TRADE OPENNESS, TECHNOLOGY ADOPTION AND THE DEMAND FOR SKILLS: EVIDENCE FROM TURKISH MICRODATA

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Abstract

In this paper we report evidence on the relationship between trade openness, technology adoption and relative demand for skilled labour in the Turkish manufacturing sector, using firm level data over the period 1980-2001.

We first depict the simultaneous increasing trends in international openness and in demand for skills and we show that the shift of the relative demand for labour was mainly due to the within-industry component, suggesting the relevance of the skill biased technological change (*SBTC*) hypothesis.

We then estimate – in a dynamic panel data setting using a unique database of 88,561 firms – an augmented cost share equation whereby the wage bill share of skilled workers in a given firm is related to international exposure and technology adoption. Overall, results suggest that trade openness and technology play a key role in shifting the demand for labour towards more skilled workers within each firm. Technology related variables (domestic R&D expenditures and technological transfer from abroad) are positive and significantly related to skill upgrading, as it is the involvement of foreign capital in firm's ownership. Moreover, firms belonging to those sectors that most raised their imports also experienced a higher increase in the labour cost share of skilled workers. This finding is consistent with the idea that imports by a middle income country imply a transfer of new technologies that are more skill-intensive than those previously in use in domestic markets. This idea is reinforced by the finding that only imports from industrialised countries - where the potential for innovation diffusion comes from - enter the regressions significantly. Instead, sectoral export orientation is negatively correlated with the demand for skills, which is consistent with the predictions from the trade theory, given Turkey's comparative advantage in the production of unskilled-labour-intensive goods.

Keywords: globalization, skills, skill biased technological change, technology transfer, GMM-SYS

JEL Classification: F16, O15, O33

1. Introduction

This paper examines the relationship between trade openness, technology adoption and the relative demand for skilled labour in the Turkish manufacturing sector.

Turkey started a radical process of liberalization in the early '80s and its economy has become increasingly connected with the world market, as the volumes of exports and imports continued to grow over time. The increasing trade openness affected especially the manufacturing sector that was responsible of most of the import and export growth. This process is likely to have had important consequences in terms of labour demand and in particular in terms of the relative demand for skilled labour. In the same period, indeed, the relative demand for skilled labour increased substantially leading to higher wage-gaps between skilled and unskilled workers. Whether these two contemporaneous phenomena are in fact linked is not yet clear.

From a theoretical point of view, the increasing international exposure of firms in a developing country (DC) may lead to different outcomes in terms of labour demand. On the one hand, from the traditional trade theory - expressed in the Heckscher-Ohlin's theorem and in its Stolper-Samuelson corollary (HOSS hereafter) - we may expect a relative decrease in the demand for skilled labour. In fact, according to this main building-block of the theory of international trade, openness should benefit a country's relatively abundant factor, since trade specialisation will favour sectors intensive in the abundant factor. Taking into account that Turkey– when compared with her main trading partners, namely the EU – is relatively abundant in unskilled labour and so have a comparative advantage in this production factor, openness should have increased the demand for unskilled workers and raised their relative wages. On the other hand, if the HOSS assumption of homogeneous production functions[1] among countries is relaxed, then international openness may facilitate technology diffusion from developed countries. Imports, exports and foreign direct investment (FDI) may in fact act as a channel of technological upgrading and shift the production function towards more skill-intensive technologies. In other words, trade and FDI may induce and foster skill-biased technological change (SBTC) at the firm level.

This paper contributes to this debate presenting new empirical evidence on the Turkish manufacturing sector, making use of a detailed firm-level database (*Annual Manufacturing Industry Statistics*) which covers all manufacturing firms employing 10 or more people

[1] That is, the same technology and absence of scale economies.

(representing about 90% of (formal sector) manufacturing output) over the 1980-2001 period.

The choice of studying the Turkish experience is motivated by different sets of reasons. From an EU policy perspective, it is a country deserving investigation as it is the biggest and most populous EU candidate country. From a more strictly economic point of view, it is a middle income country[2] with sizeable commercial flows with developed countries, especially the EU. This makes it a net technology importer, and hence the ideal country to investigate the impact of potential imported SBTC. Moreover, it is a very significant and illustrative case of a country which has changed – during the '80s – its economic strategy from a protectionist model characterized by heavy state intervention to a more outward-looking one.

The reminder of this paper is organized as follows: the next section reviews the theoretical and empirical literature on the interaction between trade openness, technological change and the relative demand for skilled labour, mainly focusing on developing countries. Section 3 introduces and describes the data. In Section 4 we discuss historical trends in the Turkish economy and present some descriptive statistics. In Section 5 we present the econometric analysis: first, we explain our empirical strategy (Section 5.1); then we present and discuss our results (Section 5.2). Finally, the last section proposes some concluding remarks.

2. The literature

The increase in the relative demand for skilled labour has been documented in many countries in the last three decades (see, among others, Murphy and Welch, 1992; Katz and Murphy, 1992, for the US and Freeman and Katz, 1994; Machin and Van Reenen, 1998 for other OECD countries). In the literature there is an ongoing debate about the relative importance of SBTC vs. international trade in explaining the observed widened wage differential between skilled and unskilled labour in the developed world (see Deardorff,

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[2] Trade openness is supposed to have a greater inequality-enhancing impact in middle income countries, where "social capabilities" (Abramovitz, 1986) and "absorptive capacity" (Lall, 2004) are higher and where technology adoption form more advanced countries effectively acts as a channel of technological upgrading, thus leading to the increase in the relative demand and wages for skilled workers (see Meschi and Vivarelli, 2007).

1998 for a comprehensive review of such debate). Although some authors have argued in favour of Stolper-Samuelson effects owing to increased trade (see for example, Leamer, 1994; Wood, 1994), most papers find that pervasive (SBTC) has been the main cause of the movements in relative wages and demand for skilled versus unskilled workers in developed economies (see, for instance, Krugman and Lawrence, 1993; Lawrence and Slaughter, 1993; Berman, *et al.*, 1994).

From a theoretical point of view in the developed world both trade liberalization (through the HOSS mechanism) and technological change could be responsible for the observed pattern of increased relative demand for skilled labour. Instead, according to the traditional theory in developing countries the two processes are supposed to have opposite effect.

On the one hand, technological change could shift the labour demand toward more skilled workers. The SBTC hypothesis is in fact based on the idea that there is close complementarity between new technologies and skilled workers, given that only the latter are fully able to implement those technologies. One of the first arguments for the SBTC hypothesis emanates from the work of Arrow (1962). Arrow introduced the notion of learning-by-doing, which implies that the experience in the application of a given technology in the production process leads to increased efficiency over time. An implication of this idea is that an educated labour force should learn faster than a less educated group. Industries with more rapid technological progress may thus favour workers with great potential for learning (Wolff, 2006). A second rationale comes from Nelson and Phelps' (1966) model, which stresses that a more educated workforce may make it easier for a firm to adopt and implement new technologies. The idea is that educated workers are more able to evaluate and adapt innovations and to learn new functions and routines than less educated ones.

On the other hand, the HOSS mechanism predicts that a developing country trading with skill abundant developed economies should specialize in the production of unskilled-labour-intensive goods and therefore experience a relative increase in the demand for unskilled labour.

However, if the HOSS assumption of homogeneous production functions and identical technologies among countries is relaxed, then international openness may facilitate technology diffusion[3] from developed to developing countries implying that trade and technological change are complementary rather than alternative mechanisms. Robbins (2003) has called the effect of in-flowing technology resulting from trade liberalisation the '*skill-enhancing trade* (SET) hypothesis'. The idea is that trade liberalisation accelerates the flows of imported embodied technology (in machineries, intermediate inputs, components and final goods that can act as benchmarks for the domestic production and can be subjected to reverse engineering) to the South, inducing an adaptation to the modern skill-intensive technologies currently used in the North, resulting in the increase in the demand for skilled.

Turning our attention to the empirical literature, a large number of works have documented the relevance of the SBTC hypothesis for industrialised countries (ICs),[4] while the evidence on developing countries (DCs) is scant. Since in the case of developing countries technology upgrading is often fostered by trade liberalization, many of the works on DCs jointly consider the impact of trade and technology variables.

Berman and Machin (2000 and 2004) studied the role of SBTC in increasing the demand for skills in developing countries, trying to understand to what extent SBTC is moving across international borders, thereby altering the skill structure of labour markets. They analyzed the changes in the non-production wage-bill share in 37 countries[5] for the 1970-80 and 1980-90 time periods and found that in the '70s high income countries experienced a strong increase in skilled wages in total manufacturing wage bill (most of which was due to within industry skill upgrading). In the 1980s the skilled wage bill share increased in middle income countries as well, with a magnitude similar to that of high income countries. They then showed that the '70s' US industry pattern of skill upgrading was a good predictor of the industry skill upgrading in middle income countries in the '80s, suggesting that the same industries had increased their proportion of skilled workers. Moreover, it appeared that the patterns in middle income countries were due to the adoption of the same kinds of skill-biased technologies that had permeated into industries in developed

[3]Keller (2004) and Piva (2003) provide complete surveys of the literature on international technology diffusion and show that trade openness turned out to be a key channel of technology adoption in developing countries. International technology transfer represents in fact a crucial determinant of technological upgrading in DCs (Krugman, 1979; De Long and Summers, 1993). While some firms are engaged in the creation of new technologies, most firms simply imitate or adapt existing production techniques to local conditions (Evenson and Westphal, 1995; Almeida and Fernandes, 2007).

[4] See for example Berman *et al.* (1994) and Autor, Katz and Krueger (1998) for the US; Haskel and Heden (1999) for the UK; Piva, Santarelli and Vivarelli (2005) for Italy; Machin and Van Reenen (1998) for a panel of seven OECD countries.

[5] They divided the sample in three subgroups: high-income, middle-income and low income countries.

world: in fact, the measures of industry skill upgrading in the middle income group resulted positively correlated with global technology indicators (computer usage and R&D intensity). Thus, their results suggested that SBTC had been transferred rapidly from developed world to middle income countries and emphasized the pervasive nature of SBTC.

Conte and Vivarelli (2007) have studied the impact of technological transfer on the employment of skilled and unskilled labour in a sample of low and middle income countries. By using a direct measure of embodied technological transfer - namely the trade flows from ICs of those goods which reasonably incorporate technological upgrading - they have found that imported skill-biased technological change is in fact one of the determinants of the increase in the relative demand for skilled workers within DCs.

Turning the attention on country-specific evidence, Hanson and Harrison (1999), using data on Mexican manufacturing plants, found that firms that receive FDI, acquire technology through licensing agreements or firms that import materials tend to hire more skilled workers. However, they obtained insignificant relationship for other measures of technological change. A similar result was obtained by Feenstra and Hanson (1997) who used data on 2-digit Mexican industries for the period 1975 to 1988 and found that FDI were positively correlated with the relative demand for skilled labour and that FDI could account for a large portion of the increase in the skilled labour share in total wages. Pavcnik (2003) examined whether investment and adoption of skill-biased technology associated with trade liberalization contributed to within-industry skill upgrading in Chilean plants during the '80s. In particular, using a restricted variable translog cost function approach, she investigated whether plant-level measures of capital investment – the use of imported materials, foreign technical assistance and patented technology – did affect the relative demand for skilled workers. Her results suggested that capital deepening provided a possible explanation for the growing relative demand for skilled workers. However, once she controlled for unobserved plant characteristics, the relationship between skill upgrading and the three technology measures disappeared, suggesting that plant adoption of foreign technology was not so obviously associated to plant skill upgrading. Fuentes and Gilchrist (2005) extended her analysis over an additional nine years time span to cover the period 1979-1995. They obtained, in contrast with the findings in Pavnick, a robust association between the labour demand for skilled workers and the adoption of new technologies -

measured by foreign patent usage - even after controlling for unobserved plant-level heterogeneity[6].

Similarly, Mazumdar and Quispe-Agnoli (2002) found evidence that imported skill-biased technical change was responsible for rising wage inequality in Peru, following its trade liberalization in the early '90s. They identified the channel to be the skill-biased technology embodied in imported machinery.

As far as we know, Gorg and Strobl (2002) is the only paper in this field focusing on a low-income country. They analyzed a panel of manufacturing firms in Ghana over the '90s in order to understand whether the imports of technology-intensive capital goods or the export activities might provide an explanation for the increase in the relative wages of skilled workers in Ghana. Their results suggested that while the purchase of foreign machinery for technological purposes had significantly raised the relative demand for skilled labour, the greater participation in the world output market via exporting activities did not play a direct role in the skill composition of manufacturing firms in Ghana.

3. Data

The data used in this paper are drawn from the *Annual Manufacturing Industry Statistics*, provided by the Turkish Statistical Institute (TurkStat, formerly known as the State Institute of Statistics, SIS). The database covers the 1980-2001 period and includes all private firms employing at least ten employees and all public firms.[7] In terms of value added, it accounts for around 90 % of all (formal sector) manufacturing output.

This database provides a wide array of information on each individual firm. In every year firms report detailed information on aspects such as size and composition of workforce, wages, output, input, sales, and investments among others. All variables are expressed in 1994 Turkish Lira, using sector-specific deflators.

Employment is measured as the number of workers hired per year and is split in two broad categories: production and administrative workers. Production employment is made by technical personnel, foremen and supervisors and all those who work physically in the

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[6] By using a different methodology relying on individual level data (Labour Force Survey), Beyer et al. (1999) also found that trade openness did rise the skill premium in Chile. However, they argued that the explanation for this effect went beyond technological transfers or a sector biased technical progress.

[7] Strictly speaking, the observation unit is a plant that has decision-making authority and keeps its own accounts. Since most of the firms are single plant firms, we use the terms firm and plant interchangeably.

production activities. The administrative category includes management and administrative personnel and officers. We use these two categories of workers to distinguish between skilled (administrative workers) and unskilled (production workers) labour[8].

Indeed, the survey also provides a more detailed disaggregation of skill-types: for every year it reports the number of workers with different qualifications. These data would allow us to build a more precise measure of skilled workers, defined as the sum of skilled production workers (high level technical personnel and medium level technical personnel) and skilled administrative workers (management and administrative personnel). Unfortunately, the survey does not provide wage data for this disaggregation. Therefore, our analysis will be based on the broad distinction between production and administrative labour. However, thanks to the disaggregated data, we were able to check for the appropriateness of our categorization by calculating the share of "effective" unskilled workers in the "production" category and of "effective" skilled workers in the "administrative" one. They were respectively 89 and 69 percent. We are thus confident that the two broad categories may be considered rather reliable proxies of the actual distinction between unskilled and skilled workers.

The average number of firms per year is about 9600 in the private sector and about 400 in the public sector. Firms are classified by type of activity in accordance with the "International Standard Industrial Classification" (ISIC Rev.2). Table 1 reports the distribution of firms across two-digit ISIC sector.

[8] The classification of workers into "production" and "non-production" groups in order to approximate skilled and unskilled labour respectively is very common in the literature: among others, Berman, Bound, and Griliches (1994) Feenstra and Hanson (1996), Leamer (1998) have used a production/non-production classification. Although this categorization is not the ideal one (as skills are better described by classifications based on educational characteristics), the production and non-production distinction is often the only available in firm level data. Moreover, Berman, *et al.* (1994) argue that identifying skilled and unskilled labour on the basis of job classifications and educational attainment leads to very similar results. They in fact show that the proportion of non-production workers follows the same trend increase as the proportion of skilled workers in the US manufacturing sector.

Table 1: Distribution of private and public firms across sectors

ISIC Industry	Private Sector	Public Sector
Food Beverages Tobacco	18.28%	53.27%
Textile and Clothing	27.02%	8.70%
Wood Products	3.93%	5.08%
Paper and Printing	3.79%	4.85%
Chemicals and Petroleum, Coal, Rubber and Plastic	9.75%	7.51%
Non-Metallic Mineral Prods.	7.35%	6.40%
Basic Metal	4.39%	3.33%
Metal Products, Machinery and Equipment	24.41%	10.63%
Other Manufacturing	1.09%	0.28%

Source: Own calculation from the *Annual Manufacturing Industry Statistics*

Data on international trade are collected by TurkStat and provide information on exports and imports flows in each of 86 four-digit ISIC (Rev.2) sectors. Moreover, for each year and sector, data allow to disentangle trade flows according to their origin and destination areas. In particular, it is possible to distinguish if imports and exports are from/to ICs and DCs.

4. Economic trends and descriptive evidence

This section provides some stylized facts on the recent process of trade liberalization in Turkey (section 4.1) and describes the contemporaneous main trends in the Turkish labour market (section 4.2). In particular, we will look at the evolution of the skilled versus unskilled relative wages and employment, in order to understand whether the relative demand for skilled labour did in fact increase during the phase of rapid integration of Turkish economy in the international markets. Finally, in Section 4.3, we will decompose the relative aggregate demand shift into its between- and within-industry components.

4.1. Trade Liberalization

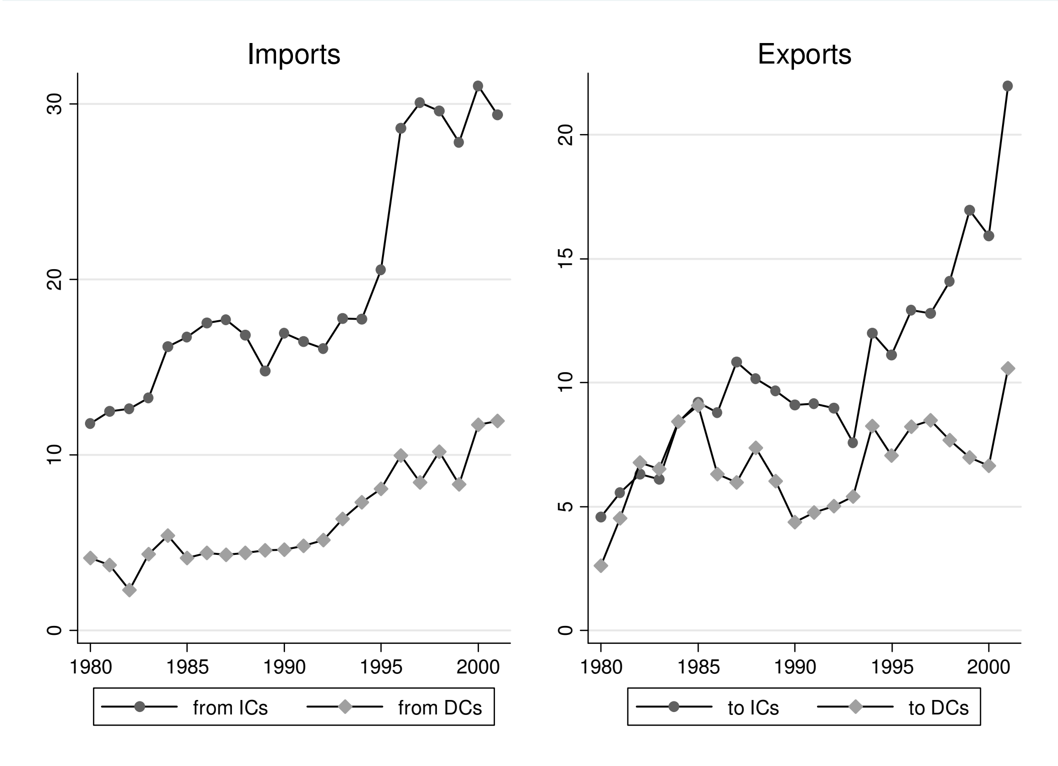
Until 1980 Turkish economic and trade policies were characterized by import-substituting (IS) industrialization under heavy state protection. Despite a good performance in terms of economic growth, IS strategy led to a number of problems which became unsustainable at the end of the 1970s: a substantial inefficiency at the firm level (Celasun, 1994); macroeconomic instability and high unemployment, high inflation and severe balance of payments difficulties (Senses, 1994). The consequent growing public sector deficits and import shortages contributed to the acceleration of inflation which reached the average rate of 69 per cent during 1978-80. All these problems had a detrimental impact on the manufacturing sector, which registered negative growth rates in 1978-80.

In January 1980, a comprehensive structural adjustment reform program (SSAP[9]) was launched under the guidance and the auspices of the International Monetary Fund and the World Bank. A major component of the reform package consisted of policy changes to achieve greater openness; this liberalization process can be divided in two distinct phases (Yeldan, 2000 and Taymaz and Yilmaz, 2007). The first one covers broadly the period 1981-1988 and its main characteristic is structural adjustment through export promotion and commodity trade liberalization, albeit under a foreign exchange system of regulated foreign capital inflows. The second phase started in 1989 with the elimination of controls on foreign capital transactions and the declaration of convertibility of the Turkish Lira. In this second period the most important changes in the trade regime in Turkey were constituted by the Custom Union (CU) between the EU and Turkey (January 1996) and the consequent Free Trade Agreements (FTAs) signed with the European Free Trade Association countries, Israel, and the Central and Eastern European (CEE) countries (2001).

As a result of these changes in trade policy, the volumes of Turkish exports and imports increased substantially since the early '80s. Figure 1 plots the evolution of exports and imports as a percentage of total manufacturing output over the sample period, distinguishing trade flows according to their origin and destination areas.

[9] SSAP: Stabilization and Structural Adjustment Program.

Figure 1: Exports and Imports (% tot. manuf. output) by origin and destination areas

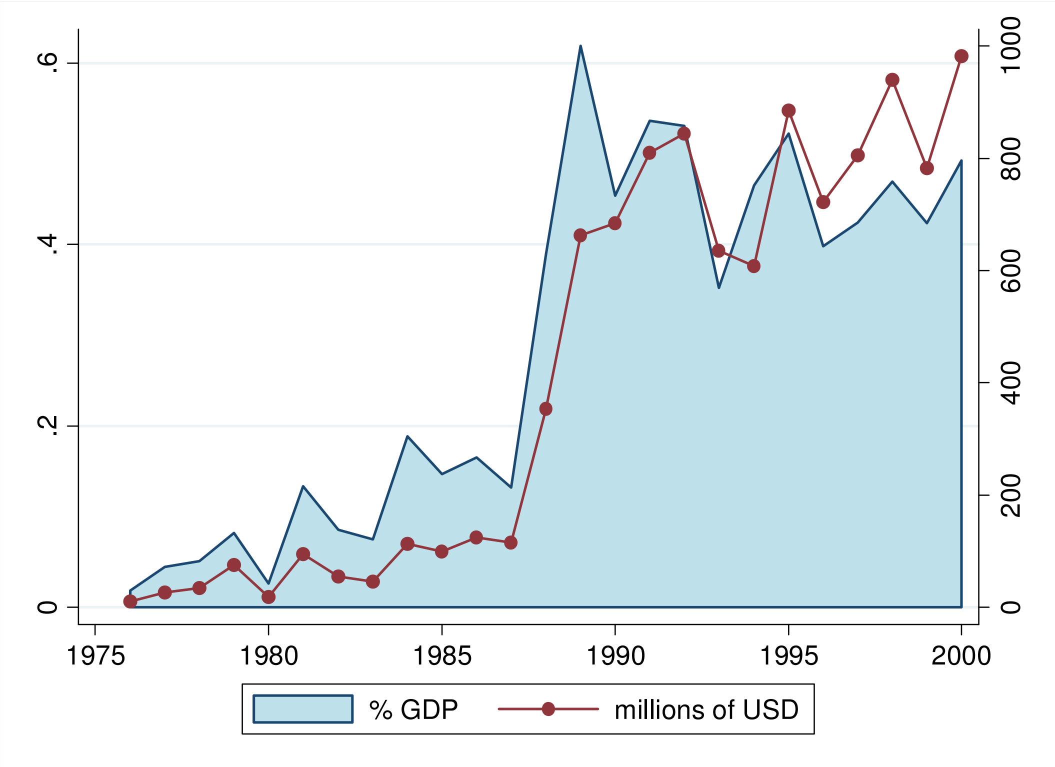


Source: Own elaborations from *Annual Manufacturing Industry Statistics* and Turkstat.

The figure underlines the significant import and export growth over the 1980-2001 period. Moreover, it shows that the bulk of imports come from industrialized countries (ICs). Exports patterns are instead changing over time: at the beginning of the period exports to ICs and to DCs represented the same shares of manufacturing output, while starting from the 1985 exports to ICs significantly increased with respect to those to DCs.

During the same years, total FDI flows increased as well, both in absolute terms and as a share of GDP. Figure 2 shows these trends for the 1975-2001 period. The figure reveals that until 1980 the level of FDI in Turkey was very low. The reason for that can be found in the restrictive bureaucratic practices by government institutions - and most importantly by the State Planning Organization- who were suspicious of foreign capital (Taymaz and Lenger, 2006). In the early '80s, in accordance with the general outward-oriented strategy, the administrative system regulating FDI was reorganized in order to simplify investment procedures and to eliminate ambiguities arising from the fragmented bureaucratic structure; moreover, the discriminatory treatments toward foreign investor were gradually eliminated. The complete liberalization of capital accounts and the elimination of certain restrictions on FDI in 1989 provided an additional impetus for foreign investment.

Figure 2: FDI inflows



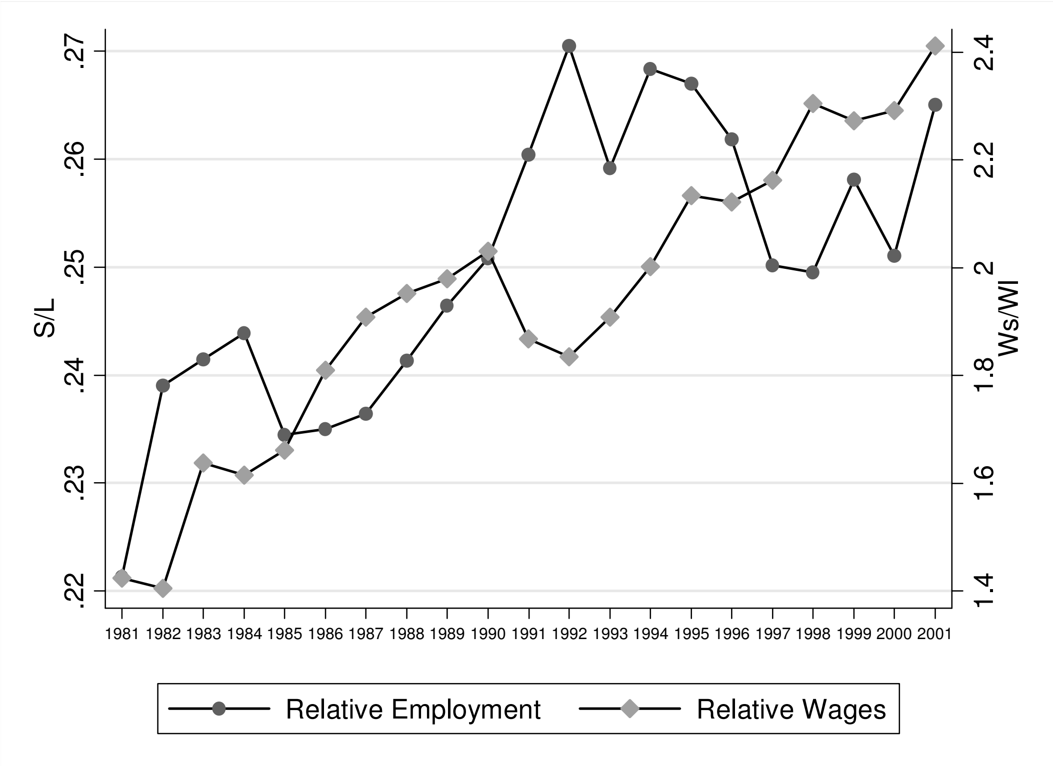
Source: FDI/TNC database, UNCTAD

Summing up, what emerges from this brief overview is that over the last 25 years Turkish economy has become increasingly connected with the world market. In the next section we will analyse the trends of relative employment and wages, trying to understand whether the demand for skilled labour has in fact changed during the years of globalization.

4.2. Trends in the Labour Market

Figure 3 plots the contemporaneous trends in relative wages (right axis) and relative employment (left axis) in private sector over the 1980-2001 period. The figure clearly shows that both relative wages and relative employment have followed a rising trend. This is particularly obvious during the '80s when trade liberalization has been especially rapid.

Figure 3: Relative Employment and Wages in Private Sector



Source: Own elaborations from *Annual Manufacturing Industry Statistics*

The observed simultaneous increase in relative employment and relative wages suggests that relative demand for skilled labour should have increased. Considering a very simple relative demand and supply framework, it is easy to show that when the demand curve shifts outward, the economy ends up with simultaneously higher relative wages and employment for the skilled worker. This means that a simultaneous increase of relative wages and relative employment necessarily implies an outward shift in the relative demand curve (see Berman *et al.*, 2005). This is even more so, if we consider that in the long run the relative supply curve is likely to move to the right and thus tend to reduce the relative wage. Indeed, in order to generate simultaneously higher wages and employment for the skilled, relative demand must have increased by more than relative supply.

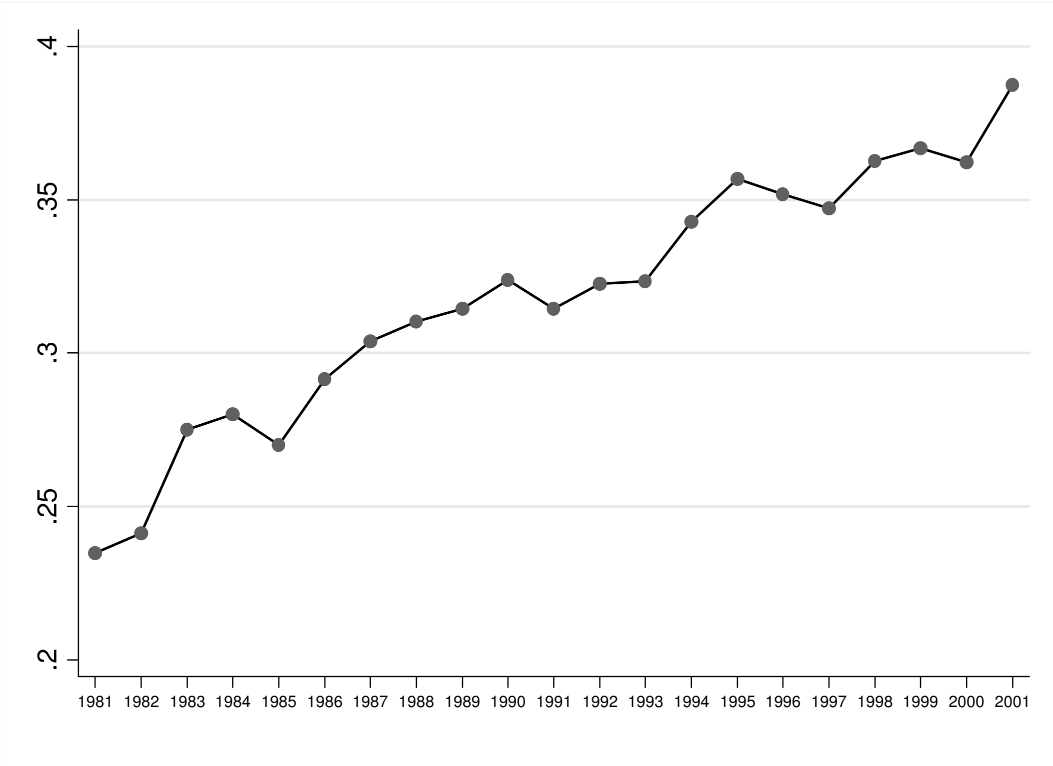
Another way to evaluate whether the relative demand for skilled labour increased and to distinguish the effects of labour supply from those of labour demand is to observe the evolution of the labour cost share of skilled workers[10], under the hypothesis of elasticity of

[10] The labour cost share is the share of total labour cost accruing to skilled workers. Differently from other papers that look at the skilled workers' share on the *wage bill*, here we focus on *labour cost*. The labour cost is given by the wages plus employees' social contribution and premiums. Since we are interested in the plant-

substitution between skilled and unskilled labour equal to one (Berman and Machin, 2000 and Berman *et al.*, 2005). If the elasticity of substitution is unity, the labour cost share of skilled labour (S*LCSH*) is invariant to movements along the relative demand curve and therefore S*LCSH* can be considered a measure of the demand for skills[11].

Figure 4 plots the evolution of S*LCSH* during the sample period, strongly confirming the uprising trend in the demand for skills.

Figure 4: Evolution of the labour cost share of skilled workers (SLCSH)



Source: Own elaborations from *Annual Manufacturing Industry Statistics*

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level determinants of the demand for labour, what is important here are the effective costs - including non-wage ones - the firms have to sustain.

[11] The labour cost share of skilled workers can be expressed as: $SLCSH = \frac{w_s S}{w_s S + w_l L} = \frac{w_s S}{wE}$ where *w* is wages, *s* subscript denotes skilled, *l* subscript denotes low-skilled, S and L are respectively the number of skilled and low-skilled workers and E is total employment. Taking the logarithm, the formula can be decomposed as follows: $\log(SLCSH) = \log(w_s / w) + \log(S / E)$. If the elasticity of substitution between S and L is one, *SLCSH* is constant along a relative demand curve, so that the log change in relative wages and that of relative employment sum to zero: $\Delta \log(SLCSH) = \Delta \log(w_s / w) + \Delta \log(S / E) = 0$.

4.3: Decomposition analysis

The previous figures document an increasing demand for skilled labour that occurred simultaneously with a rapid increase in international trade. A preliminary way to understand the main forces behind the skill upgrading is to split the aggregate change of demand for skilled labour into its between- and within-industry components. The aggregate increase in the demand for skills may in fact be driven by (a) employment reallocation across industries (for a number of reasons, such as trade shift, structural change, taste changes, or changes in economic policy) or by (b) skill upgrading within industries (mainly due to technological change). Following Berman, *et al.* (1994) we decompose the aggregate change in labour cost share for skilled workers ($\Delta SLCSH$) for i = 1,…, N (with N=86) industries over a period of time according to the following formula:

$$\Delta SLCSH = \sum_{i=1}^{N} \Delta SLCSH_i \overline{P_i} + \sum_{i=1}^{N} \Delta P_i \overline{SLCSH_i} \qquad \textbf{(1a)}$$

The first term is the within-industry component of skill upgrading (weighted by $\overline{P_i}$, the relative size of industry i – namely the share of industry *i*'s labour cost in the aggregate labour cost – where the bar is a time mean). The second term measures the contribution of the between-industry shifts, namely how much bigger or smaller an industry is becoming over time (weighted by time averaged skill demand).

The results of this decomposition are shown in Table 2. We report the decomposition obtained from the full sample period (in the first row of the table) as well as the decomposition over different sub-sample periods defined accordingly to the timing of the main Turkish policy changes and the major cycles of adjustment-growth-recession[12]. The first period (1980-1983) corresponds to the first phase of trade liberalization characterized by export promotion strategy. The 1983-88 is the second period of trade liberalization when most of the tariffs and non-tariff barriers to the imports were reduced or eliminated. These two phases correspond to the growth cycle promoted by export orientation, followed by the recession of 1988. The second cycle (1988-93) was generated by foreign capital inflows following the financial deregulation and came to an end with the eruption of

[12] See Yeldan (2000) for a detailed description of macroeconomic phases of the post 1980 Turkish economy.

the 1994 financial crisis (the forth sub-period in the table). The last growth cycle was that of 1995-2000 short-circuited by the second financial crisis in 2001.

Table 2: Decomposition of *SLCSH* changes within and between sectors

Years	Within component	Between component	Total Change	Within/Total
1981-2001	*0.135*	*0.013*	*0.148*	*0.886*
1980-83	0.005	0.001	0.006	0.871
1983-88	0.034	0.000	0.034	1.004
1988-93	0.002	0.011	0.013	0.159
1993-94	0.018	0.001	0.019	0.950
1994-00	0.021	-0.002	0.019	1.123
2000-01	0.024	0.003	0.027	0.891

The results suggest that the aggregate labour cost share of skilled workers rose by 14.8 percentage points over the full sample period (see also Figure 4). The table also shows that this increase has been mainly driven by within-industry variation, which represents more than 88 percent of the overall change. Looking at the results for different periods, it emerges that in each phase the within-sector component is positive and dominant (except for the 1988-93 sub-period), suggesting that aggregate demand shifts are persistently due to within-sector upgrading. The aggregate change and the within-industry component are particularly high in the 1983-88 interval which corresponds to a period of rapid trade liberalization during which most of import barriers were eliminated.

While many papers put forward the dominance of the within-industry component as an evidence of the relevance for the SBTC hypothesis (e.g Berman, Bound and Machin, 1998), rejecting the importance of trade-based explanations[13], we instead argue that the two

[13] Feenstra and Hanson (2001) challenge the conclusions of many previous works that use the evidence of within-industry shift as an argument against the relevance of trade. They in fact argue that "this line of reasoning emphasizes trade in final goods and ignores the globalization of production and recent dramatic increases in trade in intermediate inputs. Much recent growth in trade has resulted from firms breaking industries apart by locating low-skill activities in low-wage countries and high-skill activities in high-wage countries. (…). Recent literature shows that trade to merchandise GDP ratios have risen sharply in recent years, with much of the growth in trade attributable to intermediate inputs, that changes in the relative prices of domestic versus imported goods are consistent with trade shifting out the relative demand for skilled labor, and that trade in intermediate inputs is consistent with skill upgrading being a within-industry phenomenon" (Feenstra and Hanson, 2001, pp. 46-47)

explanations are not necessarily alternative, especially in the case of middle-income open economies such as Turkey. Indeed, trade intensification and SBTC may be complementary in explaining the observed dominance of the within-industry component in the increase in the demand for skills. Trade liberalization may have in fact fostered the process of technological upgrading increasing the magnitude of the within component. The fact that the within-industry effect was higher in the periods of more intensive trade liberalization preliminarily confirms this idea, suggesting that trade may have played a role by fostering and accelerating the adoption of the new skilled-biased technologies.

This analysis may be further developed by looking at the inter-plants demand shifts. At the industry and at the aggregate level, the observed change in the demand for skilled labour may in fact reflect within-firms as well as between-firms variations. Another important source of variation in labour demand comes from the entry and exit of firms. The relative demand for skilled labour may increase also because, in each period, the new entrant firms are relatively more skill-intensive than the exiting ones. Disentangling between these three different aspects may be interesting at the descriptive level and provides a more complete picture of the skill upgrading process within the manufacturing sector. At the interpretive level, in this case we cannot infer the relevance of the contribution of technology on the one hand and trade or structural change on the other. In fact, technology may play a role in all the three components. It can induce skill upgrading within each firm, but it can also cause between- firms shifts. It could be the case that the firms with successful production techniques expand at the cost of their less successful contracting counterparts (see, for example, Foster, Haltiwanger and Krizan, 2001). The most productive firms may then increase their market share and displace old and technology backward firms.

Drawing on Abowd *et al.* (2001) we summarize the relative contribution of the between and within-firms components using the following decomposition, which also takes into account the entry and exit effects:

$$\Delta Sn_t = \sum_{j \in C} P_{jt-1} \Delta Sn_{jt} + \sum_{j \in C} \Delta P_{jt} (Sn_{jt-1} - \overline{Sn}_{t-1}) + \sum_{j \in C} \Delta P_{jt} \Delta Sn_{jt} + + \sum_{j \in N} P_{jt} (Sn_{jt} - \overline{Sn}_{t-1}) - \sum_{j \in E} P_{jt-1} (Sn_{jt-1} - \overline{Sn}_{t-1}) \quad \textbf{(1b)}$$

where j= individual firm, C= set of continuous firms; N= set of new entrants firms; E= set of exiting firms; *Sn*=skilled labour cost share; P= firm labour cost share in total manufacturing; the bar stands for mean over the manufacturing sector.

The decomposition in equation (2) splits the source of change in the relative demand for skilled labour at the industry (or aggregate) level into four components: (1) the part due to within-firm changes (first term in the equation); (2) the part due to variations in the composition of labour demand across firms (second term); (3) a cross-product term (third term) indicating whether increases in skilled labour cost share are positively or negatively related to changes in the labour cost share in total industry; (4) the change due to net entry (fourth and fifth terms). The results of this decomposition are reported in Table 3.

Table 3: Decomposition between and within firms at manufacturing level

Years	Within	Between	Interaction	Entry	Exit	Net Entry	Total	Within/ Total
1980-83	0.006	0.005	-0.006	0.002	0.000	0.003	0.008	0.822
1983-88	0.028	-0.002	0.001	0.003	0.005	0.007	0.035	0.798
1988-93	0.008	0.010	-0.005	-0.003	0.004	0.002	0.015	0.525
1993-94	0.017	0.003	-0.001	-0.001	0.001	0.001	0.020	0.853
1994-00	0.026	0.001	-0.004	-0.008	0.002	-0.006	0.018	1.459
2000-01	0.015	0.006	0.005	0.000	0.000	0.000	0.025	0.605

The decomposition exercise reveals that the within-firm component is again dominant in all periods. Moreover for all periods, except 1994-2000, the contribution of net entry is also positive, with entrants having a higher demand for skills that the exiting firms they displaced. For certain periods, the combination of the within component plus net entry accounts of more the 100 % of the overall change. In these cases the negative between component or cross term offset the positive impact of the within and the net entry component. The negative between-firms variation during the 1983-88 is consistent with the view that during the phase of export promotion and given Turkey's comparative advantages, some unskilled-labour-intensive exporting firms were expanding. The negative cross term means that downsizing firms exhibit substantial up-skilling (Abowd *et al.*, 2007): in other words, there is a negative covariance between changes in the demand for skilled labour and changes in firms' size. Therefore, it looks like part of the reallocation process across firms is associated with firms dismissing their less skilled workers.

5. Econometric Analysis

The aim of this section is to analyze the determinants of the changes in *SLCSH* at both industry and plant level. In particular, we are interested in understanding whether the changes in the skilled labour cost share are correlated to any measure of technology adoption (as the SBTC literature predicts) and to the exposure to international markets. We expect trade and technology to play a complementary role in shaping the demand for skills. As discussed above - in the case of middle-income developing countries such as Turkey - trade openness may in fact foster technological upgrading through the imports of capital goods and through the potentially skill-enhancing impact of exports. Our empirical strategy is explained in the next section, while section 5.2 and 5.3 present and discuss our results at the sectoral and firm level respectively.

5.1. The Empirical Strategy

Our empirical strategy consists in the estimation of a cost share equation, whereby changes in the wage bill share in a given firm are related to observable measures of international openness and technology adoption. Drawing on Berman *et al.* (1994), Doms *et al.* (1997) and Machin and Van Reenen (1998), the factor share equation is derived from a *translog* cost function[14] where the two factors of production are skilled (S) and unskilled (L) labour, while physical capital (K) and "technological capital" (T) are assumed to be quasi fixed. Consequently, the cost function assumes the following form:

[14] As emphasized by Pavcnik (2003), the translog cost function is very appealing because it provides a second order approximation to any cost function and it does not impose any restrictions on the substitutability of various inputs.

$$\log C = \alpha_0 + \sum_{i=S,L} \beta_i \log w_i + \sum_{i=S,L} \sum_{j=S,L} \beta_{ij} \log w_i \log w_j + \beta_q \log Q + \sum_{i=S,L} \beta_{iq} \log w_i \log Q +$$
$$\beta_k \log K + \sum_{i=S,L} \beta_{ik} \log w_i \log K + \beta_T \log T + \sum_{i=S,L} \beta_{iT} \log w_i T \qquad \textbf{(2)}$$

where C are variable costs. The β parameters measure the effect on total cost of factor prices (w_i), output (Q), technology (T) and capital stock (K).

According to the Shephard`s Lemma, the optimal cost minimising demand for an input can be derived through differentiation of the cost function with respect to its price. Therefore, we obtain the cost share of skilled labour (*SLCSH*) which can be expressed as follows[15]:

$$SLCSH = \alpha_S + \sum_{i=S,L} \beta_S \log(w_S / w_L) + \beta_{SK} \log K + \beta_{SQ} \log Q + \beta_{ST} \log T \qquad \textbf{(3)}$$

Therefore, the estimating equation of the labour cost share of skilled workers can be expressed as a stochastic form of equation (3). In particular, for firm *i* at time *t* it takes the following form:

$$SLCSH_{it} = \alpha_0 + \beta_1 \log(w_S / w_L)_{it} + \beta_2 \log(K_{it}) + \beta_3 \log(Q_{it}) + \beta_4 \log(T_{it}) + \varepsilon_i + u_{it} \quad \textbf{(4)}$$

In such a specification, β_2 captures the potential capital–skill complementarity (see Griliches, 1969). If capital is complementary to skilled labour, then β_2 should have a positive sign. One reason behind the capital–skill complementarity hypothesis is that higher priced capital equipment generally incorporates more sophisticated technology, and more educated labour is often needed to operate that equipment effectively (see Section 2). The output coefficient allows to test the constant-returns hypothesis which implies that input shares are invariant to scale. Indeed, if $\beta_3 > 0$, this hypothesis is violated indicating that faster growing firms also increase their labour cost share of skilled workers. Moreover, the log output allows to control for business cycle fluctuations; such fluctuations may occur if

[15] Equation 3 and 4 are derived after having imposed homogeneity of degree one in prices, which implies that $\sum_{i=S,L} \beta_{ij} = \sum_{j=S,L} \beta_{ij} = \sum_{i=S,L} \sum_{j=S,L} \beta_{ij} = \sum_{i=S,L} \beta_{iT} = \sum_{i=S,L} \beta_{ik}$

firms are more likely to layoff unskilled workers than skilled workers during a temporary downturn (see Fuentes and Gilchrist, 2005). β_4 represents our coefficient of interest and captures the impact of different technology-related variables. In this context, 'technology' has to be interpreted in a wider sense; we will use different variables which are potentially channels of technological upgrading: besides the usual proxies of technological change, such as R&D expenditures, we will also include variables describing international technological transfer and firms' international exposure.

Starting from equation (4), we employ a dynamic specification in order to account for the occurrence of significant employment adjustment costs which determine serial correlation in the labour-cost-share series. Moreover, as usual in this literature (see Chennels and Van Reneen, 1999), we drop the relative wage term which is endogenously determined, since it is directly involved in the construction of the dependent variable. We instead insert in the equation time dummies which should capture the movements in wages bill share due to supply shifts as well as other economy wide mechanisms[16]. Therefore, our estimating equation will be:

$$SLCSH_{it} = \alpha_0 + \beta_1 SLCSH_{it-1} + \beta_2 \log(K_{it}) + \beta_3 \log(VA_{it}) + \beta_4 \log(T_{it}) + \eta_t + \varepsilon_i + u_{it} \quad \textbf{(5)}$$

where the subscripts *i* and *t* denote respectively firms and years; *SLCSH* is the skilled workers labour cost share; K is capital[17], VA is the value added, T is a vector of mechanisms leading to technological upgrading, η_t are year dummies, ε_i are the individual fixed effects and finally u_{it} are the usual error terms. All variables are expressed in natural logarithms. In order to control for fixed firm's effects (ε_i)[18], we estimate this equation in differences. The final specification is thus as follows:

$$\Delta SLCSH_{it} = \beta_1 \Delta SLCSH_{it-1} + \beta_2 \Delta \log(K_{it}) + \beta_3 \Delta \log(VA_{it}) + \beta_4 \Delta \log(T_{it}) + \eta_t + \Delta u_{it} \quad \textbf{(6)}$$

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[16] This is a very common solution adopted by most of the literature. See, among others, Machin and Van Reneen (1998), Pavcnik (2003) and Berman *et al.* (2005)

[17] Capital is proxied by annual depreciation allowances, as in Taymaz and Lenger (2006)

[18] Chennels and Van Reneen (1999) stress the importance of controlling for fixed effects in this context. There is in fact unobserved heterogeneity across firms that may result in biased estimations. This is because certain types of firms are more or less likely to experience skill biases due to the specificities of their production processes and possible different abilities of their managers.

where Δ is the first difference operator.

However – here, as in any dynamic specification - the correlation of the lagged dependent variable with the error term implies an endogeneity problem. To solve this problem, Arellano and Bond (1991) proposed to use a Generalized Method of Moment (GMM) estimation, in which the instrument matrix includes all (or at least more) previous level values of the lagged dependent variable (GMM-DIFF estimator). However, the GMM-DIFF estimator is found to be weak if there is a strong persistence in the investigated time series and if cross-section variability dominates time variability (Bond *et al*., 2001). An efficiency improvement may be obtained through the additional consideration of the original equation in levels, instrumented by their own differences (Blundell and Bond, 1998, GMM SYS). Indeed, in the following econometric exercise, the availability of R&D and trade variables has limited the analysis to 17,434 private firms over the sub-period 1992-2001 for a total of 88,561 observations. Moreover, the correlation between *SLCSH* and *SLCSH* (-1) has turned out to be 0.766, while the coefficient of the linear regression of *SLCSH* on *SLCSH* (-1) has resulted equal to 0.769. Since both the conditions calling for the more comprehensive GMM-SYS methodology seem to characterise our data, we have chosen this estimation method.

5.2 Results at the sectoral level

We first estimate equation (6) aggregating firm-level data at the (4-digit ISIC) sectoral level. The main reason why we first adopt a sectoral perspective is that at the sectoral level we can rely on detailed data on trade[19] and merge them with aggregated firm-level data. In this way we can directly investigate the specific impact of import and export on the sectoral relative demand for skilled labour. Another important advantage of using sectorally aggregated data is that this reduces the extent of possible measurement errors (as long as the measurement errors are normally distributed across firms)[20].

Given the availability of trade data at the sectoral level, we expanded equation (6) to include data on both imports and exports at the sectoral level. We expect import penetration to be positively correlated with the demand for skills: import may in fact act as

[19] The source of trade data is Turkstat, the Turkish Statistical Institute (http://www.turkstat.gov.tr)

[20] The other side of the coin is that sectoral estimates may be affected by a composition bias and this call for a complementary firm's level analysis (See next section 5.3).

a channel of technological transfer, in that new technologies are embodied in the imported goods (especially machinery and intermediate inputs). The role of exports is theoretically less clear. On the one hand, export activity may induce a technological upgrading as well, by allowing firms to acquire knowledge of international best practice and by making the adoption of new technologies profitable. Moreover, the international market is more demanding than the domestic one[21] in terms of product quality and thus exporting may stimulate the demand for a better qualified workforce. In this sense we may expect exports to have a positive impact on the demand for skilled labour. On the other hand, Turkey is a developing country relatively abundant in unskilled labour, with comparative advantages in low-skill intensive sectors. According to HOSS, in an economy abundant in unskilled labour increased exports should induce a shift towards the production of unskilled-labour-intensive goods. To the extent that this shift occurs within industries, we expect the coefficient on exports to be negative. See, for example, Berman *et al.* (2005) who pursue the same argument for India.

The direct contribution of domestic technology is here tested by including the R&D expenditure as a share of sectoral value added. A positive and significant sign of this coefficient would support the SBTC hypothesis, independently from trade openness.

Table 4 shows the results of the basic specification and some diagnostic tests[22]. All standard errors have been adjusted for heteroskedasticity using the White (1980) correction.

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[21] This is especially true for developing economies.

[22] The Wald test, asymptotically distributed as a χ^2 where the degrees of freedom equate the number of restricted coefficients, allows to test the overall significance of the independent variables. The last two rows report the Lagrange Multiplier (LM) based test for first and second order serial correlation of the residuals proposed by Arellano-Bond (1991). The test is applied to the residuals of the first-differenced equation, and the null hypothesis is the absence of *n*-th order serial correlation. As expected, the test detects first order serial correlation, but rejects the hypothesis of serial correlation of higher order. The Sargan test of overidentifying restrictions verifies the overall validity of the GMM instruments where the null hypothesis suggests that the instruments are uncorrelated to some set of residuals. In our regression, the null is never rejected, confirming the exogeneity of the instruments[22]. The Difference-Sargan statistic, reported in the last row of the table, tests the improved efficiency of the GMM-SYS *versus* the GMM-DIF estimator, by testing the validity of additional instruments, namely the instruments used in the equation in levels. As it can be seen, the null hypothesis that supports the model with the total sets of instruments is never rejected.

Table 4: Basic Specification. Sectoral level. GMM-sys estimation.

	(1)	(2)	(3)
SLCSH (-1)	0.774***	0.825***	0.777***
	(0.069)	(0.079)	(0.070)
VA	0.00668**	0.00531*	0.00307
	(0.0026)	(0.0028)	(0.0022)
K	-0.000355	0.000180	-0.00119
	(0.0018)	(0.0018)	(0.0018)
IMP	0.00184***		0.00138**
	(0.00068)		(0.00066)
EXP	-0.00583***	-0.00442***	
	(0.0014)	(0.0016)	
R&D_VA	0.00677***	0.00654**	0.00642***
	(0.0024)	(0.0025)	(0.0024)
Constant	0.0681***	0.0716***	0.0522***
	(0.017)	(0.019)	(0.015)
year dummies	*Yes*	*Yes*	*Yes*
Observations	1452	1469	1455
Number of sectors	76	76	76
Wald[a]	1725*** (0.000)	1588*** (0.000)	1423*** (0.000)
AR(1)[b]	-9.248*** (0.000)	-8.770*** (0.000)	-9.210*** (0.000)
AR(2)[b]	1.101 (0.271)	1.614 (0.107)	1.186 (0.236)
Sargan test[c]	0.795 (0.851)	3.156 (0.368)	1.411 (0.703)
Sargan Diff test[d]	0.16 (0.685)	3.12 (0.077)	0.66 (0.418)

Notes: Dependent variable is the share of skilled workers in labour cost. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.
a: Wald test for the overall significance of the regression; b: Arellano-Bond LM test for autocorrelation of residuals; c: Sargan test of over identifying restrictions; d: Difference-Sargan test. P-values for the tests are reported in parentheses.

First of all, it emerges that the domestic technological variable has a positive and significant impact on the labour cost share. Consistently with many other works focusing on developed economies, the expenditures in R&D tend to raise the demand for skilled labour at the sectoral level, indicating the occurrence of SBTC even in the case of a middle-income developing country such as Turkey. However, the results do not support the capital-skill complementarity hypothesis at the sectoral level.

Interestingly, the results show that those sectors that most raised their imports also experienced a higher increase in the labour cost share of skilled workers. Instead, sectoral export orientation is negatively correlated with the demand for skills. While imports seem to imply a transfer of new technologies that are more skill-intensive than those previously in use in domestic markets, exports seem to have caused a within-industry shift towards less skill-intensive firms. The latter result is consistent with the predictions of the HOSS theorem. However, this theorem is based on the assumption of constant and identical technology among countries and is not able to take into account the potentials for technology diffusion arising from trade intensification. ***Our results suggest that both forces are at work***. On the one hand, trade openness – expressed as export intensification – tends to shift the production toward less skill-intensive firms. On the other hand, import penetration facilitates the adoption of new technologies embodied in capital and intermediate goods, thus shifting the production toward more skill-intensive technologies. In order to support these interpretations, we disaggregate import and export flows according to their origin and destination areas. If technological diffusion is the channel through which imports increase the demand for skilled labour, we should expect a greater impact of imports from industrialized countries, where the potential for innovation diffusion comes from. As discussed above, in the case of exports the predictions are less univocal. The results of this disaggregated analysis are reported in Table 5.

Looking at Table 5, it can be noticed that also in this case all the diagnostic tests confirm the appropriateness of the model. In column 1, imports and exports are jointly inserted, while in columns 2 and 3 we included only imports and exports respectively. When imports and exports are jointly included no significant results emerge (although the coefficients have the expected signs), probably because of collinearity between the four variables. Instead, looking at columns 2 and 3, it emerges that only imports and exports from/to industrialized countries are significantly related to the labour cost share's change. In the case of imports, this result reinforces the idea that the technological level of trading partner matters, meaning that only imports that embody a superior technological content imply a skill bias effect. Also in the case of exports, it seems that what matters are the exchanges with the developed world. This result can be interpreted in the light of the "Cones of Diversification" theory[23]. The intensification of exports leads to a reduction in the demand for skilled labour accordingly with HOSS only when exports are directed toward industrialized countries. Turkey has in fact a comparative advantage in the production of unskilled-labour-intensive goods only if it is compared with richer countries.

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[23] According to the "Cones of Diversification" theory (Davis, 1996), if the HOSS model is extended to many countries, then factor abundance should be assessed in relation not to the world as a whole, but only with respect to the group of countries that have similar endowment proportions and produce the same ranges of goods. These countries are said to constitute a '*cone of diversification*'. What matters for the distributive consequences of trade liberalisation is the relative position of the country amongst the other countries within its own cone. In fact, a developing country may be considered as "unskilled abundant" in global terms, but this may not be true in relation to other DCs.

Table 5: Disaggregating import flows according to their origin. GMM-sys estimation.

	(1)	(2)	(3)
SLCSH (-1)	0.780***	0.797***	0.742***
	(0.17)	(0.070)	(0.079)
VA	0.00684	0.00370	0.00880***
	(0.022)	(0.0023)	(0.0028)
K	-0.00350	-0.00168	-0.00151
	(0.011)	(0.0019)	(0.0018)
IMP_IC	0.00371	0.00330***	
	(0.0038)	(0.0013)	
IMP_DC	-0.00176	-0.00160	
	(0.0035)	(0.0010)	
EXP_IC	-0.000841		-0.00414***
	(0.029)		(0.0014)
EXP_DC	-0.0000837		-0.000594
	(0.028)		(0.0011)
R&D_VA	0.00611	0.00604**	0.00735***
	(0.0051)	(0.0024)	(0.0024)
Constant	0.0264	0.0358**	0.0695***
	(0.065)	(0.015)	(0.018)
year dummies	*Yes*	*Yes*	*Yes*
Observations	1368	1383	1455
Number of sectors	76	76	76
Wald[a]	1499*** (0.000)	1491*** (0.000)	1856*** (0.000)
AR(1)[b]	-5.789*** (0.000)	-9.271*** (0.000)	-8.553*** (0.000)
AR(2)[b]	0.811 (0.417)	1.266 (0.206)	1.148 (0.251)
Sargan test[c]	0.526 (0.468)	0.610 (0.894)	1.656 (0.647)
Sargan Diff test[d]	0.53 (0.468)	0.37 (0.544)	1.40 (0.237)

Notes: Dependent variable is the share of skilled workers in labour cost. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.
a: Wald test for the overall significance of the regression; b: Arellano-Bond LM test for autocorrelation of residuals; c: Sargan test of over identifying restrictions; d: Difference-Sargan test. P-values for the tests are reported in parentheses. IC= Industrialized countries; DC= Developing countries.

5.3 Results at the firm-level

This section presents the results at the firm level. Starting from eq. (6) - and after considering persistence (*SLCSH* (-1)), capital complementarity (K) and firm's size (VA) - we used our data to characterise T, that is the vector of the additional mechanisms leading to skill upgrading.

First, we included R&D expenditure as a share of the firm's value added (**R&D_VA**) to proxy firms' technological activity and to catch a possible role of pure SBTC on the demand for skilled labor. Hence we expect a positive sign of **R&D_VA** in affecting *SLCSH*.

However, since we are interested in the impact of trade-related technological transfer from abroad, we used other indicators that can capture technology adoption. The first one (**ttrans**) was created by looking at the foreign patent and licence usage. ttrans is a dummy variable which is equal to one if a firm in a given year got the right to use a foreign technology (know-how or patent) by a license agreement. This variable is particularly interesting since it describes the process of (disembodied) technology adoption and hence it captures incremental innovations which allow a progressive catch-up to the world technology frontier (Almeida and Fernandes, 2007). This variable can be thought as a proxy of imported SBTC and its impact is supposed to be positive.

We then used two other variables to proxy the firms' international engagement. First, a dummy variable (**xdum**) which is equal to 1 if the firm is an exporter and 0 otherwise[24]. The second proxy of integration into global markets is built looking at firms' ownership structure; **foreign** is a dummy equal to 1 if 10% or more of firm's capital is owned by foreigners. In this way, we are able to evaluate the skill-biased impact of FDI (the expected sign is positive; see the previous empirical evidence surveyed in Section 2).

Error! Reference source not found. reports the estimation results[25]. Each column differs according to the indicator used to describe the skill bias source. All standard errors have been adjusted for heteroskedasticity using the White correction (see White, 1980).

[24] Ideally, we would have used data on the value of exports as we did in the sector analysis. Unfortunately, our data do not provide this information as we only have information on whether a firm is an exporter or not.

[25] In this case the GMM SYS estimator has been implemented by using as instruments second, third and fourth lags of the dependent variable. We decided to start from the second lag because the test for residual autocorrelation (reported in the tables) often rejects the null hypothesis of absence of second order serial correlation.

Table 6: Results at the firm level

	(2)	(3)	(4)	(5)	(7)
SLCSH (-1)	0.822***	0.835***	0.805***	0.806***	0.801***
	(0.091)	(0.032)	(0.054)	(0.031)	(0.054)
K	0.00221**	0.00202***	0.00243***	0.00250***	0.00221***
	(0.0010)	(0.00036)	(0.00061)	(0.00036)	(0.00056)
VA	0.00735*	0.00534***	0.00727***	0.00622***	0.00640***
	(0.0038)	(0.0011)	(0.0020)	(0.00100)	(0.0018)
R&D_VA	0.00145*				
	(0.00079)				
Ttrans		0.0153***			0.0144**
		(0.0036)			(0.0061)
Xdum			0.00323*		0.00299*
			(0.0017)		(0.0017)
Foreign				0.0241***	0.0264***
				(0.0040)	(0.0081)
Constant	0.00422	-0.00138	-0.0174**	-0.00902***	-0.0101
	(0.012)	(0.0033)	(0.0075)	(0.0028)	(0.0062)
year dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	12445	149517	37922	164473	37922
Number of firms	5283	22985	12774	24543	12774
Wald (chi2)[a]	5016***	38013***	11731***	37843***	13999***
AR (1)[b]	-6.40***	- 28.74***	-16.24***	-28.66***	-16.18***
AR (2)[b]	1.59	14.52***	6.09***	15.77***	6.10***
Sargan Test[c]	0.55 (0.759)	27.87 (0.000)	5.99 (0.050)	18.07 (0.000)	5.63 (0.060)

Notes: Dependent variable is the share of skilled workers in labour cost. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. a: Wald test for the overall significance of the regression; b: Arellano-Bond LM test for autocorrelation of residuals; c: Sargan test of over identifying restrictions (p-value in parenthesises)

The results at the firm level underline the occurrence of capital-skill complementarity: the capital coefficient is always positive and highly significant which means that *ceteris paribus* the firms with higher capital intensity also demand a higher share of skilled workers. The real value added also enters the equation significantly pointing out that plant size is not neutral with respect to the relative demand for skills.

Turning the attention to our main focus of analysis, the estimates' outcomes show a positive and significant relationship between all the variables used as possible sources of skill bias and the labour cost share of skilled workers. The variables that directly measure technological input (domestic R&D expenditures and technological transfer) and the two variables capturing international openness through FDI and exports exert a significant impact on the demand for skills. It is worth noting that the result on the skill-bias effect of being exporter does not contradict the previous sectoral results showing that an increase in the sectoral export-orientation would reduce the skill intensity. In fact, while at sectoral level export intensification seems to shift the production toward the least skill-intensive firms according to the HOSS mechanism, at the firm level the fact of being an exporter may cause within-firm efficiency gains and increase the quality of the production, thus rising the relative demand for skilled workers.

These findings indeed support the SBTC argument and suggest that involvement in the global market also plays a role. When the three dummy variables capturing the extent (ttrans) and the potentials (xdum and foreign) for technology adoption from abroad are jointly included (column 5), it seems that the foreign-ownership has the higher impact However, all the three variables keep to be significant, at least at the 90% level of confidence.

5.3.1: Relative or absolute skill-bias?

The previous results have underlined a positive impact of both international exposure and technological variables on the labour cost share of skilled workers. In this section we will employ a different specification in order to evaluate the impact of these variables on the employment component alone, isolated from the wage component.

The specification proposed in (5) can be proxied by using information on employment (see Bartel and Lichtenberg, 1987, pp. 7-8), and in this case the dependent variable can be measured as the ratio of skilled (S) to low-skilled (L) workers. As emphasised by Piva *et al.* (2005), although less straightforward from a theoretical point of view, the specification in employment shares has been used by many researchers (see Berman *et al.*, 1994; Machin, 1996, Doms *et al.*, 1997; Machin and Van Reenen, 1998; Siegel, 1998; Aguirregabiria and Alonso-Borrego, 2001).

Starting from the general specification (5) with S/L as dependent variable, we use a Seemingly Unrelated Regression (SUR; see Zellner, 1962) method jointly testing two equations: one for the skilled workers and one for the unskilled ones. This method enables us to distinguish between relative and absolute skill bias effect[26]. In particular, we will be

[26] The definition of absolute skill bias implies an absolute decline in the demand for unskilled labour and an absolute increase of the demand for skilled labour, while relative skill bias only implies a faster increase of

able to understand the causes of the movements in the employment ratio. The share of skilled workers on total labour force can in fact increase due to a variety of reasons. A positive shift of the skill-ratio may be the result of the reduction of unskilled workers only, the increase of skilled workers only, a faster increase of skilled workers, or a simultaneous increase of skilled and reduction of unskilled workers. A single-equation setting cannot explain these different mechanisms and therefore the estimation of two separate equations is more informative in this sense.

Formally, our specification is the following:

$$\begin{cases} \Delta \log(S_{it}) = \alpha_S + \beta_{S1}\Delta \log(w_{S,it}) + \beta_{S2}\Delta \log(K_{it}) + \beta_{S3}\Delta \log(VA_{it}) + \beta_{S4}\Delta T_{it} + \eta_t + \varepsilon_{S,it} \\ \Delta \log(L_{it}) = \alpha_L + \beta_{L1}\Delta \log(w_{L,it}) + \beta_{L2}\Delta \log(K_{it}) + \beta_{L3}\Delta \log(VA_{it}) + \beta_{L4}\Delta T_{it} + \eta_t + \varepsilon_{L,it} \end{cases}$$

(10)

where S and L are the stock of skilled (non-production) and unskilled (production) workers respectively and the other variables are those defined above (see section 5.1). The equation is expressed in first differences in order to wipe out plants fixed effects and to control for plants' unobserved heterogeneity.

The SUR method is based on the assumption that the right-hand part of the equation is independent of the error term and that the errors are crossed. In other words, using this method I assume that the error terms between the labour inputs of one plant are correlated, but not those of different plants. These assumptions are likely to hold in my specification where the same equation is applied to two different components (S and L) of the same workforce within the same unit of analysis. The SUR methodology has been in fact often used in order to estimate the skill bias effect of technology (see for example, Betts, 1997; Adams, 1999 and Piva *et al.*, 2005).

Table 7 reports the outcomes of these estimates. It seems that all our variables of interest have an employment-enhancing effect. The columns 1, 3, 5, 7, 9, 11 report the results for the unskilled (production) workers' equation, while columns 2, 4, 6, 8, 10, 12

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demand for skilled labour with respect to unskilled labour. In other words, absolute skill bias implies a diverging pattern between skilled and unskilled labour demand, while relative skill bias does not.

refer to the skilled workers' equation. All the specifications include capital intensity, value added, wages, and sector and year dummies.

The last row of the table reports the Breusch-Pagan[27] test for independence of the two equations, which is always rejected at 1 % level of significance. This reassures us on the correctness of the SUR specification. The different columns vary according to the variable of interest that has been inserted. In particular (majority) foreign ownership dummy in columns 1 and 2, export dummy in col. 3 and 4, technological transfer dummy in col. 5 and 6, FDI dummy in col. 7 and 8, R&D expenditure over value added in col. 11 and 12. In columns 9 and 10 we have jointly inserted export, FDI and technological transfer dummies. As expected an increase in value added and capital investment leads to an increase in total employment. Moreover, it seems that also R&D investment and the fact of being exporter and of receiving FDI have a positive and significant impact on total employment. In particular the exporting firms and those with a share of foreign ownership have witnessed a skill bias effect, in that the demand for skilled labour has increased more than that for unskilled labour. Interestingly, we find that FDI and technological transfer do not entail a skill bias effect in terms of employment. This contrasts with the results in **Error! Reference source not found.** where these variables were seen to exert a significant and positive impact on the labour cost share of skilled workers. These results together imply that the overall impact on the labour cost share is due to an increase in relative wages rather than to employment shifts. This may be due to the fact that both FDI and technological transfer may increase the relative productivity of skilled workers and this is reflected in their higher wages.

27 The null hypothesis of the Breusch-Pagan test (distributed as χ^2) is that the residuals from the two equations are independent

Table 7: Impact of trade and technology variables on relative employment

	(1) D_lprod	(2) D_ladmin	(3) D_lprod	(4) D_ladmin	(5) D_lprod	(6) D_ladmin	(7) D_lprod	(8) D_ladmin	(9) D_lprod	(10) D_ladmin	(11) D_lprod	(12) D_ladmin
D.lva	0.151***	0.120***	0.150***	0.110***	0.151***	0.121***	0.151***	0.120***	0.150***	0.110***	0.134***	0.113***
	(0.0016)	(0.0023)	(0.0031)	(0.0046)	(0.0017)	(0.0024)	(0.0016)	(0.0023)	(0.0031)	(0.0046)	(0.0076)	(0.0099)
D.lk_va	0.0702***	0.0599***	0.0680***	0.0565***	0.0702***	0.0595***	0.0702***	0.0599***	0.0680***	0.0565***	0.0529***	0.0678***
	(0.0013)	(0.0019)	(0.0024)	(0.0036)	(0.0013)	(0.0019)	(0.0013)	(0.0019)	(0.0024)	(0.0036)	(0.0056)	(0.0073)
D.lpwage	-0.142***		-0.161***		-0.143***		-0.142***		-0.161***		-0.134***	
	(0.0022)		(0.0049)		(0.0023)		(0.0022)		(0.0049)		(0.0095)	
D.lawage		-0.218***		-0.228***		-0.224***		-0.218***		-0.228***		-0.235***
		(0.0022)		(0.0048)		(0.0023)		(0.0022)		(0.0048)		(0.0094)
foreign	0.0177**	0.0232**										
	(0.0075)	(0.011)										
xdum			0.0135***	0.0318***					0.0132***	0.0321***		
			(0.0037)	(0.0055)					(0.0038)	(0.0055)		
ttrans					0.00861	0.00226			-0.00360	-0.00782		
					(0.0062)	(0.0088)			(0.013)	(0.019)		
fdidum							0.0147***	0.0134*	0.00970	0.000975		
							(0.0050)	(0.0072)	(0.0096)	(0.014)		
D.lRD_va											0.00744***	0.00634**
											(0.0024)	(0.0031)
Constant	0.0612***	0.114***	0.0640***	0.140***	0.0716***	0.141***	0.0706***	0.114***	0.00584	0.140***	0.0726***	0.141***
	(0.0051)	(0.0067)	(0.0044)	(0.0063)	(0.0048)	(0.0072)	(0.0048)	(0.0067)	(0.0044)	(0.0063)	(0.015)	(0.019)
Year dummy	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	124543	124543	31620	31620	119318	119318	124544	124544	31620	31620	5989	5989
R-squared	0.10	0.09	0.10	0.08	0.10	0.09	0.10	0.09	0.10	0.08	0.09	0.11
BP test	*558.0****		*249.2****		*612.134****		*557.9****		*249.3****		*87.99****	

Notes: Dependent variables are the log changes in number of production workers (odd columns) and the log changes in number of administrative workers (even columns). Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Breusch-Pagan test in the last row.

6. Concluding Remarks

This paper has reported evidence on the relationship between trade openness, technology adoption and relative demand for skilled labour in the Turkish manufacturing sector. The data employed in the analysis are drawn from the *Annual Manufacturing Industry Statistic* and cover more than 90 percent of all manufacturing firms over the 1980-2001 period. Our results can thus be interpreted as representative of the dynamic in the whole formal manufacturing sector.

We have first depicted the simultaneous trends in international openness and in demand for skills at a descriptive level. In particular, we showed that in the aftermath of the rapid and thorough liberalization process, relative demand for skilled labour did significantly increase. This conclusion is motivated by the observation of the contemporaneous rising trends of both relative employment and relative wages.

We have then investigated in depth the possible sources of such increase in relative demand by decomposing the aggregate demand shift into the within- and between-sectors components (disaggregated at four-digit level). The analysis revealed that the aggregate shift was mainly due to within-sector skill upgrading, which provides a preliminary evidence of the relevance of the SBTC hypothesis. Technological change is in fact supposed to cause a shift within each industry as opposed to other structural changes – like trade-induced specialization or consumption demand shifts – which should cause a reallocation of demand between industries. We have then further disaggregated the aggregate demand change into within- and between-firms components, also taking into account the firms' entry and exit effects. Again, it turned out that the within-firm skill upgrading constitutes the dominant part of the overall shift. Interestingly, both the within-industry and within-firm shifts appear to be larger during the periods of more rapid trade liberalization, which opens the way to the hypothesis that trade openness may interact with technological upgrading, causing the adoption of more skill intensive technologies at both sectoral and firm level. This hypothesis is in line with the growing literature that has stressed the key role of trade openness in the international technology diffusion.

We have then tested more properly this idea through an econometric analysis at both sector and firm level. Thus, we estimated a cost share equation – derived from a *translog* cost function – whereby changes in the wage bill share of skilled workers in a given sector/plant are related to observable measures of international exposure and technology adoption.

In the sector level analysis we aggregated firm-level data at four-digit ISIC industry level and matched them with data on international trade, in order to evaluate the impact of both import and export flows in shaping the relative demand for skills within each industry. The results show that the sectors that most raised their imports have also experienced a higher increase in the labour cost share of skilled workers. This finding is consistent with the idea that imports imply a transfer of new technologies that are more skill-intensive than those previously in use in domestic markets, thus leading to a higher demand for skilled labour. This idea is reinforced by the finding that only imports from industrialised countries - where the potential for innovation diffusion comes from - enter the regression significantly. Instead, sectoral export orientation is negatively correlated with demand for skills, which is consistent with the HOSS predictions, given Turkey's comparative advantages in the production of unskilled-labour-intensive goods. Indeed, export-oriented policies seem to have caused a within-industry shift towards less skill-intensive firms who gained higher market shares. To sum up, the sectoral results are consistent with both the HOSS indications and the technology-based explanations. On the one hand, trade openness – expressed as export intensification – tends to shift the production toward less skill-intensive firms. On the other hand, import penetration facilitates the adoption of new technologies embodied in capital and intermediate goods, thus shifting the production toward more skill-intensive technologies.

We then turned to a firm-level analysis and tested the impact of a set of variables that are potential sources of skill-biased effect. It emerged that technology related variables (R&D expenditures and technological transfer - proxied by a dummy variable indicating if a firm got the right to use a foreign technology by a license agreement and paying a royalty) are positive and significantly related to skill upgrading at firm level. This result supports the SBTC argument also in the case of a middle income country. This is an interesting result in itself because most papers on SBTC focus on developed countries and the evidence for developing countries is scant. Moreover, we tested the impact of variables reflecting firms' international engagement (a dummy variable for exporter firms and a dummy variable for firms with a share of foreign ownership). Both turned out to be positive and significant, emphasizing the importance of firms' international exposure in the process of technology adoption and upgrading with the related consequences in terms of demand for skills.

Finally, the estimation of two separate equations for skilled and unskilled employment using SURE method shed some light on the nature of the observed skill-bias effect. It seems that all the variables analysed entail a relative rather than an absolute skill-bias effect. Both technological and trade variables seem to lead to an overall increase in employment, but this increase seems to be higher for skilled workers.

Overall, the analysis reveals that in Turkey the relative demand for skills increased substantially over the 1980-2001 period during which Turkey underwent radical policy changes toward trade liberalization. The descriptive evidence and the econometric estimates suggest that the interplays between trade openness and technology adoption have played a key role in shifting the demand for labour towards more skilled workers within each industry and firm. We have thus provided a piece of evidence in which trade and technology are not treated as competing explanations, but are rather complementary in explaining the observed increase in the relative demand for skilled labour. Whether these results may be extended to other middle-income developing countries is a matter for further research.

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