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Globalization and Employment: Imported Skill Biased Technological Change in Developing Countries

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ABSTRACT

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This paper discusses the occurrence of Skill-Enhancing Technology Import (SETI), namely the relationship between imports of embodied technology and widening skill-based employment differentials in a sample of low and middle income countries (LMICs). In doing so, this paper provides a direct measure of technology transfer at the sector level from high income countries (HICs), namely those economies which have already experienced the occurrence of skill-biased technological change, to LMICs. GMM techniques are applied to an original panel dataset comprising 28 manufacturing sectors for 23 countries over a decade. Econometric results provide robust evidence of the determinants of widening employment differentials in LMICs. In particular, capital-skill complementarity represents a source of *relative skill-bias* while SETI provides an *absolute skill-bias* effect on the employment trends of skilled and unskilled workers witnessed in these countries.

JEL Classification: F16, J23, J24, O33

Keywords: skill biased technological change, capital skill complementarity, GMM estimation, general industrial statistics, world trade analyzer

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1 Introduction

Since the beginning of the 1980s, a growing wage and employment divide between skilled and unskilled workers has been documented in the US (Murphy and Welch, 1992; Juhn *et al.,* 1993; Goldin and Katz, 1999), in the UK (Machin, 1996b), in Japan (Katz and Revenga, 1990) and in other OECD countries (Freeman, 1988; Davis, 1992; Nickell and Bell, 1995 and 1996). The emergence of this common pattern across countries has attracted two main streams of economic research. On one side, many scholars have applied the insights of the classical Stolper-Samuelson (S-S) theorem and related the rising trend of inequality in high-income countries (HICs) to trade with low and middle income (LMICs) economies (Wood, 1995 and 1998; Borjas *et al.*, 1997). On the other side, technology-based explanations have emphasised the role of Skill-Biased Technological Change (SBTC) in shifting relative employment levels between skilled and unskilled labour (Bound and Johnson, 1992).

While a large economic literature has dealt with the determinants of within-country inequality in OECD economies (Katz and Autor, 1999), recent contributions have started to assess the inequality-enhancing effect of the contemporaneous occurrence of economic integration and technology diffusion in LMICs (Robbins, 1996; Harrison and Hanson, 1999; O'Connor and Lunati, 1999; Arbache *et al.*, 2004; Vivarelli, 2004).

This paper discusses the occurrence of Skill-Enhancing Technology Import (SETI), namely the relationship between imports of embodied technology and the employment of skilled and unskilled labour in a sample of LMICs. The aim is to provide clear-cut evidence of the skill bias effect of international technology transfer in countries which rely mainly on this channel for their technological upgrading.

Three aspects make this paper different from other empirical studies in this field. First, this paper provides an original detailed measure of SETI (Section 3.2) while previous research has focused only on indirect proxies of technology transfer across countries. In doing so, we offer a workable procedure for a meaningful conversion of trade-related data into sector data. Second, this study offers a unified multi-country analysis and, thus, it avoids the limitations which characterise country-specific research. In particular, the effect of SETI is investigated through an original time-series cross-sectional dataset of 4934 observations at the sector level for 23 LMICs. Finally, the empirical analysis verifies the hypotheses of "capital-skill complementarity" and "skill-enhancing technology import" by looking at two separate employment equations for skilled and unskilled workers rather than in a single-equation framework.

The remainder of the paper is organized as follows: the discussion about the theoretical framework (Section 2) is followed by the description of the data (Section 3) and the adopted econometric methodology (Section 4). Subsequently, the empirical results obtained from the descriptive analysis (Section 5) and the econometric estimates (Section 6) are discussed. Section 7 concludes this paper by summarising the main findings obtained.

2 Interpretative Background

Two main streams of literature have provided competing theoretical frameworks for assessing the employment evolution of skills over time (Baldwin and Cain, 2000; Moore and Ranjan, 2005). On one side, some scholars have focused on the employment effect of trade and foreign direct investment (FDI) by stressing the role of recipient economies in the international division of labour. On the other side, technology-based explanations have pointed at the intrinsic factor bias of technological change (TC) by neglecting the effect of international trade and/or a country's relative factor endowments. The core of the disagreement between these two approaches refers to the degree of endogeneity between TC and trade, namely which factor has to be ultimately declared responsible for the increase in within-country inequality worldwide. Although starting from different perspectives, these two lines of research have found convergent spots over time in the assessment of the employment effect of international technology transfer. This section provides a comparative survey of these topics.

2.1 The Employment Effect of Economic Integration

The classical Heckscher-Ohlin (H-O) and Stolper-Samuelson (S-S) trade theorems provide an analytical framework consistent with the expansion of international trade and widening skill-based inequality in HICs (Burtless, 1995; Freeman, 1995; Wood, 2000). However, its predicted egalitarian effect in LMICs appears at odds with available empirical evidence of increased within-country inequality (Revenga, 1997; Reuveny and Li, 2003; Taylor, 2004)[1].

The basic dychotomic framework depicted by the H-O/S-S theorem has been extended in three main directions (Slaughter, 1998). These research lines have related the degree of within country inequality to the distributive outcome of a country' specific trade flows. For instance, the skill-based tripartite distinction of the workforce proposed by Wood (1994, p. 213) allows the possibility that international trade may lead to different within-country inequality trends in LMICs[2]. In a similar way, the representation of countries along a skill supply continuum, rather than in a standard North-South framework, suggests that the direction of a LMIC´s trade flows will determine the final distributional outcome[3]. A final departure from the standard H-O/S-S theorem is represented by the classification of traded goods according to their embodied (skill-related) technological content (Dornbusch *et al.*, 1980). Indeed, this setting allows for the possible counter-effects of economic integration on within-country inequality while promoting technological upgrading in LMICs (Francois and Nelson, 1998). Trade economists have advocated the H-O/S-S theorem as a suitable analytical framework

[1] H-O/S-S theory suggests that trade specialisation and FDI inflows should increase the international demand for unskilled labour and, thus, decrease wage dispersion and inequality in unskilled-labour abundant LMICs. In this setting, international trade does not affect the share of real wages/profits since the difference in skill supply represents the unique determinant of trade between HICs and LMICs (Wood, 1994, p. 59).

[2] Indeed, the expansion of labour-intensive manufactured exports may decrease inequality in LMICs with a relatively-abundant supply of basic-educated workers while having uncertain effects in countries with high proportions of no-educated workers (Wood, 1994, p. 246).

[3] Indeed, economic integration with relatively skilled-labour abundant trading partners will produce opposite effects to the ones obtained by trade with relatively unskilled-labour abundant countries (Davis, 1996). The distributional predictions of the H-O/S-S theorem are therefore better identified by looking at a country´s terms of trade in terms of "cones of diversification" (Davis *et al.*, 1996; Davis, 1998).

for explaining long-run distributional dynamics whereas competing trade-based factors, such as the occurrence of defensive endogenous innovation (Leamer, 1994 and 1996), "market stealing" effects and/or "crowding out" of domestic production (Aitken and Harrison, 1999; Beyer *et al.*, 1999; Markusen and Venables, 1999), explain the upward short-run inequality trend in LMICs.

2.2 The Employment Effect of Technological Change

Economic research on the employment effect of Technological Change (TC) goes back to its factor-biased content in the context of growth equations (Hicks, 1932; Harrod, 1939). Economic scholars have mainly focused on the occurrence of both a mismatch technology-based explanation of unemployment and the effectiveness of compensation mechanisms in the labour markets (Myers, 1929; Vivarelli, 1995; Vivarelli and Pianta, 2000)[4]. Research has then moved into the employment impact of TC on different skills by providing a significant amount of evidence of the occurrence of SBTC among OECD countries (Machin and Van Reenen, 1998)[5]. The SBTC hypothesis implies that the exogenous adoption of a new technology will result in a *relative* employment shift from unskilled to skilled workers which rises both *relative* wage and employment levels[6]. Several findings support the SBTC hypothesis against competing explanations of within-country inequality (Baldwin, 1995). First, the predominance of the within-industry component of the overall employment shift of different skills is more consistent with SBTC rather than changes in product demand, trade patterns or Hicks-neutral sector-biased TC. The latter, on the contrary, favour between-industry reallocations towards skill-intensive sectors (Katz and Murphy, 1992). Second, such within-industry employment shifts, coupled with available evidence of higher relative wages, are consistent with the occurrence of a pervasive phenomenon across industries and countries such as the diffusion of SBTC (Bresnahan and Tratjenberg, 1995; Krugman, 1995)[7]. Finally, some authors support SBTC by providing evidence of within-industry correlations between measures of TC and skilled employment (Berndt and Morrison, 1995; Autor *et al.*, 1998)[8].

While the bulk of economic research on the employment effect of TC has focused on HICs, there has been a growing recognition over time of the role of SBTC in rising within-country

[4]Mainstream economic theory has generally downsized the aggregate employment effect of TC (Layard *et al.,* 1991) by likening its occurrence to fluctuating productivity shocks (Lilien, 1982; Nickell, 1990).

[5]Support to the hypothesis of SBTC in the US is offered by Krueger (1993), Murphy and Welch (1993a and 1993b), Levy and Murnane (1996), Doms *et al.* (1997); Siegel (1999); Chay and Lee (2000) and Baltagi and Rich (2005); in Canada by Betts (1997); in the UK by Machin (1996a and 1996b) and Borghans and Well (2003); in France by Greenan *et al.* (2001); in Italy by Piva and Vivarelli (2002 and 2004).

[6]Indeed, this definition does not require an *absolute* decline in the demand for unskilled workers or an *absolute* increase in the demand for skilled workers (Berman *et al.*, 1998; Berman, 2000).

[7]Indeed, such widespread labour market outcomes weaken competing explanations of within-country inequality based on country-specific shifts in domestic labour demand/supply (Wood, 1994 p. 171) or institutional variables, such as the decline in trade unions membership, the real value of the minimum wage and the extent of pay-setting norms (DiNardo *et al.,* 1996).

[8]At the same time, weak within-industry correlations between aggregate imports in HICs and skilled labour stand against the trade-based explanation (Berman *et al.,* 1994). Moreover, the insufficient growth rate of both within-industry capital-output ratios (Berman and Machin, 2000) and the investment share over GDP (Wood, 1994, p. 275) has been interpreted against the hypothesis of capital-skills complementarity (Griliches, 1969).

inequality in LMICs (Cragg and Epelbaum, 1996; Feenstra and Hanson, 1997; Hanson and Harrison, 1999; Pavcnik, 2003). Trade and technology based explanations of within-country inequality have found common analytical patterns in the assessment of the effects of technology transfers to LMICs.

2.3 The Employment Effect of Technology Transfer

International technology transfer represents a crucial determinant of technological upgrading and economic growth in LMICs given the negligible level of aggregate R&D investment in these economies (Rosenberg, 1970; De Long and Summers, 1993; Coe *et al.*, 1997). Economic literature has discussed several channels of international technology diffusion (Reddy and Zhao, 1990; Piva, 2003), such as trade and FDI (Grossman and Helpman, 1990; Bin and Jianmao, 1999; Eaton and Kortum, 2001), licensing, scientific journals, internet, and other sources of cross-borders communication (Schiff *et al.,* 2002). Moreover, trade, imports and imitations of capital goods have entered both endogenous growth (Grossman and Helpman, 1991; Lee, 1995; Hendricks, 2000) and evolutionary "catching-up" models (Fagerberg, 1995). From a theoretical perspective, the relaxation of the H-O hypothesis of technological homogeneity among countries opens the way to the assessment of the within-country employment and inequality effects of technology transfer in LMICs (Acemoglu, 1998; Lall, 1999; Zhu and Trefler, 2001; Cornia 2003 and 2004).

The extent and the timing of the employment effect of technology transfer in LIMCs depend on the interaction between a country´s degree of economic integration, the characteristics of the imported technologies and some specific “absorptive capacities" of recipient economies (Cohen and Levinthal, 1989; Lumenga-Neso *et al.,* 2005)[9]. The autonomous effect of a country´s economic openess may result in a one-off increase in skilled employment due to the international transfer of relatively skill-intensive capital goods and FDI (Feenstra and Hanson, 1996a and 1996b). The extent of such inequality-enhancing effect depends on the intrinsic labour-saving and skill-bias features of imported technologies and it may be reinforced by trade-based adverse competitive effects over time. Indeed, integration among markets increases international competitive pressures and the need for firms in LMICs to modernize. On one side, this may stimulate investments in human capital and, therefore, the occurrence of *defensive skill-bias* (Thoenig and Verdier, 2003). On the other side, firms in LMICs may invest more in the imports of capital goods from HICs. Trade liberalization, therefore, shows a skill-enhancing effect in LMICs (Robbins, 2003) since it induces both capital deepening, which increases relatively skilled employment because of capital-skill complementarities, and SBTC diffusion (Berman and Machin, 2004). Economic literature does not provide clear-cut evidence of the relative importance of these two factors in explaining skill upgrading in LMICs. The methodology and the econometric analysis adopted in this paper aim at providing an answer to this question.

[9] These capacities are strongly related to a LMIC´s labour market institutions (Acemoglu, 2003), skill supply (Schiff and Wang, 2004a and 2004b) and the extent of skill biased organizational changes (Aghion *et al.*, 1999; Aguirregabiria and Alonso-Borrego, 2001; Caroli and Van Reenen, 2001; Caroli *et al.,* 2001; Piva *et al.*, 2005).

3 Dataset and Indicators

The empirical analysis in this paper is based on an original panel dataset characterised by an unbalanced structure comprising 4934 observations representative of 28 three-digit ISIC Rev. 2 manufacturing sectors (Major Division 3) of 23 LMICs over the period 1980 - 1991. The main original data source is the United Nations General Industrial Statistics Vol. 1 (GIS) which provides annual sector data on employment and wage by production categories, value added and capital formation. These variables are merged with the Skill-Enhancing Technology Import (SETI) indicator (Section 3.2) which is computed on data obtained by Statistics Canada´s World Trade Analyzer. This dataset allows to track the economic value of bilateral trade flows worldwide since 1980 at the four-digit level of SITC Rev. 2 classification. Finally, purchasing power parity and GDP deflator are taken from Penn World Tables 6.1 and The World Bank Development Indicators 2004 respectively.

Table 1 provides a list of the variables employed in the empirical analysis and their definitions. Appendix A describes these indicators in more details.

Table 1. List of Variables and Definitions

BC	Number of employees engaged in production activities (or "blue collar")
WC	Number of employees engaged in non-production activities (or "white collar")
WBC	Per-capita wage/payment made to BC workers
WWC	Per-capita wage/payment made to WC workers
VA	Value Added - value of census output less the value of census input
KA	Gross Fixed Capital Formation
SETI	Trade Value of Technology Import
SECTORS	International Standard Industrial Classification Rev. 2 - 28 Man. Sectors
COUNTRIES	23 LMICs - The World Bank Development Indicators - Classification at 1980
YEARS	Annual Observations - Time Period: 1980 - 1991

3.1 Methodological Issues

The absence of exhaustive sources of innovation and employment data in LMICs represents a common problem faced by applied research in this field. Such issue becomes critical in the context of a multi-country study since the lack of comparability between different national data sources restricts the choice of data providers to international agencies only. In particular, the only available dataset which offers data for "operative" and "non-operative" workers at the sector level is the UN-GIS Vol. 1[10]. Nevertheless, the UN-GIS Vol. 1 represents a unique

[10] After 1993, the collection of industrial statistics changed over from UN to UNIDO. However, the new dataset, whose name became UNIDO Industrial Statistics, did not comprise data for "operative" workers by

valuable source of information over the labour market of many LMICs in a very informative decade - the 1980s - which has witnessed the appearance of the globalization process in terms of exponential increase of total real trade between HICs and LMICs (Wood, 1994). This data source allows therefore to gain useful insights over the occurrence of some structural relationships among economic variables such as, in this paper, the impact of technology transfer on within-country inequality in LMICs. Indeed, exactly this approach justifies recent use of this dataset among scholars (Berman and Machin, 2000 and 2004; Zhu, 2005).

The lack of primary data does not represent the only problem tackled by empirical research. The merging procedure of different available datasets allows indeed to overcome the absence of a specific data source on innovation and employment in LMICs. The absence of a direct one-to-one conversion table between trade and sector classifications represents nevertheless a serious challenge for the empirical definition of a measure of technology transfer. Next Section discusses a suitable solution to this problem by offering an original procedure for dealing with a meaningful one-to-one conversion table of SITC values into ISIC values.

3.2 Skill-Enhancing Technology Import (SETI)

The methodological problems discussed in the previous Section have affected economic research in two ways. First, many studies dealing with TC and employment in LMICs have adopted a country-study approach[11]. Second, empirical research adopting a multi-country perspective has been mainly based upon means of indirect tests[12]. Although this line of research has advocated the occurrence (and pervasiveness) of skill-biased technology transfer in LMICs, it does neglect, in fact, a direct measure of technology transfer and, thus, the technologies transferred, the transmission channels adopted and, finally, the actual direct employment impact of technology transfer on different skills in LMICs. In summary, the key issue is that "*... about low-income countries we know very little. Our data are not particularly informative about technology transfer...* " (Berman and Machin, 2004, p. 66). The absence of a direct measure of technology transfer inevitably weakens empirical analysis. Such ideal indicator would make possible a more reliable and straightforward assessment of the casual relationship between TC and employment of different skills in LMICs.

This paper provides an original measure of Skill-Enhancing Technology Import (SETI) which exactly aims at overcoming the use of indirect proxies of technology transfer. This indicator is direct and accountable since it comprises the annual sum of the economic value of trade flows from HICs to each LMIC of those specific goods which reasonably incorporate technological upgrading (Appendix B). Two motivations sustain the strategy adopted in the construction of this variable. First, HICs are also those economies which produce and

providing, instead, an aggregate variable "employees" only. Such methodological shift has resulted in the disturbing lack of updated cross-country statistics on relative employment and wage by production categories.

[11] Some examples are Robbins and Gindling (1999) for Costa Rica; Feliciano (2001) and Lopez-Acevedo (2002) for Mexico; Görg and Strobl (2002) for Ghana; Kang and Hong (2002) for Southern Korea; Mazumdar and Quispe-Agnoli (2002) for Perú; Attanasio *et al.* (2004) for Colombia; Berman *et al.* (2005) for India.

[12] In particular, technology transfer has been proxied by the occurrence of pairwise correlations of within-industry skill upgrading in different countries (Berman *et al.,* 1998) and by cross-country correlations between skill upgrading in LMICs and current and lagged technological variables in OECD countries (Berman and Machin, 2000 and 2004).

employ the most advanced technologies[13]. Second, LMICs have a negligible level of R&D and innovative investment and their (almost) unique channel of technological upgrading is given by the import of TC from HICs (Section 2.3). The indicator of SETI allows, furthermore, a detailed analysis of such trade flows since goods are selected at the highest available level of detail, namely four-digit level of SITC Rev. 2 taxonomy.

However, the choice of such measure arises the above-mentioned problem of value conversion between different taxonomies. This consists in a meaningful distribution of the aggregate SETI value - for instance 445.6 millions of US $ in Peru in 1986 - across recipient ISIC manufacturing sectors in this country. Three competing strategies have been evaluated. The first one requires the definition of a vector of (theoretical) sector weights for each (SITC) imported good - say Electronic Microcircuits - which would describe its final distribution across ISIC sectors. This hypothesis has been rejected because of the computational effort required in providing/assuming reasonable weights over time, across sectors and countries[14]. A second option suggests the aggregation of the total annual value of SETI for each LMICs and, then, its distribution through annual sector input-output tables. Unfortunately, such tables are not available at the necessary level of detail neither for the LMICs discussed in this paper nor for the years of interest.

The adopted choice consists, therefore, in an original procedure which aims at exploiting the different sources of variability available in the dataset without introducing heroic assumptions and possible distorsions in its empirical verification. This is based upon the following hypothesis:

Hypothesis: *An annual SETI value is distributed across the recipient country' sectors in each year by assuming the following relationship:*

$$\frac{(SETI)_{cit}}{Tot(SETI)_{ct}} = Sh(SETI)_{cit} = Sh(KA)_{cit} = \frac{(KA)_{cit}}{Tot(KA)_{ct}} \quad (1)$$

where $Sh(SETI)_{cit}$ and $Sh(KA)_{cit}$ represent the annual share (over total manufacturing) of SETI and KA respectively, for each sector i of country c in year t. A sector's distribution of total manufacturing investment is used to distribute the annual value of SETI received by each LMIC across its different manufacturing sectors. The assumption is that cross-sectoral differences in SETI, in each country and each year, may be reasonably proxied by the inter-sectoral shares of total investment. This means that sectors with a relatively high share of total investment are also those sectors with a higher proportion of SETI in each country.

[13] The following countries are classified as HICs: USA, UK, Italy, Japan, Israel, Switzerland, Sweden, Norway, Germany, France, Netherlands, Australia, Austria, Belgium, Canada, Denmark, Finland, Iceland, New Zealand.

[14] However, an original (unweighted) conversion table has been developed and it is available on request. This comprises the following taxonomies: 5-digit SITC, Rev. 2; 4-digit SITC, Rev. 2; 5-digit SITC, Rev. 3; 4-digit ISIC, Rev. 2; 4-digit ISIC, Rev. 3; SITC - modified by Statistics Canada; BEA - Bureau of Economic Analysis of the U.S. Department of Commerce.

A statistical implication of this hypothesis is that KA and SETI are correlated in one of the three dimensions of variability, namely in the "within-country/year cross-sector" component. This might arise a problem of collinearity in the following econometric exercise. However, two sets of evidence support such allocative procedure among sectors as indicated in the following table:

Table 2. Pairwise Correlations between SETI - KA and KA - Machinery

Source of Variability:	Overall (1)	Country Year (2)	Country Industry (3)	Industry Year (4)	Sectors (5)
SETI - KA	-0.0244	-0.1022	-0.0370	0.1350*	1 (by construction)
Obs.	5015	204	560	336	28
KA - MACH	0.8869**	0.9810**	0.9591**	0.7003**	0.9097**
Obs.	2500	104	299	329	28

Notes:
1) * significant at 5%; ** significant at 1%
2) Each column indicates the source of data variability. For instance column (1) refers to the entire dataset while column (2) means that the dataset does not include observations for different manufacturing sectors within country/years.
3) Column (5) indicates the within-country/year cross-sector variability component only.
4) MACH indicates the investment in machinery and equipment. This variable belongs to the UN-GIS Vol. 1, but the scarce number of observations hampers its direct use in the analysis.

The first group of correlations between SETI and KA indicates that the joint effect of different sources of variability makes these two variables not statistically correlated, except column (4) where the coefficient appears, however, quite small (0.1350). At the same time, the strong significant correlation between KA and MACH (note 4) advocates the assumption described above as a workable solution to the problem of a correct sector distribution of SETI. Indeed, investment in machinery can be considered a good proxy of a sector's potential in implementing embodied technological change.

4 Econometric Issues

This section provides a framework for the theoretical specification of an employment equation and its econometric analysis. The SETI hypothesis, namely the relative increase of skilled employment in LMICs due to the imports of embodied technology from HICs is verified through GMM techniques applied to two distinct equations for skilled and unskilled labour.

4.1 Model Specification

The starting framework for the empirical estimation of an employment equation is given by the consideration of a perfectly-competitive industry operating under the following general constant elasticity of substitution (CES) production function:

$$Y = H[(AL)^{\frac{\sigma-1}{\sigma}} + (BK)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where Y is the output, L and K represent conventional inputs such as labour and capital; H, A and B distinguish a Hicks-neutral, a labour-augmenting and a capital-augmenting technology respectively. The first-order profit-maximization condition for labour allows to express the previous equation in the following format:

$$\ln(L) = \ln(Y) - \sigma \ln(W) + (\sigma - 1)\ln(A) \tag{3}$$

where W indicates real wages (equated with the marginal product of labour) and $\sigma = \frac{1}{(1-\rho)}$ measures the elasticity of substitution between capital and labour (Van Reenen, 1997). This setting may be extended by including some proxies of the unobserved labour-augmenting technology component. Two hypotheses are tested directly in the adopted specification. The first one, that is capital deepening, verifies the importance of capital-skill complementarities (Griliches, 1969; Krusell *et al.,* 2000; Tyers and Yongzheng,2000). Similarly to Berman *et al.* (1994) and Zhu (2005), capital deepening is defined as KA_{cit}/VA_{cit}[15]. The second hypothesis is represented by the SETI indicator (Section 3.2) which is obtained in a similar way ($SETI_{cit}/VA_{cit}$) for comparative reasons.

The empirical analysis focuses, therefore, on the following stochastic specification of the two employment equations:

$$\begin{aligned} BC_{cit} &= \alpha + \beta BC_{cit-1} + \gamma VA_{cit} + \delta WBC_{cit} + KD_{cit} + TID_{cit} + (\varepsilon_i + v_{cit}) \\ WC_{cit} &= \alpha + \beta WC_{cit-1} + \gamma VA_{cit} + \delta WWC_{cit} + KD_{cit} + TID_{cit} + (\varepsilon_i + v_{cit}) \end{aligned} \tag{4}$$

where all variables are expressed in logs. BC_{cit} and WC_{cit} are, respectively, the number of "blue-collar" workers (or operatives) and "white-collars" (or non-operatives) in sector i of country c at time t. VA represents Value Added, WBC and WWC the wage of each skill category. KD indicates capital deepening whereas TID represents the sector share of "technological import deepening" (Table 1 and Appendix A provides a description of the variables adopted in this study). Finally, the error term includes the idiosyncratic individual and time-invariant sector fixed effect ε_i and the usual white-noise error term v_{cit}.

[15]Indeed, the capital-output ratio represents a more correct measure of capital intensity than the capital-labour ratio (Pasinetti, 1981, pp. 180-188).

4.2 Econometric Analysis

This paper adopts a dynamic specification for studying the relationship between TC and skills. This choice is based on the occurrence of significant adjustment costs which determine serial correlation in the employment series (Nickell, 1984; Van Reenen, 1997). Both the presence of sector-specific effects and the dynamic specification of the econometric model lead the pooled ordinary least squares (POLS) estimator to provide inconsistent and upward biased estimates (Sevestre and Trognon, 1985; Hsiao, 2003)[16]. While the presence of sector-specific effects does not affect the within-group (WG) estimator, the violation of the assumption of strict exogeneity makes this estimator inconsistent and downwards biased (Nickell, 1981; Judson and Owen, 1999)[17]. A more effective solution to obtain consistent estimates in a dynamic panel framework is, therefore, to consider a first-difference transformation (Anderson and Hsiao, 1981; Baltagi, 2001) which wipes out time-invariant sector effects and provides consistent estimators with an instrumental variable (IV) procedure[18]. The availability of additional moment conditions when the time dimension increases can be used to increase the efficiency of the estimator by means of a Generalized Method of Moments (GMM) procedure (Holtz-Eakin *et al.*, 1988; Ahn and Schmidt, 1995). Based on Arellano (1989), which compares the use of instruments in difference and level, Arellano and Bond (1991) define the First-Differenced GMM (GMM-DIF) where standard deviations and t-statistics are based on a heteroscedasticity-robust covariance matrix (White, 1980) and each instrument depends on the specific assumption made about endogeneity, predetermination and exogeneity of the corresponding instrumented variable. However, two conditions weaken the efficiency of the GMM-DIF estimator, namely a short time dimension of the panel and/or a strong persistence in the time series[19]. If one of these circumstances applies, the available instruments are only weakly correlated with the variables in first differences and the GMM-DIF estimate is close to its WG estimate (Bond *et al.*, 2001). In this case, an efficiency improvement may be obtained through the addition of the original equations in level, instrumented by their own first differences, to the equations in first differences which are instrumented as in the GMM-DIF case (Arellano and Bover, 1995)[20]. Indeed, this new estimator, called System GMM (GMM-SYS), exploits all available information through these additional moment conditions and it is based on the assumption that $E(\Delta v_{cit}\varepsilon_i) = 0$ (Bond, 2002). The improved efficiency of the GMM-

[16] In particular, the former determine the correlation between the lagged dependent variable y_{cit-1} and the individual fixed effect ε_i. The latter implies the violation of the assumption of strict exogeneity of the regressors due to the presence of an endogenous first-order lagged dependent variable.

[17] Kiviet (1995) provides a correction of the WG estimator bias which declines as the time dimension approaches infinity. Nevertheless, the limited time dimension of the panel adopted in this analysis does not allow a satisfactory use of a WG estimator.

[18] IV techniques are necessary since the lagged difference of the dependent variable, Δy_{cit-1} is correlated by construction with the differenced error term Δv_{cit}. Generally, further lags from the lagged level (y_{cit-2}) or difference (Δy_{cit-2}) can be used as instruments if there is not serial correlation in the v_{cit} process.

[19] This condition represents a common problem in the context of production functions due to persistence of the capital series (Griliches and Mairesse, 1998).

[20] Blundell and Bond (1999) and Blundell *et al.* (2000) verify for the AR(1) model the efficiency improvement of GMM-SYS estimator by using Monte Carlo analyses. GMM-DIF and GMM-SYS are connected by the common presence of the equations in differences and by a general rule which applies to the instruments of both estimators: in particular, Δx_{cit-s} represents a good instrument for the equations in levels if it is not correlated with ε_i and $x_{cit-(s+1)}$ is a valid instrument for the first-difference equations.

SYS versus GMM-DIF estimator may be tested through a Difference-Sargan statistic which tests the validity of additional instruments, namely the instruments used in the equation in levels[21]. The (robust) Hansen J statistic, which is the minimized value of the two-step GMM criterion function, replaces the Sargan statistic in both one-step GMM robust estimation and two-step GMM estimation since the latter is not robust to either heteroskedasticity or autocorrelation. A two-step GMM estimation results in asymptotically more efficient standard errors than a one-step GMM estimation. Although these may be strongly biased downwards in presence of a small sample size and/or heteroschedasticity (Blundell and Bond, 1998), a small-sample variance correction suggested by Windmeijer (2000) eliminates such bias and suggests, therefore, the adoption of this two-step estimator in the following econometric estimates.

5 Descriptive Analysis

A first assessment of the sources of variability in the dataset comes from the results of Table 3. In particular, an ANOVA analysis indicates that all the three dimensions which characterise the data sample, that is countries, sectors and year, are relevant for explaining the observed variability in the growth rates of the relevant variables.

Table 3. Factorial ANOVA. Annual Growth Rates of Key Variables.

	BC	WC	WBC	WWC	VADDED	KD	TID
Country	16.01**	7.48**	27.89**	8.43**	7.38**	2.20**	2.48**
Industry	6.05**	5.95**	2.94**	2.31**	4.03**	2.20**	1.64*
Year	25.71**	18.07**	25.98**	18.04**	11.55**	3.63**	9.71**

Notes:
1) * significant at 5%; ** significant at 1%
2) Data are weighted by the annual sector number of employees.

A detailed summary of the main features of the data is provided by Tables 4 and 5 which provide the growth rates of the variables adopted in the econometric analysis at the sector and country level respectively[22].

[21] This statistic is the difference between the Sargan tests of the GMM-SYS and GMM-DIF estimates where the H_0 supports the former, namely a model with the total set of instruments, whereas the H_1 supports the latter, that is the use of a restricted set of instruments (Rouvinen, 2002). This is distributed as χ^2 with the *dof* which equates the number of instruments used in the levels equation.

[22] Growth rates at the country level are computed for the available period on data for the total Manufacturing sector ("Major Division 3"). Other industrial sectors, such as Mining and Quarrying ("Major Division 2") and Electricity, Gas and Water ("Major Division 4"), do not belong to the dataset. Differently, the unbalanced structure of the panel makes the analysis of annual growth rates more meaningful at the sector level. These growth rates are weighted by the sector' share of total manufacturing employment.

Table 4. Sector Annual Growth Rates of Key Variables

ISIC Rev. 2 - Sectors	Tech. Intensity[23]	BC	WC	Rel. Wage	VA	KD	TID
3110 - Food Products	Low	-.0069	-.0002	.0055	.0947	.0265	.0895
3130 - Beverages	Low	.0084	.0176	.0303	.0823	.0594	.0608
3140 - Tobacco	Low	.0167	-.0110	.0709	.0198	.3144	.3132
3210 - Textiles	Low	-.0155	-.0050	.0013	.0121	.0519	.1091
3220 - Wearing Apparel	Low	.0463	.0783	.0023	.0960	.1360	.1543
3230 - Leather Products	Low	.0320	.0638	-.0001	.0943	.1306	.2315
3240 - Footwear	Low	.0068	.0460	.0104	.0311	.2711	.3112
3310 - Wood Products	Low	.0084	-.0014	.0223	.0496	.1694	.1695
3320 - Furniture, Fixtures	Medium-Low	.0245	.0534	.0239	.0651	.1327	.2008
3410 - Paper Products	Low	.0078	.0149	.0111	.0563	.2125	.2370
3420 - Printing, Publishing	Low	.0067	.0332	.0153	.0670	.1810	.2185
3510 - Industrial Chemicals	Medium-High	.0165	.0208	.0064	.1171	.0867	.1155
3520 - Other Chemicals	High	.0119	.0230	-.0041	.0651	.1062	.1434
3530 - Petrol. Refineries	Medium-Low	.0242	.0729	-.0415	.2425	.3978	.3302
3540 - Petrol. Coal Prod.	Medium-Low	.0302	.0171	.0281	.2437	.6071	.7625
3550 - Rubber Products	Medium-Low	.0434	.0637	-.0174	.1072	.1504	.1608
3560 - Plastic Products	Medium-Low	.0513	.0841	-.0044	.1053	.0878	.1524
3610 - Pottery, China etc.	Medium-Low	.0259	.0532	.0225	.0806	.2893	.2911
3620 - Glass and Products	Medium-Low	.0007	.0231	.0227	.0693	.3864	.4404
3690 - Non-metal Products	Medium-Low	.0160	.0331	.0337	.0797	.1826	.1781
3710 - Iron and Steel	Medium-Low	.0019	.0031	.0133	.0650	.1665	.1402
3720 - Non-ferrous Metals	Medium-Low	.0158	.0476	.0090	.1528	.3035	.3371
3810 - Metal Products	Medium-Low	.0097	.0254	.0061	.0705	.0689	.0980
3820 - Machinery	Medium-High	.0230	.0430	.0019	.0824	.0605	.0896
3830 - Electrical Machinery	Medium-High	.0459	.0519	.0110	.1214	.0804	.0907
3840 - Transport Equipm.	Medium-High	.0147	.0169	.0062	.0818	.0851	.1357
3850 - Professional Goods	High	.0416	.0686	.0042	.1166	.2508	.2230
3900 - Other Industries	Low	.0300	.0510	-.0064	.0898	.1852	.2049

[23] Technological intensity is defined by OECD Science, Technology and Industry Scoreboard which classifies ISIC sectors according to the three-digit Rev. 3 taxonomy (at four-digit for some specific sub-sectors). Sector conversion from ISIC Rev. 3 to ISIC Rev. 2 is provided by the author (see note 14). Another source of equivalent information on technological intensity is provided by Keller (2002) which finds that about 80% of all manufacturing expenditure in R&D is conducted in the following industries: Chemical Products (3510/3520), Electrical and Non-Electrical Machinery (3820/3830) and Transportation Equipment (3840).

Table 5. Growth Rates of Key Variables by Country

	BC	WC	Rel. Wage	VA	KD	TID	Period
Middle-Income Countries							
Chile	.4399	.4530	.0099	.6412	.0256	.1334	1980-1990
Cyprus	.2475	.3128	.0280	.4755	-.2804	.0838	1980-1991
Greece	-.2089	.2698	-.0911	-.0572°	-.3007	.4768	1980-1990
Ireland	-.1971	-.0045	.0601	.7372°	-.4396	-.0396	1980-1989
Malaysia	.7560	.1387	.3295	.9955°	.8149	.0064	1983-1990
Malta	-.0926	.1536	.0080	.2150	.7339	.0888	1980-1988
Mexico	-.1640	.2617	.4151	-.0418	.3319	1.4537	1986-1991
Panama	-.1080	-.0216	-.1908	-.1951	-.7022	-.2147	1981-1989
Portugal	-.0966	-.0164	.1415	.1059	-.2573	.1250	1980-1987
South Korea	.4213	.6420	-.0984	2.1222	.0382	-.0804	1980-1990
Spain	-.2256	-.0861	.1671	-.0308°	.4927	2.0223	1980-1990
Turkey	.1408	.8146	-.1139	1.0770	.7104	.3889	1980-1990
Venezuela	.1223	.4846	-.0161	.2558	.1093	-.3429	1981-1991
TOT - MICs♣	.1118	.3179	.0757	.7953	.2526	.6547	1980-1991
Low-Income Countries							
Bangladesh	.1443	.0226	.0036	.2634	.1095	-.5299	1981-1988
Colombia	-.1168	.1775	-.0189	.2931	.9445	-.2517	1980-1990
Egypt	.1453	.3548	-.0509	.8656	-.5262	-.1951	1980-1988
Ethiopia	.1889	.6340	-.1211	.1646	.1559	.6800	1980-1988
Guatemala	-.3149	.1082	-.1966	-.2287	-.4480	.3916	1980-1988
India	-.0207	.0302	-.0763	.5922°	.1043	.0624	1980-1988
Pakistan	.1347	.1593	.2015	.6704	-.2188	.3641	1981-1988
Peru	.0663	.2056	.1552	.4197	-.4205	-.6732	1980-1988
Philippines	-.2386	1.1727	-.4131	.3189	-.3832	-.5733	1980-1988
Tanzania	-.1123	.0894	.1049	-.2910°	.1432	-.0751	1980-1985
TOT - LICs♣	-.0145	.1850	-.0787	.5452	.0118	-.0586	1980-1990
TOT♣	.0438	.2463	-.0074	.6606	.1229	.2705	

Notes:
1) Chile: 1987-1988; Cyprus: 1987; Malaysia: 1984 not available.
2) Malta. Purchasing Power Parity from The World Bank Development Indicators 2004.
3) Mexico. Econometric analysis for the period 1980-1991 (1986 not available).
Estimates of total manufacturing investment for missing years are computed in order to calculate sector shares through a three-years backward moving average.
VA and KA from UNIDO Industrial Statistics Database 2002.
4) Pakistan: 1985; Panama: 1986-1987-1988 not available.
5) Perú. Employment from UNIDO Industrial Statistics Database 2002.

° Value added based on factor prices - otherwise measured on producer´s prices.
♣ Weighted by a country' share of total employment averaged over the initial and final period. Values are obtained from data on aggregate manufacturing.

At the sector level, there has been *relative* skill bias in 25 industries out of 28, except for Tobacco (3140), Wood Products (3310) and Petroleum, Coal Products (3540). Such widespread increase in the ratio of skilled to unskilled employment has not been followed by a similar marked trend in the ratio of skilled to unskilled wages which, differently, has appeared quite constant over time (Berman and Machin, 2000). This pattern is consistent also across countries. Indeed, there has been *relative* skill bias in all countries with the exception of Malaysia and Bangladesh where the growth rate of BC has been faster than the growth rate of WC. Eight countries out of 23 (three LICs) have witnessed absolute diverging employment paths between WC and BC whereas four countries - all MICs - have experienced a decrease in both the employment of "operative" and "non operative" workers.

Such preliminary evidence allows to introduce the econometric assessment of the determinants of WC and BC employment described in the next Section.

6 Empirical Results

Section 4.2 has already indicated that a short time dimension of the panel and a strong persistence in the time series recommend the adoption of a GMM-SYS estimator. Indeed, these two conditions occur in the context of the empirical analysis of this paper since the time span covers only a decade whereas Table 6 shows the high persistence of the employment series of both BC and WC.

Table 6. Time Persistence in the Employment Series

	BC	WC
AR(1)	.9851***	.9928***
	(.0011)	(.0014)

Notes:
1) *** significant at 1%
2) Standard errors in brackets.
3) AR(1) computed on OLS in levels.

Previous economic research has discussed the relative upskilling of the workforce mainly through shifts of the payroll share of skilled labour in a cost-function setting (Bartel and Lichtenberg, 1987; Berman *et al.*, 1994; Haskel and Heden, 1999; Zhu, 2005). A single-equation setting cannot distinguish however the determinants of neither *relative* and *absolute* skill bias nor the employment dynamics of BC and WC separately. On the contrary, the econometric strategy adopted in this paper allows to overcome these two problems through the estimation of two indipendent employment equations for BC and WC.

This Section presents therefore the outcome of the two employment equations, together with some sensitivity checks. Each specification is augmented by the inclusion of country and sector dummies (time dummies are always included) to control the robustness of the results obtained. Further tests and results are presented in Appendices C and D. The former offers the results obtained by the estimation of a single relative employment equation, where the dependent variable is the number of WC over the total number of employees. The latter supplies a similar set of related GMM-SYS estimates where the hypotheses of "Capital Deepening" and SETI are tested separately.

Table 7. Employment Equation of "Blue Collar" Workers

Dependent Var. Employment "Blue Collar" Workers			
Variable	GMM - SYS		
	(1)	(2)	(3)
Lag_Employment	0.889***	0.859***	0.921***
	(0.038)	(0.050)	(0.024)
BC Wages	-0.112***	-0.219**	-0.073***
	(0.034)	(0.089)	(0.020)
Value Added	0.094**	0.115**	0.066***
	(0.034)	(0.045)	(0.022)
Capital Deepening	0.048***	0.057***	0.039***
	(0.009)	(0.018)	(0.006)
SETI Deepening	-0.014***	-0.031**	-0.006*
	(0.004)	(0.014)	(0.004)
Constant	-0.658**	-0.810**	-0.436**
	(0.270)	(0.344)	(0.177)
Country Dummies		3.06***	
Sector Dummies			1.99***
Time Dummies	7.48***	6.56***	9.17***
Wald Test	7.48***	7.00***	5.18***
Hansen Test	16.93	19.07	17.52
AR(1)	-6.60***	-6.38***	-6.68***
AR(2)	-0.82	-1.24	-0.60
Observations	3468	3468	3468

Notes:
1) * significant at 10%; ** significant at 5%; *** significant at 1%
2) White-robust standard errors in brackets.
3) Wald Test applied to the joint significance of the dummies.

Table 7 provides the GMM-SYS estimator for the BC equation. All the three estimates obtain similar and significant results. There is a confirmation of the high persistence of the employment series and a predictable behaviour of the coefficients of BC wages and value added. In particular, wages depict the usual negative relationship which occurs between a factor price and its quantity adopted. On the contrary, the expansion of a sector's value added generally affects the derived employment of the production factor "labour" in a positive way. An interesting pattern emerges from the comparison between the coefficients of Capital Deepening and SETI Deepening since they provide opposite effect on the employment of BC workers. This result appears at odds with the homogeneous treatment of capital stock and technology commonly adopted in empirical literature. In particular, "generic" capital, rather than weakening employment of BC workers, displays a positive significant coefficient. On the contrary, the coefficient of SETI deepening, namely of capital goods which embody the technological level of most advanced countries, is more consistent with the setting described in Section 2.2 and it indicates a direct negative effect - although small - on the employment of unskilled workers.

All these results appear robust to the introduction of country and sector dummies which, in turn, are jointly significant, as indicated in Table 7[24]. The Hansen test advocates the goodness of the GMM instruments, which have been chosen through a comparison of different hypotheses about the relationship between the regressors and the white-noise error term v_{cit}. The AR tests support the overall validity of the model by providing evidence of AR(1) in first differences and the absence of AR(2)[25].

The outcome obtained by the Differenced Hansen test suggests the assumption of strict exogeneity of wages and SETI deepening, and predetermination of value added and capital deepening.

Finally, the different effect of Capital Deepening and SETI Deepening on BC employment is confirmed by Table D1 in Appendix D, which shows the outcome of GMM-SYS estimations similar to those of Table 7, except that the two regressors are included separately. Again, the coefficient of Capital Deepening appears positive and significant while SETI Deepening turns out not statistically significant[26].

[24] A Wald test, asymptotically distributed as χ^2 where the degrees of freedom (dof) equates the number of restricted coefficients, allows to test the overall significance of the independent variables and both time and individual effects.

[25] Since the consistency of the GMM estimates requires non serial-correlated errors v_{cit}, Arellano-Bond (1991) provide a Lagrange multiplier (LM)-based test of autocorrelation which is applied to the residuals of the first-difference equation in order to drop the time-invariant fixed effect ε_i. This test, distributed as $N(0,1)$ under the H_0 of no autocorrelation, provides strong evidence of AR(1) in first differences because of the correlation between the first differences of the (uncorrelated) errors Δv_{cit} and Δv_{cit-1} due to the common term v_{cit-1}. Finally, the absence of AR(2) supports the consistency of the GMM estimator.

[26] Further support to the overall validity of the chosen GMM-SYS estimator comes from the comparisons between the coefficients of the lagged dependent variable in table 7 and the WG and POLS estimators. Indeed, the former lie within the lower and upper bounds obtained by the latter. The same outcome applies to both the WC and the relative employment equations (results available on request).

Table 8. Employment Equation of "White Collar" Workers

Dependent Var. Employment "White Collar" Workers			
Variable	GMM - SYS		
	(1)	(2)	(3)
Lag_Employment	0.807***	0.743***	0.799***
	(0.039)	(0.051)	(0.039)
WC Wages	-0.120***	-0.222***	-0.113***
	(0.032)	(0.064)	(0.030)
Value Added	0.154***	0.222***	0.156***
	(0.034)	(0.049)	(0.033)
Capital Deepening	0.105***	0.076**	0.114***
	(0.023)	(0.037)	(0.025)
SETI Deepening	0.029**	0.062**	0.035**
	(0.015)	(0.029)	(0.015)
Constant	-1.104***	-1.643***	-1.058***
	(0.281)	(0.412)	(0.268)
Country Dummies		2.19***	
Sector Dummies			1.47*
Time Dummies	3.94***	2.77***	3.04***
Wald Test	3.94***	3.05***	2.58***
Hansen Test	70.82	80.75	71.57
AR(1)	-7.57***	-8.99***	-8.70***
AR(2)	-0.12	-0.38	-0.22
Observations	3468	3468	3468

Notes:
1) * significant at 10%; ** significant at 5%; *** significant at 1%
2) White-robust standard errors in brackets.
3) Wald Test applied to the joint significance of the dummies.

Table 8 provides the GMM-SYS estimator for the WC equation. Also in this case, the three estimates obtain similar and significant results. The coefficient of the lagged dependent variable indicates a high persistence of the employment series of WC. The coefficients of WC wages and value added are similar to the ones of the BC equation by showing a negative and a positive sign respectively. Nevertheless, the growth of value added seems more friendly to these workers. The coefficient of capital deepening is positive and higher than the one in the BC equation. Capital deepening affects, therefore, the *relative* skill bias of the employment series since it increases the labour requirement of both BC and WC. In turn, this result is consistent with a line of economic research which has related the employment of skills in

LMICs to the capital-skill complementarity hypothesis (Barba Navaretti *et al.,* 1998; Goldin and Katz, 1998; Flug and Hercowitz, 2000)[27]. On the contrary, SETI deepening determines *absolute* skill bias since it affects positively the employment of skilled labour while, at the same time, its coefficient in the BC equation is negative. As can be seen from the comparison of Tables 7 and 8, this outcome is robust to the inclusion of both country and sector dummies.

The Hansen test and the AR tests validate the model of Table 8. However, the procedure driven by the Differenced Hansen test suggests a different choice of the instruments for the WC wage, which appears predetermined rather than exogenous (as in the BC equation).

Finally, the importance of SETI deepening is reinforced by the findings presented in Appendix C and D. The former shows that this variable is the relevant factor for the relative upskilling of the labour force in the relative employment equation. On the contrary, the coefficient of capital deepening does not appear statistically significant, even after the inclusion of both country and sector dummies. The latter allows to distinguish the positive significant effect of SETI deepening on WC employment from the insignificant effect in the BC equation. Finally, Table D3 indicates that technology, rather than generic capital investment, affects the witnessed upskilling trend of the employment series.

To sum up, the amount of evidence described in this paper suggests the occurrence of different factors which explain the widening differentials between skilled and unskilled workers. However, econometric results highlight that technology transfer from HICs, rather than homogeneous measures of capital deepening, seems to lead the tendency towards a larger employment divide in LMICs.

7 Concluding Remarks

This paper has discussed the occurrence of Skill-Enhancing Technology Import (SETI) in a sample of LMICs. In doing so, this study has provided a detailed measure of direct technology transfer across countries. In turn, this is obtained by an original procedure for the conversion of trade data into sector values which may be valuable for future research in this field.

The econometric analysis has verified the hypotheses of SETI and Capital-Skill Complementarity through an original (unbalanced) panel dataset comprising 4934 observations for 28 manufacturing sectors of 23 LMICs in the period 1980-1991.

GMM techniques have been applied to the estimation of two similar employment equation for both BC and WC. In turn, this setting has allowed to distinguish the determinants of *relative* and *absolute* skill bias of employment over time. Econometric results indicates that capital deepening is responsible for *relative* shifts toward skilled labour. This does not reduce, however, the absolute employment of unskilled labour. Differently, SETI appears the crucial determinant of an *absolute* diverging path between skilled and unskilled employment in LMICs.

[27] For instance, Berman and Machin (2000 and 2004) verify the occurrence of SBTC in LMICs through changes in capital-labour ratios (based on the capital-skills complementarity hypothesis) whereas Wood (1994, p. 224) controls for the average ratio of investment to GDP.

Appendix A: Variables Definition and Data Source

Number of Operatives / Blue Collars (BC): All employees engaged in production or the related activities of the establishment, including any clerical or working supervisory personnel whose function is to record or expedite any step in the production process. **Source: United Nations General Industrial Statistics, Vol. 1 (GIS)[28].**

Number of Non Operatives / White Collars (WC): All persons engaged other than working proprietors, active business partners, unpaid family workers and operatives. **Source: GIS.**

Wage: All payments in cash or in kind made to "*operatives*" or "*non operatives*" during the reference year. The payments include: (a) direct wages and salaries; (b) remuneration for time not worked; (c) bonuses and gratuities; (d) housing allowances and family allowances paid directly by the employer; and (e) payments in kind. Excluded are the employers' contributions in respect of their employees paid to social security, pension and insurance schemes, as well as the benefits received by employees under these schemes and severance and termination pay. **Source: GIS.**

Value Added: The value of census output less the value of census input, which covers: (a) value of materials and supplies for production (including cost of all fuel and purchased electricity); and (b) cost of industrial services received (mainly payments for contract and commission work and repair and maintenance work). The valuation may be in factor values or in producers' prices, depending on the treatment of indirect taxes and subsidies. **Source: GIS.**

Gross fixed capital formation: The value of purchases and own-account construction of fixed assets during the reference year less the value of corresponding sales. The fixed assets covered are those, whether new or used, with a productive life of one year or more which are intended for the use of the establishment, including fixed assets made by the establishment's own labour force for its own use. Major additions, alterations and improvements to existing assets which extend with normal economic life or raise their productivity are also included. **Source: GIS.**

Skill-Enhancing Technology Import (SETI): The annual value of the import from high income countries (HICs) of a detailed list of capital goods which embody a technological component (Appendix C). **Source: World Trade Analyzer (WTA).**

Purchasing Power Parity: The number of currency units required to buy goods equivalent to what can be bought with one unit of the base country (US). **Source: Penn World Tables 6.1.**

US GDP Deflator: Rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. Base year = 1986. **Source: World Bank Development Indicators 2004.**

[28] Economic literature adopts two competing definitions of skills based on either the wage level of the workers or the amounts of education, training and experience they possess. The two indicators are often correlated, but they can also diverge (Wood, 1994, p. 47). The concept of skills throughout this paper refers to the latter concept - namely human capital accumulated through education which is assumed to be reflected by the dycothomic distinction between occupational categories in this empirical analysis. A craftsman with low education is therefore classified among blue collars and he will be loosely considered as an "unskilled" worker.

Appendix B: Skill-Enhancing Technology Import (SETI)

SETI is created through the sum of the following SITC Revision 2 codes[29]:

SITC	DESCRIPTION
7111	Steam & Other Vapour Generating Boilers
7112	Auxiliary Plant For Use With Boilers, Condensors
7119	Parts Of Boilers & Aux. Plant Of 711.1- / 711.2-
711A	Steam & Other Vapour Generating Boilers & Parts
7126	Steam & Other Vapour Power Units, Steam Engines
7129	Parts Of The Power Units Of 712.6-
712A	Steam & Other Vapour Power Units, Steam Engines
7131	Internal Combustion Piston Engines For Aircraft
7132	Int. Combustion Piston Engines For Propelling Veh.
7133	Int. Combustion Piston Engines For Marine Propuls.
7138	Int. Comb.Piston Engines, N.E.S.
7139	Parts Of Int. Comb. Piston Engines Of 713.2- / 713.8-
713A	Internal Combustion Piston Engines & Parts
7144	Reaction Engines
7148	Gas Turbines, N.E.S.
7149	Parts Of The Engines & Motors Of 714- And 718.8-
714A	Engines & Motors, Non-Electric
7161	Motors & Generators, Direct Current
7162	Elect.Motors & Generators, Generating Sets
7163	Rotary Converters
7169	Parts Of Rotating Electric Plant
716A	Rotating Electric Plant And Parts
7187	Nuclear Reactors And Parts
7188	Engines & Motors, N.E.S. Such As Water Turbines Etc.
718A	Other Power Generating Machinery And Parts
71AA	POWER GENERATING MACHINERY AND EQUIPMENT

[29] Letter A indicates the sum of the related sub-SITC codes. SETI represents the total annual economic value of the following goods classified at the four-digit level of SITC Rev. 2.

7243 Sewing Machines, Furniture For Sewing Mach.& Parts
7244 Mach. For Extruding Man-Made Textiles And Parts
7245 Weaving, Knitting Mach. For Preparing Yarns, Parts
7246 Auxil. Machinery For Headings 724.51 / 52 / 53
7247 Mach. For Washing, Cleaning, Drying, Bleaching Text.
7248 Mach. For Preparing, Tanning Or Working Hides
724A Textile & Leather Machinery And Parts

7251 Mach. For Mak. / Finis. Cellul. Pulp, Paper, Paperbo.
7252 Paper & Paperboard Cutting Mach. Of All Kinds
7259 Parts Of The Mach. Of 725–
725A Paper & Pulp Mill Mach., Mach For Manuf. Of Paper

7263 Mach., Appar., Access. For Type Founding Or Setting
7264 Printing Presses
7267 Other Printing Mach. For Uses Ancillary To Printing
7268 Bookbinding Machinery And Parts
7269 Parts Of The Machines Of 726.31, 726.4-, 726.7-
726A Printing & Bookbinding Mach. And Parts

7271 Mach. For Working Of Cereals Or Dried Vegetables
7272 Other Food Processing Machinery And Parts
727A Food Processing Machines And Parts

7281 Mach. Tools For Specialized Particular Industries
7283 Mach. For Sorting, Screening, Separating, Washing Ore
7284 Mach. & Appliances For Spezialized Particular Ind.
728A Mach. & Equipment Specialized For Particular Ind.

72AA MACHINERY SPECIALIZED FOR PARTICULAR INDUSTRIES

7361 Metal Cutting Machine-Tools
7362 Metal Forming Machine Tools
7367 Other Mach. - Tools For Working Metal Or Met. Carbide
7368 Work Holders, Self-Opening Dieheads & Tool Holders
7369 Parts Of The Machine-Tools Of 736-
736A Mach. Tools For Working Metal Or Met. Carb., Parts

7371 Converters, Ladles, Ingot Moulds And Casting Mach.
7372 Rolling Mills, Rolls Therefor And Parts
7373 Welding, Brazing, Cutting, Soldering Machines & Parts
737A Metal Working Machinery And Parts

73AA METALWORKING MACHINERY

7411 Producer Gas And Water Gas Generators And Parts
7412 Furnace Burners For Liquid Fuel And Parts
7413 Ind. & Lab. Furnaces And Ovens And Parts
7414 Refrigerators & Refr. Equipment, Ex. Household, Parts
7415 Air Conditioning Mach. Self-Contained And Parts
7416 Mach. Plant & Sim. Lab. Equip. Involv. A Temp. Change
741A Heating & Cooling Equipment And Parts

7421 Reciprocating Pumps, Other Than 742.81
7422 Centrifugal Pumps, Other Than 742.81
7423 Rotary Pumps, Other Than 742.81
7428 Other Pumps For Liquids & Liquid Elevators
7429 Parts Of The Pumps & Liq. Elevators Of 742-
742A Pumps For Liquids, Liq.Elevators And Parts

7431 Air Pumps, Vacuum Pumps & Compressors
7432 Parts Of The Pumps & Compressors Of 743.1-
7433 Free-Piston Generators For Gas Turbines, Parts
7434 Fans, Blowers And The Like, And Parts
7435 Centrifuges
7436 Filtering & Purifying Mach. For Liquids & Gases
7439 Parts Of The Machines Of 743.5-, 743.6-
743A Pumps & Compressors, Fans & Blowers, Centrifuges

7441 Work Trucks, Mechanically Propelled, For Short Dist.
7442 Lifting, Handling, Loading Mach.Conveyors
7449 Parts Of The Machinery Of 744.2-
744A Mechanical Handling Equip. And Parts

7451 Tools For Working In The Hand, Pneumatic, Parts
7452 Other Non-Electrical Mach. And Parts
745A Other Non-Electrical Mach.Tools, Apparatus & Parts
7491 Ball, Roller Or Needle Roller Bearings
7492 Taps, Cocks, Valves Etc. For Pipes, Tanks, Vats Etc
7493 Transmission Shafts, Cranks, Bearing Housings Etc.
7499 Other Non-Electric Parts & Accessories Of Mach
749A Non-Electric Parts And Accessories Of Machines

74AA GENERAL INDUSTRIAL MACHINERY & EQUIPMENT, AND PARTS

7511 Typewritters; Cheque-Writting Machines
7512 Calculating Machines, Cash Registers. Ticket & Sim.
7518 Office Machines, N.E.S.
751A Office Machines

7521	Analogue & Hybrid Data Processing Machines
7522	Complete Digital Data Processing Machines
7523	Complete Digital Central Processing Units
7524	Digital Central Storage Units, Separately Consigned
7525	Peripheral Units, Incl.Control & Adapting Units
7528	Off-Line Data Processing Equipment. N.E.S.
752A	Automatic Data Processing Machines & Units Thereof
7591	Parts Of And Accessories Suitable For 751.1-, 751.8
7599	Parts Of And Accessories Suitable For 751.2-, 752-
759A	Parts Of And Accessories Suitable For 751- Or 752-
75AA	OFFICE MACHINES & AUTOMATIC DATA PROCESSING EQUIP.
7641	Elect. Line Telephonic & Telegraphic Apparatus
7642	Microphones, Loudspeakers, Amplifiers
7643	Radiotelegraphic & Radiotelephonic Transmitters
7648	Telecommunications Equipment
7649	Parts Of Apparatus Of Division 76-
764A	Telecommunications Equipment And Parts
76AA	TELECOMMUNICATIONS & SOUND RECORDING APPARATUS
7711	Transformers, Electrical
7712	Other Electric Power Machinery, Parts Of 771-
771A	Electric Power Machinery And Parts Thereof
7721	Elect. App.Such As Switches, Relays, Fuses, Pwgs Etc.
7722	Printed Circuits And Parts Thereof
7723	Resistors, Fixed Or Variable And Parts
772A	Elect. App. Such As Switches, Relays, Fuses, Plugs Etc.
7731	Insulated, Elect. Wire, Cable, Bars, Strip And The Like
7732	Electric Insulating Equipment
773A	Equipment For Distributing Electricity
7764	Electronic Microcircuits
7781	Batteries And Accumulators And Parts
7782	Elect. Filament Lamps And Discharge Lamps
7783	Electr. Equip. For Internal Combustion Engines, Parts
7784	Tools For Working In The Hand With Elect. Motor
7788	Other Elect. Machinery And Equipment
778A	Electrical Machinery And Apparatus, N.E.S.
77AA	ELECTRICAL MACHINERY, APPARATUS & APPLIANCES N.E.S.

Appendix C: Relative Employment Equation

Table C1. Time Persistence in the Relative Employment Series

	Relative Employment
AR(1)	.9759***
	(.0011)

Notes:
1) *** significant at 1%
2) Standard errors in brackets.
3) AR(1) computed on OLS in levels.

Table C2. Relative Employment Equation

Dependent Var. Relative Employment			
Variable	GMM - SYS		
	(1)	(2)	(3)
Lag_Rel. Employment	0.697***	0.392***	0.716***
	(0.063)	(0.072)	(0.060)
Relative Wages	-0.109***	-0.404***	-0.099***
	(0.020)	(0.039)	(0.017)
Value Added	0.086***	0.068	0.084***
	(0.027)	(0.059)	(0.025)
Capital Deepening	-0.007	-0.036	-0.020
	(0.047)	(0.030)	(0.047)
SETI Deepening	0.067**	0.044*	0.068***
	(0.027)	(0.026)	(0.025)
Constant	-1.311***	-1.291**	-1.411***
	(0.312)	(0.647)	(0.340)
Country Dummies		6.26***	
Sector Dummies			1.15
Time Dummies	2.58***	4.08***	2.92***
Wald Test	2.58***	5.77***	1.85***
Hansen Test	19.94	17.31	20.51
AR(1)	-9.06***	-7.27***	-9.33***
AR(2)	-0.09	-0.90	-0.08
Observations	4177	4177	4177

Notes:
1) * significant at 10%; ** significant at 5%; *** significant at 1%
2) White-robust standard errors in brackets.
3) Wald Test applied to the joint significance of the dummies.

Appendix D: Robustness Checks - Employment Equations with either Capital Deepening or SETI Deepening

Table D1. Employment Equation of "Blue Collar" Workers[30]

Dependent Variable: Employment "Blue Collar" Workers						
Variable	GMM - SYS			GMM - SYS		
	(1)	(2)	(3)	(4)	(5)	(6)
Lag_Employment	0.889*** (0.037)	0.896*** (0.059)	0.922*** (0.024)	0.869*** (0.069)	0.875*** (0.061)	0.875*** (0.044)
BC Wages	-0.103*** (0.035)	-0.212** (0.083)	-0.074*** (0.022)	-0.123** (0.058)	-0.250** (0.108)	-0.109*** (0.033)
Value Added	0.097*** (0.033)	0.086* (0.051)	0.071*** (0.021)	0.121* (0.065)	0.105** (0.054)	0.120*** (0.043)
Capital Deepening	0.037*** (0.009)	0.022** (0.010)	0.032*** (0.007)	——	——	——
SETI Deepening	——	——	——	0.006 (0.012)	0.032 (0.024)	0.018 (0.013)
Constant	-0.689*** (0.262)	-0.508 (0.400)	-0.487*** (0.166)	-0.963* (0.551)	-0.612 (0.375)	-0.985*** (0.369)
Country Dummies		5.89***			4.39***	
Sector Dummies			2.52***			1.15
Time Dummies	7.37***	6.11***	9.23***	4.88***	3.65***	4.98***
Wald Test	7.37***	8.33***	5.35***	4.88***	8.06***	4.49***
Hansen Test	18.05	19.65	17.28	18.99	19.28	17.50
AR(1)	-6.60***	-6.08***	-6.67***	-6.02***	-6.02***	-6.32***
AR(2)	-0.71	-0.83	-0.57	-0.65	-0.74	-0.60
Observations	3468	3468	3468	3487	3487	3487

Notes:
1) * significant at 10%; ** significant at 5%; *** significant at 1%
2) White-robust standard errors in brackets.
3) Wald Test applied to the joint significance of the dummies.

[30] The number of observations varies among different estimates because of the chosen instrument matrices, whose final structure has been obtained by the Difference Hansen test and implemented by the command *xtabond2* in STATA v. 9.2. More specifically, the introduction of two-period (or longer) lags in the instrument matrix as an IV-style standard instrument reduces the number of observations in the sample (Baum *et al.*, 2003). The instrument matrices of the estimates in Appendix F maintain the same assumptions about the relationship between the regressors and the white-noise error term v_{cit} already discussed in Section 6.

Table D2. Employment Equation of "White Collar" Workers

Dependent Variable: Employment "White Collar" Workers						
Variable	GMM - SYS			GMM - SYS		
	(1)	(2)	(3)	(4)	(5)	(6)
Lag_Employment	0.797***	0.756***	0.793***	0.764***	0.746***	0.742***
	(0.042)	(0.050)	(0.043)	(0.057)	(0.054)	(0.054)
BC Wages	-0.137***	-0.181***	-0.125***	-0.129**	-0.245***	-0.137***
	(0.032)	(0.056)	(0.031)	(0.053)	(0.076)	(0.049)
Value Added	0.146***	0.208***	0.137***	0.207***	0.223***	0.223***
	(0.032)	(0.048)	(0.031)	(0.057)	(0.052)	(0.053)
Capital Deepening	0.141***	0.124***	0.156***	———	———	———
	(0.034)	(0.029)	(0.037)			
SETI Deepening	———	———	———	0.076***	0.098***	0.081***
				(0.015)	(0.020)	(0.015)
Constant	-0.935***	-1.650***	-0.733***	-1.784***	-1.660***	-1.890***
	(0.257)	(0.424)	(0.264)	(0.497)	(0.455)	(0.469)
Country Dummies		2.61***			2.89***	
Sector Dummies			1.32			1.30
Time Dummies	4.41***	2.96***	3.83***	3.04***	3.06***	2.95***
Wald Test	4.41***	3.26***	2.25***	3.04***	2.94***	1.98***
Hansen Test	69.79	80.23	72.51	45.02	46.65	43.36
AR(1)	-6.41***	-8.92***	-7.42***	-7.60***	-9.03***	-8.37***
AR(2)	-0.11	-0.61	-0.17	1.00	1.03	0.88
Observations	3481	3481	3481	4154	4154	4154

Notes:
1) * significant at 10%; ** significant at 5%; *** significant at 1%
2) White-robust standard errors in brackets.
3) Wald Test applied to the joint significance of the dummies.

Table D3. Relative Employment Equation

Dependent Variable: Relative Employment (WC/TOT)						
Variable	GMM - SYS			GMM - SYS		
	(1)	(2)	(3)	(4)	(5)	(6)
Lag_Employment	0.691***	0.404***	0.716***	0.695***	0.399***	0.718***
	(0.057)	(0.068)	(0.050)	(0.063)	(0.069)	(0.061)
BC Wages	-0.136***	-0.395***	-0.132***	-0.110***	-0.399***	-0.098***
	(0.021)	(0.037)	(0.022)	(0.020)	(0.037)	(0.017)
Value Added	0.069***	0.069	0.081***	0.083***	0.069	0.083***
	(0.021)	(0.056)	(0.022)	(0.025)	(0.056)	(0.027)
Capital Deepening	-0.014	0.004	-0.029	———	———	———
	(0.043)	(0.044)	(0.049)			
SETI Deepening	———	———	———	0.064***	0.014**	0.065***
				(0.023)	(0.007)	(0.025)
Constant	-1.319***	-1.334**	-1.589***	-1.276***	-1.301**	-1.358***
	(0.315)	(0.617)	(0.375)	(0.261)	(0.608)	(0.321)
Country Dummies		6.30***			6.43***	
Sector Dummies			0.95			1.14
Time Dummies	2.57***	3.58***	2.62***	2.88***	4.27***	3.23***
Wald Test	2.57***	5.62***	1.65**	2.88***	5.79***	1.75***
Hansen Test	13.80	20.47	13.02	19.25	18.78	19.77
AR(1)	-9.54***	-7.48***	-9.73***	-9.25***	-7.43***	-9.37***
AR(2)	0.06	-0.58	0.01	-0.08	-0.67	-0.07
Observations	4177	4177	4177	4177	4177	4177

Notes:
1) * significant at 10%; ** significant at 5%; *** significant at 1%
2) White-robust standard errors in brackets.
3) Wald Test applied to the joint significance of the dummies.

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