groups, allows rapid access to information needed for exchanging, buying, producing, and selling products and leads to increased productivity gains.

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coefficient of the schooling variable.

When we classify countries into five latent groups by allocating them to the group with the largest posterior probability, we find that locations for all random coefficients are similar to those obtained with the prior probabilities (table 5). Remember that numbers in the table illustrate not the overall ICT and schooling effect but country specific deviations from the average effect represented by coefficients in the third column of Table 4. By considering this we find that in all areas the schooling and the ICT coefficients remain negative even after correcting for group specific random components, even though their impact is sometimes magnified, sometimes reduced almost to zero.

When we look at components of the five classes we find that the first class (with a positive deviation on the intercept, an almost negligible but positive deviation on the schooling coefficient and a strong negative deviation on the ICT coefficient) is represented mainly by Catholic and/or South European countries (most of them with high family values and low women participation rates) . Our interpretation is that social norms of these countries are relatively more pro fertility than average (the intercept random effect), education is almost in line with average, while the negative impact of ICT is much stronger than average, since it is through ICT that contacts with different (and more secularized and less fertility oriented) cultural backgrounds is realized.

The second group is much more heterogeneous and evidences a significantly stronger negative impact of schooling and a significantly less negative impact of ICT on fertility. This group includes so many low or middle income countries in which ICT diffusion is so small that it is very likely that all the effect of fertility reduction passes through education (the initial ICT level effect may drive the ICT result). In the third group both ICT and education have significantly more negative effects on fertility than average. This group is very heterogeneous in terms of income and geographical location but has a common feature of strong secularization and absence of strong pro fertility religious groups (Tunisia is one of the most laic muslim countries, France and Germany are highly secularized Christian countries, Mexico is the most laic latinamerican country). The fourth group has small positive deviations from average coefficients and seems quite in line with general world results. The fifth group is probably the one where schooling and ICT negative impact on fertility is weaker. Not surprisingly, most muslim countries are in this group.

4. Conclusions

Cross country regressions generally suffer from a relevant omitted variable bias since many variables affecting both the intercept and the magnitude of the impact of different regressors on the dependent variable are missing or non recordable. The widespread use of panel random or fixed effects solves only partially this problem as it captures time invariant country specific hidden factors, but it is not capable of measuring how these factors affect the magnitude of the impact of the available regressors.

This is clearly the case of the analysis of the determinants of fertility in which many hidden variables, such as cultural norms, the degree of secularization or country specific fertility policies (which may affect the impact of traditional determinants such as schooling on fertility) are hardly measurable and other unnkwnown omitted variables may also bias estimate results.

We try to take seriously the heterogeneity and omitted variable problem by devising a random coefficient estimate in which we calculate random components for the intercept and for two main measured regressors (ICT and schooling).

Our results show that the random coefficient approach has several advantages and provides unexplored insights with respect to the traditional homogeneous parameters approach. It shows that the incapacity of the second in finding significant effects for ICT on fertility rates depends from the impossibility of disentangling the general effect from some significant group specific deviations from it.

More specifically, when we optimally identify five subgroups of countries with significant deviations from non random general parameters we find that the latter becomes highly significant. Furthermore, subgroup deviations from non random general parameters demonstrate to have sensible interpretations. They seem to be strongly affected by three latent factors: pro fertility religious norms of catholic and Islamic culture, the degree of secularization of domestic culture and education, and the digital divide.

In this sense our variable measuring access to ICT seem to proxy the effect on fertility of openness to world highly secularized culture. The effects are strong in countries where ICT has a significant diffusion and where it seems to prevail over religious norms (catholic and South Europe countries). They are much weaker in low income countries suffering from the digital divide and in countries where religious norms are so strong to overcome the ICT openness effect.

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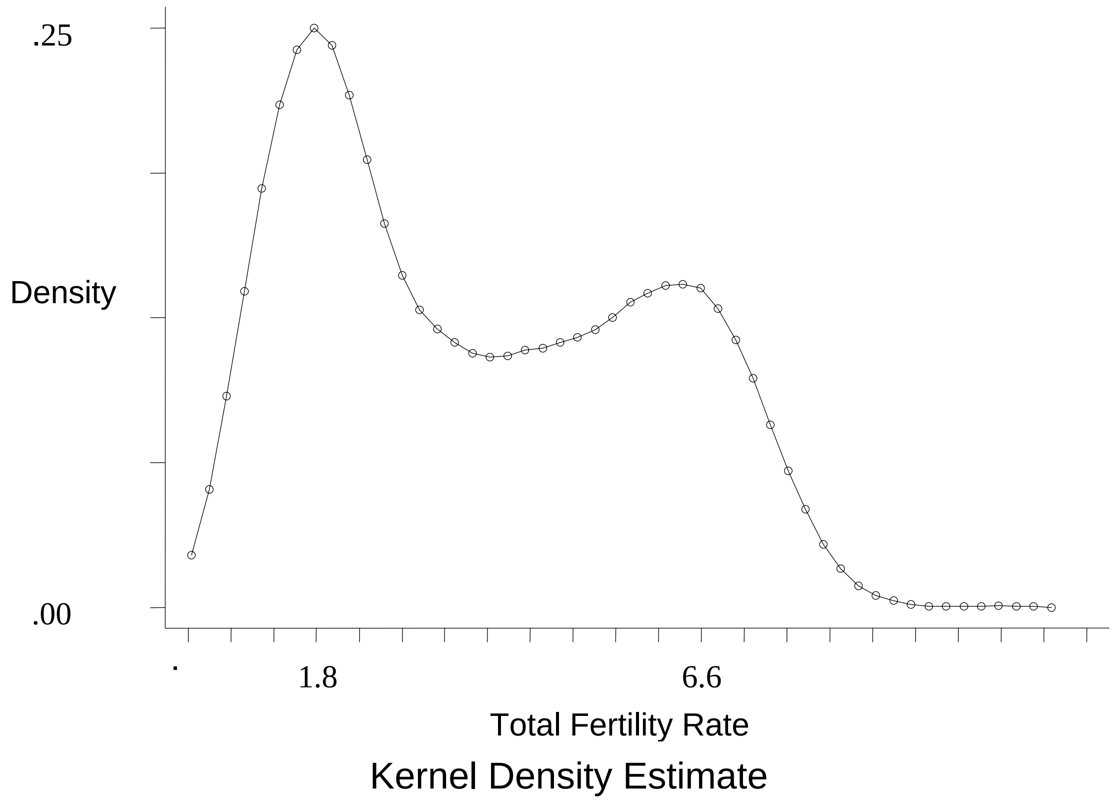
Table 1 Descriptive statistics of total fertility rates in different world macroareas

	Region 1			Region 2			Region 3			Region 4			Region 5			Region 6			Region 7			Region 8		
Year	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
1960	12	5.83	1.004	20	3.556	1.745	23	6.047	1.303	12	7.138	0.304	6	6.408	0.724	41	6.524	0.701	22	2.989	0.823	6	5.15	1.856
1965	12	5.966	0.379	25	3.351	1.597	23	5.821	1.314	12	7.152	0.406	6	6.299	0.858	41	6.553	0.761	22	2.910	0.604	6	4.923	1.885
1970	12	5.642	0.524	26	3.276	1.492	23	5.316	1.301	12	7.057	0.844	6	6.21	1.100	41	6.547	0.858	22	2.536	0.606	6	4.345	1.983
1975	12	5.013	0.968	26	3.110	1.309	23	4.765	1.273	13	6.935	1.297	6	6.043	1.234	41	6.555	0.912	22	2.094	0.522	6	3.767	1.894
1980	12	4.638	1.237	26	2.773	1.088	23	4.287	1.270	13	6.619	1.491	6	5.785	1.360	41	6.523	0.977	22	1.892	0.406	6	3.290	1.670
1985	12	4.315	1.348	27	2.708	1.017	23	3.857	1.148	13	6.017	1.479	6	5.330	1.491	42	6.398	1.023	22	1.706	0.253	6	2.851	1.460
1990	12	3.851	1.313	27	2.460	0.867	23	3.510	1.058	13	5.129	1.391	6	4.742	1.568	42	6.084	1.025	22	1.714	0.271	6	2.497	1.149
1995	12	3.358	1.160	27	1.961	0.799	23	3.194	0.983	14	4.345	1.240	6	4.280	1.638	42	5.671	1.057	22	1.611	0.257	6	2.298	0.992
2000	12	2.998	1.027	27	1.640	0.546	23	2.873	0.856	14	3.744	1.206	6	4.017	1.660	42	5.243	1.043	22	1.608	0.256	6	2.067	0.942
2001	12	2.933	1.003	27	1.634	0.517	23	2.813	0.823	14	3.656	1.189	6	3.958	1.665	42	5.153	1.035	22	1.603	0.251	6	2.008	0.918

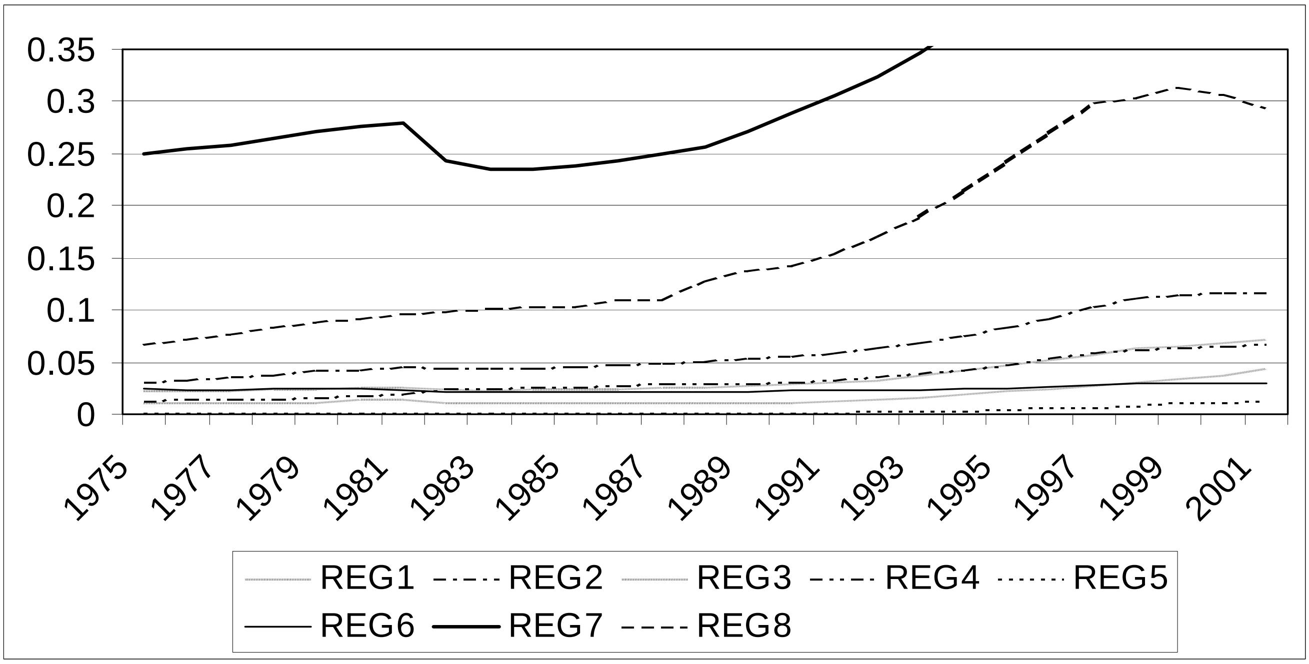
Legend: *REG1:* EastAsia & Pacific; *REG2:* Europe & CentralAsia; *REG3:* LatinAmerica & Carribean; *REG4:* MiddleEast & NorthAfrica; REG5: South Asia; *REG6*: Sub-SaharanAfrica; *REG7:* High income OECD; *REG8:* Other High Income.

Figure 1 Kernel density of total fertility rate



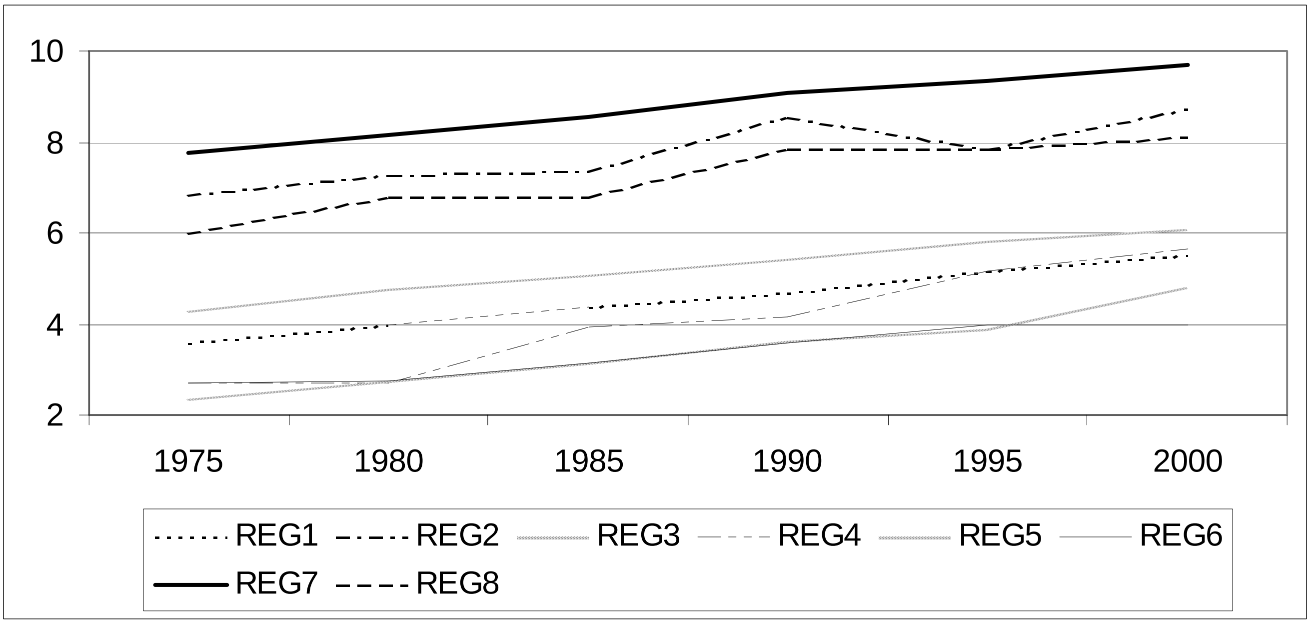
Note: $f(x) = \sum_{c=1}^{C} \pi_c f_c(x)$ where $f_c(x)$ are density function (components) not all necessarily pertaining to the same parametric family; $\pi_c \geq 0$ and $\sum_{c=1}^{C} \pi_c = 1$ (prior probability).

Figure 3 Dynamics of the ICT indicator in the eight macroareas



Note: For definitions of the macroareas, see table 1.

Figure 4 Dynamics of average years of school of the working population in the eight macroareas



Note: For definitions of the macroareas, see table 1.

Table 2 Transition matrix of fertility rate (1960-2001)

N. of Countries			1	2	3	4	5
			2001 State				
243	1	1960 State	0.9095	0.0905	0.0000	0.0000	0.0000
267	2		0.0824	0.8727	0.0412	0.0000	0.0000
237	3		0.0000	0.0464	0.8565	0.0970	0.0000
242	4		0.0000	0.0000	0.0744	0.8306	0.1757
229	5		0.0000	0.0000	0.0044	0.0786	0.8682

The distribution of fertility rates, at the time t, is defined as F_t. The evolution of fertility rates is defined by the time series $F_{t+1}= M^*F_t$, where M is the transition matrix that maps F_t into F_{t+1}. The properties of M are described by a Markov chain 5x5 in which the combination (j,k) indicates the probability that a country with fertility rate in the stage j in 1960 passes to the stage k in 2001.
The first column indicates the total number of countries that, from 1960 to 2001, were in the first, second, …fifth stage.
The cells in the main diagonal show the probability to remain in the same stage of fertility from 1960 to 2001.

Table 3 Locations and prior probabilities of the mixture

N_c	γ_{0i}	$\gamma SCHOOL_i$	γICT_i	π_c
1	2.697	.0571	-30.76	.0785
2	1.637	-.7902	5.625	.1317
3	2.229	-.2258	-4.332	.264
4	-.544	.1113	2.514	.1462
5	-2.466	.3765	6.455	.3797

Table 4 The determinants of fertility rates in the OLS and MLE homogeneous coefficient and heterogeneous random coefficient model

	Homogeneous coefficient model		Heterogeneous random coefficients model
DEPENDENT: Total Fertility rate	OLS	MLE	Family: gaussian - Link: identity
Averschoolqua	-.3160**	-.4042**	-.430**
	[.0195]	[.0289]	[.0499]
ICT	.0059	.8317	-6.953**
	[.5242]	[.5320]	[1.5961]
Credlabus	-.0424	-.0744	-.0790**
	[.0521]	[.0494]	[.0336]
Constant	5.5686**	6.2032**	5.575**
	[.2807]	[.2996]	[.3099]
Log-likelihood		-547.77	-502.214
Number of observations	472	472	472
Number of countries	81	81	81
N_c			5
σ_{ε}^2 (st.dev.)			.312 (.021)
$\sigma_{\gamma O}^2$			4.587
$\sigma_{\gamma ICT}^2$			100.164(31.57)
$\sigma_{\gamma SCHOOL}^2$			.151(18.50)

Legend: *Averschoolqua*: the average schooling of the working population corrected for quality; *ICT*: the technological index constructed using data on telephone mainlines (for 1000 people), on personal computers (for 1000 people) and on internet users; *Credlabus*: the index on Regulation of Credit, Labor and Business. All regressors are calculated as four year averages excluding the final year of the five year time spell, while the dependent variable has the end of subperiod value. Standard errors are in square brackets. N_c identified the number of mixture components which are been selected by BIC criteria (2L(ϑ)-dln (n)); $\sigma_{\gamma O}^2$ is the variance of random intercept; $\sigma_{\gamma ICT}^2$ is the variance of ICT random coefficient; $\sigma_{\gamma SCHOOL}^2$ is the variance of SCHOOL random coefficient. One (*) and two (**) starts denote statistical significance at the 10 and 5 percent level, respectively.

Table 5 Classification of countries into five latent groups (cluster analysis)

Class	Um_0	Um_{SCHOOL}	Um_{ICT}	Freq.
1	2.614	.007	-6.089	12
2	1.374	-.686	5.300	18
3	2.173	-.218	-4.284	13
4	-.614	.120	2.667	25
5	-2.390	.364	6.327	13

Note: The classification is made by allocating countries to the group with the largest posterior probability. Um_0 deviation of subgroup specific coefficient from average sample coefficient of the effects of the intercept on fertility presented in table 4. Um_{SCHOOL} deviation of subgroup specific coefficient from average sample coefficient of the effects of schooling on fertility presented in table 4. Um_{ICT} deviation of subgroup specific coefficient from average sample coefficient of the effects of ICT on fertility presented in table 4.

Group 1: Brazil Chile China Colombia Czech Republic Greece Italy Mauritius Portugal Romania Spain Turkey.

Group 2: Austria Benin Bulgaria Guatemala Iran, Islamic Rep. Kenya Netherlands Pakistan Paraguay Peru Philippines Senegal Singapore South Africa Syrian Arab Republic Tanzania Trinidad and Tobago Zimbabwe.

Group 3: Bolivia France Germany Ghana Honduras Indonesia Jamaica Mexico Nepal Papua New Guinea Sri Lanka Tunisia Venezuela, RB.

Group 4: Argentina Australia Belgium Canada Costa Rica Denmark Ecuador El Salvador Finland Hong Kong, China Hungary India Ireland Japan Korea, Rep. Kuwait Myanmar Nicaragua Norway Panama Poland Sweden Switzerland United Kingdom United States.

Group 5: Algeria Botswana Cameroon Congo Rep., Egypt Arab Rep., Estonia Israel Jordan New Zealand Uganda United Arab Emirates Uruguay Zambia