QUADERNI DEL DIPARTIMENTO DI SCIENZE ECONOMICHE E SOCIALI

TRADE, TECHNOLOGY AND SKILLS:

EVIDENCE FROM TURKISH MICRODATA

Elena Meschi, Erol Taymaz e Marco Vivarelli

Serie Rossa: Economia – Quaderno N. 62 giugno 2010

UNIVERSITÀ CATTOLICA DEL SACRO CUORE
PIACENZA

TRADE, TECHNOLOGY AND SKILLS: EVIDENCE FROM TURKISH MICRODATA

Elena Meschi
CEE, Institute of Education, University of London.
Erol Taymaz
Department of Economics, Middle East Technical University, Ankara
Marco Vivarelli
Università Cattolica del Sacro Cuore, Milano
Institute for the Study of Labour (IZA), Bonn
Max Planck Institute of Economics, Jena
Centre for the Study of Globalisation and Regionalisation (CSGR), Warwick University

Abstract

In this paper we report evidence on the relationship between trade openness, technology adoption and the relative demand for skilled labour in the Turkish manufacturing sector, using firm level data over the period 1980-2001. In a dynamic panel data setting, using a unique database comprising data from 17,462 firms, we estimate 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.

Both at the sectoral and firm level, it emerged that R&D expenditures are positive and significantly related to skill upgrading. This result supports the skill biased technological change argument in the case of a middle-income country such as Turkey.

Moreover, the sectoral analysis revealed that increasing export towards more industrialised countries (mainly the E.U.) tends to shift the production toward less skill-intensive activities. While this result is consistent with the HOSS theorem, on the other hand import penetration from more developed countries turns out to facilitate the adoption of new technologies embodied in capital and intermediate goods, thus shifting the production toward more skill-intensive technologies. This result is confirmed by the firm level analysis that finds a positive impact of technological transfer from abroad, foreign ownership and export on the demand for skills, highlighting the role of increasing globalisation in fostering skill upgrading within firms.

Our microdata also allowed us to investigate the direct impact of import flows in shaping the relative demand for skills. The results showed that those firms belonging to the sectors that most raised their inputs from more developed countries also experienced a higher increase in their labour cost share of skilled workers. This finding is a further support to the hypothesis that imports from industrialised countries imply a transfer of new technologies, in turn leading to a higher demand for skilled labour.

Keywords: globalization, technology transfer, skills, panel data, GMM-SYS
JEL Classification: F16, O15, O33

Corresponding author:
Dr. Elena Meschi
Centre for the Economics of Education (CEE)
Institute of Education, University of London
20 Bedford Way, London WC1H 0AL, UK
E-mail: e.meschi@ioe.ac.uk

1. Introduction

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

Turkey started a marked process of liberalisation in the early '80s and the volumes of exports and imports have continued to grow since then, making Turkish economy increasingly connected to the world market. This increasing trade openness has affected in particular the manufacturing sector, in which most of the growth of import and export has occurred. An important aspect of this process could be its impact on labour demand, and, more specifically, its impact on the relative demand for skilled labour. Indeed, over the same period, the relative demand for skilled labour increased substantially, leading to higher wage-gaps between skilled and unskilled workers. Whether these two simultaneous phenomena are linked has not been established yet.

Theoretical economic literature offers different predictions about the impact of trade liberalisation on labour demand in a developing country (DC). On the one hand, according to the central tenet of 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. Indeed, openness should benefit a country's relatively abundant factor, because trade specialisation should favour sectors intensive in the abundant factor. Therefore, in the case of Turkey, which is abundant in unskilled labour relatively to the EU, its main trading partner, trade 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 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).

This paper contributes to the debate presenting new empirical evidence, both at the sectoral and the firm level. We estimate the impact of trade openness on labour demand by using a unique detailed panel of Turkish manufacturing firms (*Annual Manufacturing Industry Statistics*). The dataset - by covering all manufacturing firms employing 10 or more people and so comprising data from 17,462 different firms -

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

represents about 90% of (formal sector) manufacturing output over the 1980-2001 period, and it is therefore particularly well-suited to quantify the possible impact of firms' international exposure on the labour demand for skilled workers.

We think that Turkey is a particularly interesting setting to study the relationship between trade openness, technology adoption and the relative demand for skilled labour. In fact, Turkey is a middle-income country with sizeable commercial flows with developed countries, especially the EU[2]. This makes it a net technology importer, and hence the ideal country for investigating the impact of potential imported SBTC. Indeed, 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 from more advanced countries effectively acts as a channel for technological upgrading, thus leading to the increase in the relative demand for and wages of skilled workers (see Meschi and Vivarelli, 2009 and Almeida, 2009).

From a policy perspective, Turkey presents an illustrative example for investigating the social impact of trade liberalisation policies: during the '80s, Turkey has carried out a significant trade liberalisation programme, shifting from a protectionist model characterized by heavy state intervention to a more outward-looking one.

The remainder of this paper is organised 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 and discuss the results at both the sectoral and firm level. Finally, the last section puts forward some concluding remarks.

2. The literature

The increase in the relative demand for skilled labour has been documented for many developed countries in the last three decades (see, among others, Katz and Murphy,

[2] From an EU policy perspective, Turkey is a country deserving investigation as it is the biggest and most populous EU candidate country.

1992, for the US and Machin and Van Reenen, 1998 for other OECD countries). In the theoretical 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[3]. 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 (see, for instance, Krugman and Lawrence, 1993; Berman et al., 1994; Autor et al., 2003 and 2008).

From a theoretical point of view, in the developed world both trade liberalisation (through the HOSS mechanism) and technological change could be responsible for the observed pattern of increased relative demand for skilled labour. Instead, in developing countries the two processes are supposed to have opposite effects, as follows (for an extensive analysis, see Lee and Vivarelli, 2004 and 2006).

On the one hand, technological change could shift the labour demand in favour of more skilled workers. The SBTC hypothesis is in fact based on the idea that there is close complementarity between new technologies and skilled workers, since a more educated workforce is more able and faster in learning how to adopt and implement new technologies and therefore industries with more rapid technological progress may favour workers with greater potential for learning[4].

On the other hand, the HOSS mechanism predicts that a developing country trading with skill-abundant developed economies should specialise 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 between countries is relaxed, then international openness may facilitate technology diffusion[5] from developed to developing countries, implying that

[3] See Deardorff (1998) and, more recently, Autor et al. (2008) for a comprehensive review of this debate.

[4] While increasing the *relative* demand for skilled workers, at the same time technological change may well imply a reduction in the total *absolute* demand for labour (see Piva and Vivarelli, 2005 for a theoretical discussion of the relationship between technology and employment).

[5] 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 in fact represents a crucial determinant of technological upgrading in DCs (Krugman, 1979; De Long and Summers, 1993). While some firms are

trade and technological change are complementary rather than alternative mechanisms. Robbins (2003) called the effect of in-flowing technology resulting from trade liberalisation the '*skill-enhancing trade* (SET) hypothesis'. The idea is that trade liberalisation accelerates flows of imported embodied technology (in machineries, intermediate inputs, components and final goods that can act as benchmarks for domestic production and can be subjected to reverse engineering) to developing countries, inducing an adaptation to the modern skill-intensive technologies currently used in developed countries, and resulting in an increase in the demand for skilled workers (for a more extensive analysis, see Vivarelli, 2004).

Turning our attention to the empirical literature, a large number of works have documented the relevance of the SBTC hypothesis for industrialised countries (ICs),[6] while the evidence on developing countries (DCs) is scant.

For instance, Berman and Machin (2000 and 2004) studied the role of SBTC in increasing the demand for skills, trying to determine to what extent SBTC moves across international borders, thereby altering the skill structure of labour markets. They found that the US industry pattern of skill upgrading during the '70s was a good predictor of industry skill upgrading in middle-income countries in the '80s, suggesting that the same industries had increased their proportion of skilled workers. They also showed that the within-industry skill upgrading in middle-income countries was due to the adoption of the same kinds of skill-biased technologies that had permeated into industries in the developed world, implying that SBTC had been transferred rapidly from the developed world to middle-income countries and emphasised the pervasive nature of SBTC.

Conte and Vivarelli (2007) 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 found that imported skill-biased technological change is one of the determinants of the increase in the relative demand for skilled workers within DCs.

---

engaged in the creation of new technologies, most simply imitate or adapt existing production techniques to local conditions (Evenson and Westphal, 1995; Almeida and Fernandes, 2007).

[6] 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.

Meschi and Vivarelli (2009) analysed the impact of trade openness on income distribution in a panel of developing countries. Their results suggested that total aggregate trade flows are not significantly related with income inequality in DCs. However, once they disaggregated trade flows according to their areas of origin/destination, they found a significant inequality-enhancing effect for trade with more advanced countries, possibly due to technological transfer and skill-enhancing trade. They also found this result to hold for middle-income countries only (and not for low-income ones) and interpreted this evidence by considering their greater potential for technological upgrading. Almeida (2009) reached very similar conclusions using firm-level data for East Asia. Her results in fact show a positive correlation between FDI, technological innovation and share of educated workers, suggesting that openness and the adoption of new technology have contributed to skills upgrading in the region. Interestingly her estimates show that openness and technology adoption have been more skilled biased in middle income countries than in low income, which is consistent with firms there having a higher absorptive capacity.

The evidence from country-specific studies is mixed. Hanson and Harrison (1999), using data on Mexican manufacturing plants, found that firms receiving FDI acquire technology through licensing agreements or import materials, and tend to hire more skilled workers. However, they found that skill upgrading was not related to other measures of technological change. A similar result was obtained by Feenstra and Hanson (1997) who used data on Mexican industries 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, thereby confirming FDI acting as a channel for technological diffusion across countries. Similarly, Fajnzylber and Fernandes (2004) found that increased levels of international integration were associated with an increased demand for skilled labour in a cross-section of Brazilian firms. In contrast Pavcnik (2003), who investigated the causes of skill upgrading in role in Chilean plants during the '80s, failed to find a significant relationship between measures of adoption of foreign technology[7] and the relative demand for skilled workers, once she controlled for unobserved plant heterogeneity. Fuentes and Gilchrist (2005) extended her analysis over an additional

[7] i.e. the use of imported materials, foreign technical assistance and patented technology.

nine-year time span to cover the period 1979-1995. In contrast to Pavnick's findings, they found a robust association between the demand for skilled workers and the adoption of new technologies - measured by foreign patent usage - even after controlling for unobserved plant characteristics.

Gorg and Strobl's (2002) analysed a panel of manufacturing firms in Ghana over the '90s and their estimates revealed that while the purchase of foreign machinery for technological purposes had significantly raised the relative demand for skilled labour, a 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. Other research have instead underlined the skill enhancing effects of exporting activity that makes the adoption of new technologies profitable for more firms (Yeaple, 2005), induces quality upgrading (Fajnzylber and Fernandes, 2004) and offers opportunities to acquire knowledge of international best practice (*learning-by-exporting* hypothesis, see Epifani, 2003; Bigsten et al, 2004).

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 for a total of 17,462 companies.[8] 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. For each year, firms provide 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 into two broad categories: production workers and administrative workers. Production workers include technical personnel, foremen and supervisors, and all those who work physically in the production activities. The administrative category includes

[8] 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.

management and administrative personnel and officers. We use these two categories of workers to distinguish between skilled labour (administrative workers) and unskilled labour (production workers)[9].

The average number of firms per year is about 9600 in the private sector and about 400 in the public sector. We decided to focus on private sector only. This choice is motivated by various reasons: first, the private sector accounts for a large and increasing share of total employment; secondly, it is more affected by policy changes. Third, and most importantly wages and employment in the public sector are not as much driven by market forces as those in the private sector, but they are set as the result of very different bargaining process. This makes public sector data unsuitable for the type of analysis we intend to perform.

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 the two-digit ISIC sectors.

[9] 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) used a production/non-production classification. Although this categorisation is not ideal (as skills are better described by classifications based on educational characteristics), the production and non-production distinction is often the only one 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 show that the proportion of non-production workers shows the same tendency to increase as the proportion of skilled workers in the US manufacturing sector. Indeed, the survey also provides a more detailed disaggregation of skill-types: for each 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 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.

Table 1: Sectoral distribution of private firms

ISIC Industry	Share
Food Beverages Tobacco	18.28%
Textile and Clothing	27.02%
Wood Products	3.93%
Paper and Printing	3.79%
Chemicals and Petroleum, Coal, Rubber and Plastic	9.75%
Non-Metallic Mineral Prods.	7.35%
Basic Metal	4.39%
Metal Products, Machinery and Equipment	24.41%
Other Manufacturing	1.09%

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

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

4. Economic trends and descriptive evidence

This section provides some stylised facts on the recent process of trade liberalisation in Turkey (section 4.1) and describes the main simultaneous trends in the Turkish labour market (section 4.2). In particular, we will look at the evolution of skilled versus unskilled relative wages and employment, in order to determine whether the relative demand for skilled labour did in fact increase during the phase of rapid integration of Turkey's economy into the international markets. Finally, in Section 4.3, we will first decompose the relative aggregate demand shift into its between- and within-*industry* components and then we will further decompose the demand change to understand the relative contribution of the between and within-*firms* components, also taking into account the entry and exit effects.

4.1. Trade Liberalisation

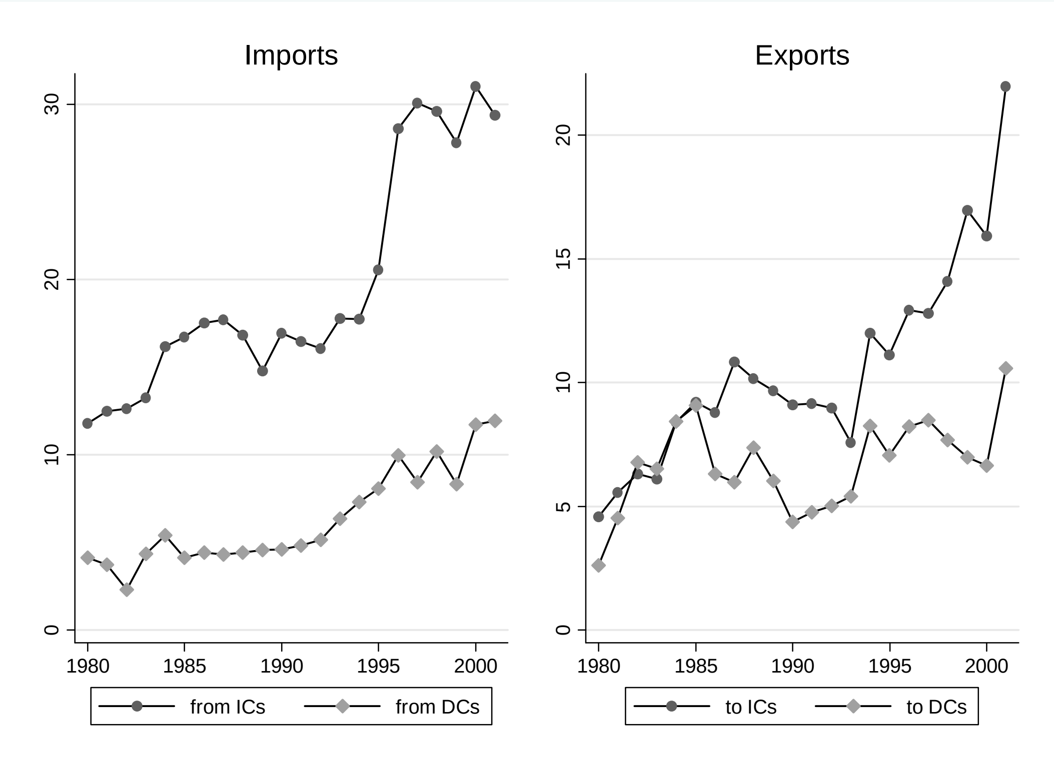
Until 1980 Turkish economic and trade policies were characterised by import-substituting (IS) industrialisation under heavy state protection. Despite good performance in terms of economic growth, IS strategy led to a number of problems which became unsustainable at the end of the 1970s: substantial inefficiency 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% 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[10]) was launched under the guidance and auspices of the International Monetary Fund and the World Bank. A major component of the reform package consisted in policy changes to achieve greater openness; this liberalisation process can be divided into two distinct phases (Yeldan, 2000 and Taymaz and Yilmaz, 2007). The first covers roughly the period 1981-1988, and its main characteristic is structural adjustment through export promotion and commodity trade liberalisation, 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 embodied in the Custom Union (CU) between the EU and Turkey (January 1996) and the subsequent 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 as of 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.

[10] SSAP: Stabilization and Structural Adjustment Program.

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

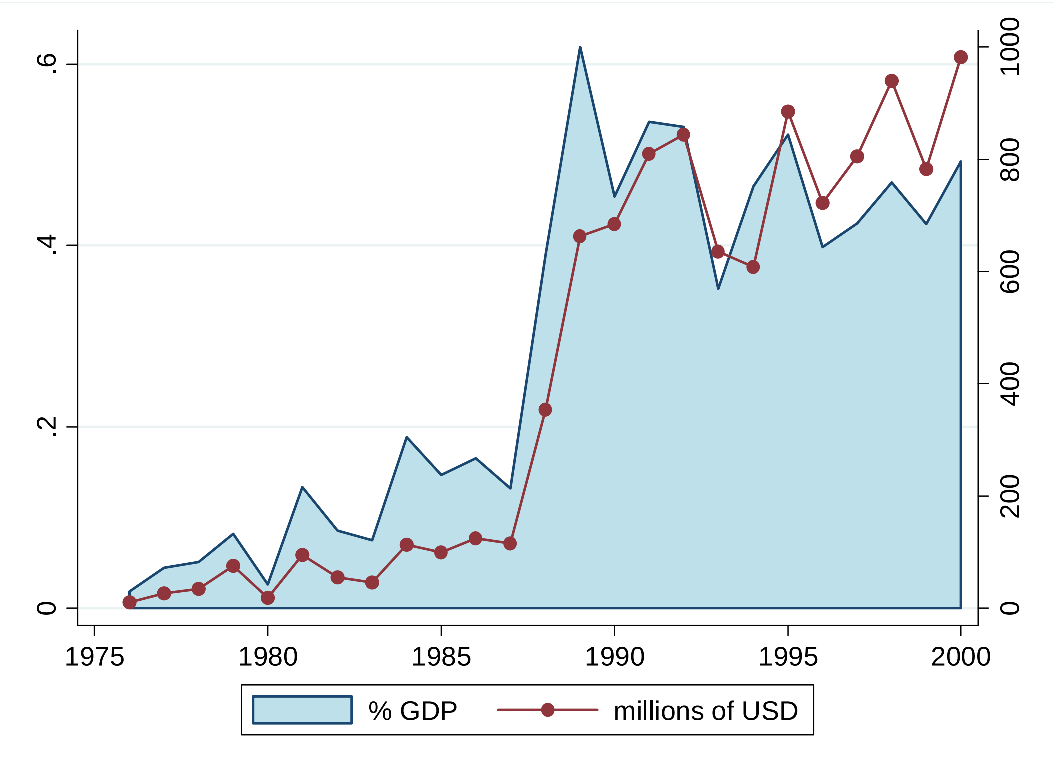


Source: Own elaborations from *Annual Manufacturing Industry Statistics* and Turkstat.

The figure underlines the significant growth in imports and exports over the 1980-2001 period. Moreover, it shows that the bulk of imports came from industrialised countries (ICs). Exports patterns instead changed over time: at the beginning of the period exports to ICs and to DCs made up equivalent proportions of manufacturing output, while as of 1985 exports to ICs significantly increased with respect to those to DCs.

During the same period, 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 this is the restrictive bureaucratic practices of government institutions - especially the State Planning Organization - that were suspicious of foreign capital (Taymaz and Lenger, 2006). In the early ’80s, in line with the general outward-oriented strategy, the administrative system regulating FDI was reorganised in order to simplify investment procedures and to eliminate ambiguities arising from the fragmented bureaucratic structure; moreover, the discriminatory treatment of foreign investors was gradually eliminated. The complete liberalisation of capital accounts and the elimination of certain restrictions on FDI in 1989 provided additional impetus for foreign investment.

Figure 2: FDI inflows



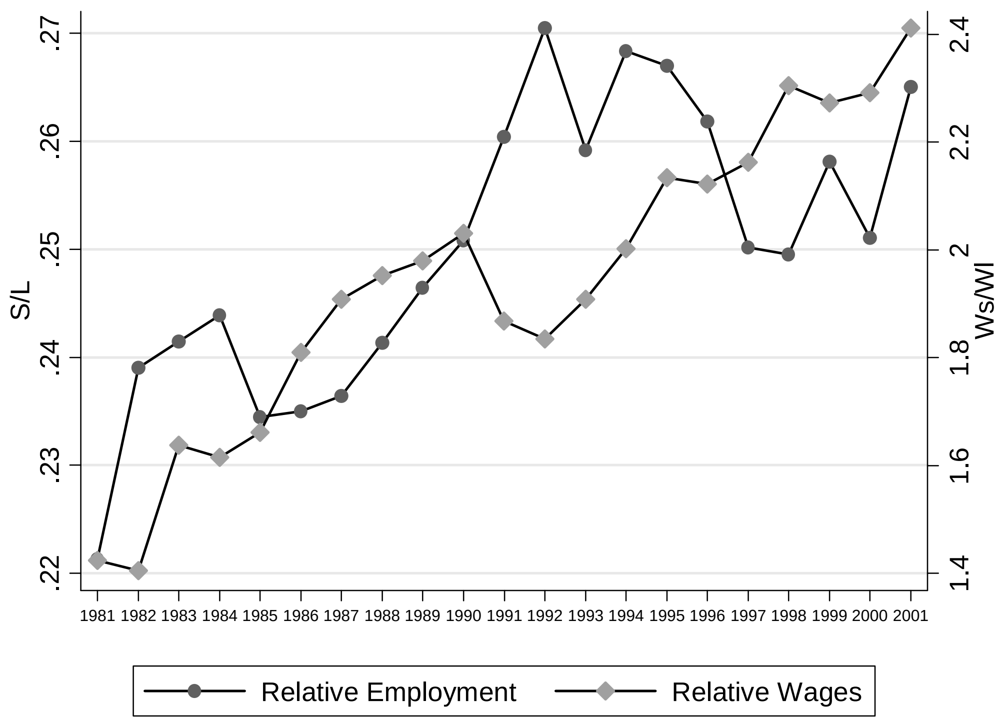
Source: FDI/TNC database, UNCTAD

Summing up, what emerges from this brief overview is that over the '80s and '90s the Turkish economy became increasingly connected with the world market. In the next section we will analyse the trends of relative employment and wages, trying to determine whether the demand for skilled labour changed during the years of globalisation.

4.2. Trends in the Labour Market

Figure 3 plots the simultaneous trends in relative wages (right axis) and relative employment (left axis) in the private sector over the 1980-2001 period. The figure clearly shows that both relative wages and relative employment tended to rise. This is particularly obvious during the ‘80s when trade liberalisation was 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 necessarily implies an upward shift in the relative demand for skilled labour (see Berman *et al*., 2005).

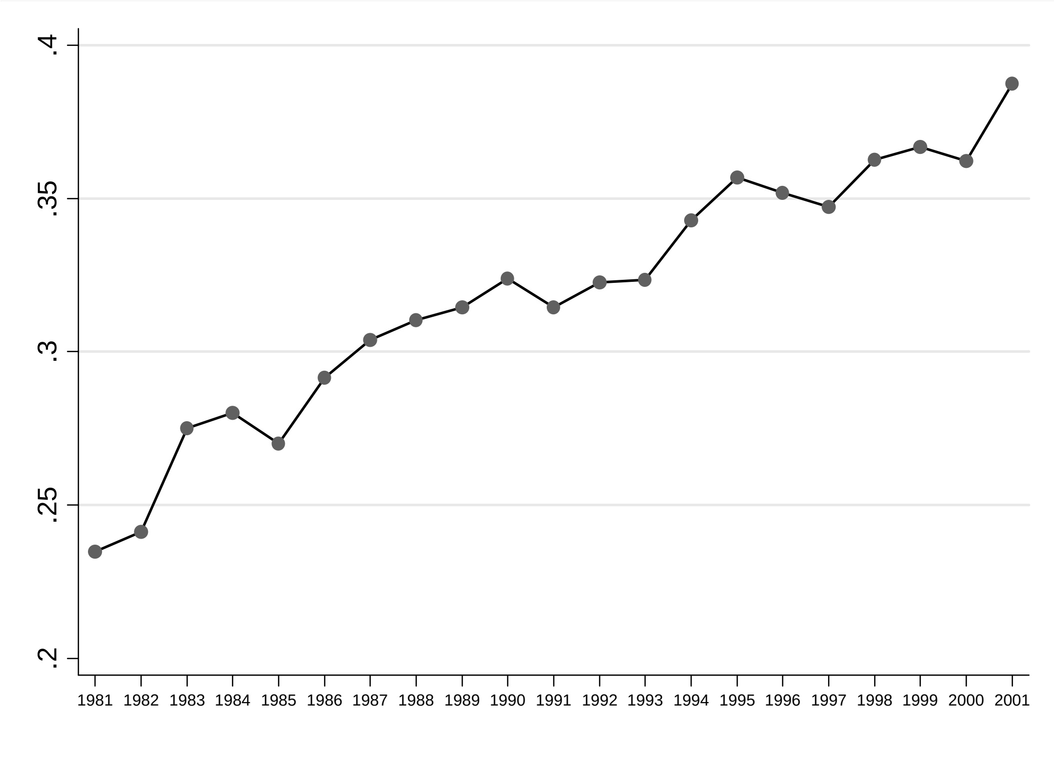
Another way to evaluate whether the relative demand for skilled labour increased, and to distinguish the effects of labour supply from those of labour demand, is to observe the evolution of the labour cost share of skilled workers[11], under the hypothesis of elasticity of substitution between skilled and unskilled labour equal to one (Berman and Machin, 2000 and Berman *et al*., 2005). If the elasticity of substitution is one, the labour cost share of skilled labour (S*LCSH*) is invariant to movements along the

[11] The labour cost share is the share of total labour costs accruing to skilled workers. Unlike other papers, which look at the skilled workers' share of the *wage bill*, here we focus on *labour cost.* The labour cost is given by wages plus employees' social contribution and premiums. Since we are interested in the plant-level determinants of the demand for labour, the effective costs are important - including the non-wage elements firms have to sustain.

relative demand curve and therefore S*LCSH* can be considered a measure of the demand for skills[12].

Figure 4 plots the evolution of S*LCSH* during the sample period, confirming the rising demand for skills.

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



Source: Own elaborations from *Annual Manufacturing Industry Statistics*

[12] 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 labour, l subscript denotes low-skilled labour, 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. An initial attempt to determine the main forces behind skill upgrading can be made by splitting the aggregate change in the demand for skilled labour into its between- and within-industry components. The aggregate increase in the demand for skills may be driven by (a) employment reallocation across industries (for a number of reasons, such as trade shift, structural change, changing tastes, 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 industries (with N=86) over a period of time according to the following formula:

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

The first term is the within-industry component of skill upgrading (weighted by $\overline{P_i}$, the relative size of industry i – i.e. 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 between-industry shifts, i.e. 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 according to the timing of the main Turkish policy changes and the major cycles of adjustment-growth-recession[13]. The first period (1980-1983) corresponds to the first phase of trade liberalisation, characterised by an export promotion strategy. The second period of trade liberalisation took place in the period 1983-88, when most of the tariffs and non-tariff barriers to imports were reduced or eliminated. These two phases correspond to the growth cycle promoted by export orientation, followed by the recession of 1988.

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

The second cycle (1988-93) was generated by foreign capital inflows following financial deregulation and came to an end with the eruption of the 1994 financial crisis (the fourth 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
1980-2001	*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 was 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 liberalisation during which most import barriers were eliminated.

While many papers propose the dominance of the within-industry component as evidence for the relevance of the SBTC hypothesis (e.g Berman, Bound and Machin, 1998), rejecting the importance of trade-based explanations[14], we instead argue that

[14] 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 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

the two 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 liberalisation may in fact have fostered the process of technological upgrading by increasing the magnitude of the 'within' component. The fact that the within-industry effect was higher in the periods of more intensive trade liberalisation would confirm this idea, suggesting that trade may have played a role by fostering and accelerating the adoption of the new skill-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 and 2007) 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:

---

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).

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

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 (1b) splits the source of change in the relative demand for skilled labour at the 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	Interact.	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, confirming a possible role of the SBTC in affecting the skill upgrading within firms. 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. 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. Finally, 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[15] 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:

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

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

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

According to 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[16]:

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

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). The output coefficient allows us to test the constant-returns hypothesis, which implies that input shares are invariant to scale (if $\beta_3 > 0$, this hypothesis is violated, indicating that in faster-growing firms the labour cost share of skilled workers also increases). Moreover, the log output allows us to control for business cycle fluctuations; such fluctuations may occur if firms are more likely to lay off 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

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

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 is usual in this literature (see Chennels and Van Reneen, 1999), we drop the endogenously-determined relative wage term, since it is directly involved in the construction of the dependent variable. We instead include time dummies which should capture the movements in the wage bill share due to supply shifts as well as other economy-wide mechanisms[17]. Therefore, our estimating equation will be:

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

(5)

where the subscripts *i* and *t* denote respectively firms and years; $SLCSH$ is the skilled workers labour cost share; K is capital[18], 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)[19], we estimate this equation in differences. The final specification is thus as follows:

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

where Δ is the first difference operator.

However, as in any dynamic specification, the correlation of the lagged dependent variable with the error term implies an endogeneity problem. To solve this problem,

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

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

[19] 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 the possible different abilities of their managers.

Arellano and Bond (1991) proposed using 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 cross-section variability dominates time variability and if there is a strong persistence in the investigated time series (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 limited the analysis to 17,462 private firms over the sub-period 1992-2001 for a total of 88,712 observations. Moreover, the correlation between *SLCSH* and *SLCSH* (-1) turned out to be 0.766, while the coefficient of the linear regression of *SLCSH* on *SLCSH* (-1) was equal to 0.769. Since both the conditions calling for the more comprehensive GMM-SYS methodology seem to characterise our data, we chose 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[20] 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)[21].

Given the availability of trade data by sectors, 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 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

[20] The source of trade data is Turkstat, the Turkish Statistical Institute (http://www.turkstat.gov.tr)
[21] 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).

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[22] 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, mainly trading with the European Union and so characterised by 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[23]. All standard errors have been adjusted for heteroskedasticity using the White (1980) correction.

---

[22] This is especially true for developing economies.

[23] 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[23]. 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. Dependent variable: SLCSH.

	(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 shift towards less skill-intensive sectors. 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 activities. 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[24]. 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[25]. The intensification of exports leads to a reduction in the demand for skilled labour accordingly with HOSS only when exports are directed toward more industrialized countries. Turkey has in fact a comparative advantage in the production of unskilled-

[24] The correlation coefficient between exports and imports to/from IC is 0.45, while the one between exports and imports to/from DC is 0.47 and they are both statistically significantly different from 0.

[25] 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.

labour-intensive goods only if it is compared with richer countries (namely the European Union as the main trading partner of Turkey).

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

	(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 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 firm level data to characterise T, that is the vector of the additional mechanisms leading to skill upgrading.

First, we included a dummy variable for R&D performers (**R&D_dum**), in order to identify a possible effect of pure SBTC on the demand for skilled labor. We expect a positive sign for the effect of R&D_dum on *SLCSH.*

However, since we are interested in the impact of trade-related technological transfer from abroad, we used other indicators able to capture technology adoption. The first (**ttrans**) was created by looking at foreign patent and licence usage. It is a dummy variable which is equal to one if a firm in a given year obtained the right to use 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 thus captures incremental innovations which allow a progressive catch-up to the world technology frontier (Almeida and Fernandes, 2007).

The second proxy of integration into global markets is constructed by looking at the firms' ownership structure; **foreign** is a dummy equal to 1 if 10% or more of a 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 previous empirical evidence surveyed in Section 2).

Thirdly, we included a dummy variable **xdum** which is equal to 1 if the firm is an exporter and 0 otherwise[26]. Following the discussion presented in Section 2, we expect the coefficient of xdum to have a positive sign in the equation as well, as exporters should be more likely to adopt new technologies than firms selling exclusively to the domestic market.

In order to analyse the skill-enhancing-trade hypothesis in more detail, we also looked at the possible role of imports. In the previous section we found that import penetration was positively correlated with the demand for skills at the sectoral level. In the following table, we test if this correlation holds in the firm level equation as

[26] Ideally, we would have used data on the value of exports. However, the available microdata do not provide this information and we only had information on whether a firm is an exporter or not.

well. Ideally, we would have liked to look at imports directly at the firm level, but unfortunately our dataset does not provide this information. Therefore we used 1990 and 1998 input-output tables to calculate the share of imported input to total input at the sectoral level (37 manufacturing industries) and we applied the obtained figures to all the firms belonging to a given sector (foreign input = finput)[27]. In addition, we disaggregated this variable according to the geographical area of origin of the imported input, distinguishing whether imports were from developed countries (fdcinput) or developing countries (fldcinput). Table 6 shows our results and diagnostic tests[28].

[27] The data for the single years were estimated by interpolation (for 1991-1997), and extrapolation (for 1999-2001).

[28] The Wald test, asymptotically distributed as a χ^2 where the degrees of freedom equate the number of restricted coefficients, allows us to test the overall significance of the independent variables; it always rejects the null hypothesis of insignificant coefficients. Three rows report the Lagrange Multiplier (LM) tests for first, second and third 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. The tests detect first- and second-order serial correlations, but reject serial correlation of higher order; hence, the GMM SYS estimator was implemented by using second, third and fourth lags of the dependent variable as instruments. 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 hypothesis is always rejected; however we are not overly worried by the failure of the test for three reasons. First, the Sargan test "should not be relied upon too faithfully, as it is prone to weakness" (Roodman, 2006, p. 12). Second, in their Monte Carlo experiments Blundell and Bond (2000) observe "some tendency for this test statistic to reject a valid null hypothesis too often in these experiments and this tendency is greater at higher values of the autoregressive parameter" (Blundell and Bond, 2000, p. 329). Third, the very large number of observations makes the occurrence of a significant Sargan more likely: indeed, we repeated the test over random subsamples of one third of firms and it was not significant in most of the subsamples. These results (available upon request) indicate that it is the very large number of observations that makes the Sargan test likely to be statistically significant.

Table 7.Dependent variable: SLCSH; GMM-SYS estimates.

	1	2	3	4
SLCSH (-1)	0.7477**	0.7471**	0.7471**	0.7471**
	[0.0311]	[0.0310]	[0.0311]	[0.0311]
log(K/VA)	0.0027**	0.0026**	0.0026**	0.0026**
	[0.0004]	[0.0004]	[0.0004]	[0.0004]
log(VA)	0.0075**	0.0073**	0.0072**	0.0072**
	[0.0010]	[0.0010]	[0.0010]	[0.0010]
R&D_dum	0.0092**	0.0091**	0.0088**	0.0088**
	[0.0016]	[0.0016]	[0.0015]	[0.0015]
fdidum	0.0313**	0.0312**	0.0307**	0.0308**
	[0.0047]	[0.0047]	[0.0047]	[0.0047]
ttrans	0.0118**	0.0116**	0.0109**	0.0107**
	[0.0041]	[0.0041]	[0.0041]	[0.0041]
expdum		0.0033*	0.0031*	0.0031*
		[0.0013]	[0.0013]	[0.0013]
finput			0.0262**	
			[0.0051]	
fdcinput				0.0361**
				[0.0073]
fldcinput				0.0129
				[0.0096]
Constant	-0.0072*	-0.0058	-0.0094*	-0.0097*
	[0.0036]	[0.0037]	[0.0039]	[0.0039]
Year dummies	*Yes*	*Yes*	*Yes*	*Yes*
Observations	88712	88712	88712	88712
N. of firms	17462	17462	17462	17462
AR (1)	-22.14**	-22.14**	-22.12***	-22.12***
AR (2)	6.635**	6.635**	6.634***	6.634***
AR (3)	-0.408	-0.401	-0.403	-0.404
Wald Test	20735**	20752**	21302**	21435**

Notes: robust standard errors in brackets; ** p<0.01, * p<0.05

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

Turning our attention to the in-house technology variable, it emerges that the occurrence of R&D investment has a positive and significant impact on the skilled labour cost share. Consistently with many other works focusing on developed economies, expenditures in R&D tend to raise the demand for skilled labour, indicating the diffusion of the SBTC effect to middle-income developing countries such as Turkey.

If we now focus on the three dummies measuring a firm's exposure to international technological transfer, the estimation results show a positive and significant relationship between these regressors and the labour cost share of skilled workers. The variable that directly measures international technological transfer (ttrans) and the variables capturing international openness through FDI and export exposure exert a significant impact on the demand for skills (statistically weaker in the case of export). 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.

Interestingly, the results show that firms belonging to those sectors that most raised their imported inputs also experienced a higher increase in the labour cost share of skilled workers. Import penetration facilitated the adoption of new technologies, thus shifting production towards more skill-intensive technologies (column 3 in Table 3). This interpretation is reinforced by the fact that only imports from the more technologically advanced industrialised countries are significantly related to changes in the skilled labour cost share (see column 4 in table 7).

Overall, these findings support the argument that involvement in the global market plays a crucial role in fostering SBTC.

6. Concluding Remarks

This paper has reported evidence on the relationship between trade openness, technology adoption and relative demand for skilled labour in Turkish manufacturing firms.

We first outlined the simultaneous increase 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 liberalisation process, the relative demand for skilled labour increased substantially.

We then investigated the possible sources of such an increase in the relative labour demand by decomposing the aggregate shift in the demand for skills into its within- and between- sector/firm components. The analysis revealed that the aggregate shift was mainly due to within-sector and within-firm skill upgrading,, suggesting the relevance of the SBTC hypothesis.

Finally, we estimated a cost share equation whereby changes in the wage bill share of skilled workers in a given firm are related to observable measures of international exposure and technology adoption.

Both at the sectoral and firm level, it emerged that R&D expenditures were positive and significantly related to skill upgrading. This result supports the SBTC argument in the case of a middle-income country such as Turkey.

Moreover, the sectoral analysis revealed that increasing export towards more industrialised countries (mainly the E.U.) tends to shift the production toward less skill-intensive activities. While this result is consistent with the HOSS theorem, on the other hand import penetration from more developed countries facilitates the adoption of new technologies embodied in capital and intermediate goods, thus shifting the production toward more skill-intensive technologies.

Turning our attention to the firm level analysis, we tested the impact of three variables reflecting firms' international engagement: a dummy variable for technological transfer from abroad, a dummy variable for firms characterised by foreign ownership and a dummy variable for exporting firms. All three turned out to be positive and significant, emphasising the importance of increasing globalisation in fostering skill upgrading within firms engaged in international markets.

Our microdata also allowed us to investigate the direct impact of import flows in shaping the relative demand for skills. The results showed that those firms belonging to the sectors that most raised their inputs from more developed countries also experienced a higher increase in their labour cost share of skilled workers. This finding is consistent with the idea that imports from industrialised countries imply a transfer of new technologies which are more skill-intensive than those previously in use in domestic markets, thus leading to a higher demand for skilled labour.

Overall, the analysis reveals that in Turkey the relative demand for skills increased substantially over the 1980-2001 period, when Turkey underwent radical policy changes favouring trade liberalisation. The descriptive evidence and the econometric estimates suggest that the interplay between trade openness and technology adoption played a key role in shifting the demand for labour towards more skilled workers. We thus provide 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.

References

Abowd, J.M, Haltiwanger, J.C., Lane, J. and Sandusky, K. (2001): "Within and Between Firm Changes in Human Capital, Technology, and Productivity", LEHD Technical Paper, N. 03, U.S. Census Bureau's Longitudinal Employer-Household Dynamics Program (LEHD) Suitland, US

Abowd, J.M., Haltiwanger, J.C., Lane, J., McKinney, K. and Sandusky, K. (2007): "Technology and the Demand for Skill: An Analysis of Within and Between Firm Differences", NBER Working Paper N. 13043.

Abramovitz, M., (1986): "Catching-up, Forging Ahead and Falling Behind", *Journal of Economic History*, Vol.46, pp. 385-406.

Almeida, R.K. (2009): "Openness and Technological Innovation in East Asia: Have They Increased the Demand for Skills?," *IZA Discussion Papers* N.4474, Institute for the Study of Labor (IZA), Bonn.

Almeida, R. and Fernandes, A.M. (2007): "Openness and Technological Innovations in Developing Countries: Evidence from Firm-Level Surveys," *IZA Discussion Papers* N. 2907; Institute for the Study of Labor (IZA), Bonn.

Arellano, M. and Bond, S. (1991): "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *Review of Economic Studies*, Vol.58, pp. 277-297.

Autor, D., Katz, L. and Krueger, A.B. (1998): "Computing Inequality: Have Computers Changed the Labor Market?", *Quarterly Journal of Economics*, Vol. 113, pp. 1169-1214.

Autor, D.H., Katz, L.F. and Kearney, M.S. (2008): "Trends in U.S. Wage Inequality: Revising the Revisionists", *Review of Economics and Statistics*, Vol. 90(2), pp. 300-323.

Autor, D.H., Levy, F. and Murnane, R.J. (2003): "The Skill Content of Recent Technological Change: An Empirical Investigation", *Quarterly Journal of Economics*, Vol. 118(3), pp.1279-1333.

Berman, E., Bound, J. and Griliches, Z. (1994): "Changes in the Demand for Skilled Labor Within U.S. Manufacturing Industries," *Quarterly Journal of Economics*, Vol. 109, pp. 367-398.

Berman, E., Bound, J. and Machin, S. (1998): "Implications of Skill-Biased Technological Change: International Evidence," *Quarterly Journal of Economics*, Vol. 113, pp. 1245-80.

Berman, E. and Machin, S. (2000): "Skill-Biased Technology Transfer Around the World", *Oxford Review of Economic Policy*, Vol.16, pp. 12-22.

Berman, E. and Machin, S. (2004): "Globalization, Skill-Biased Technological Change and Labour Demand", in Lee, E. and Vivarelli, M. (2004) (eds) "*Understanding Globalization, Employment and Poverty Reduction*", Palgrave Macmillan, New York: pp. 39-66.

Berman, E., Somanathan, R. and Tan, H. (2005): "Is Skill-biased Technological Change here Yet? Evidence from Indian Manufacturing in the 1990", *World Bank Policy Research Working Paper*, N. 3761, World Bank, Washington DC.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, W.J., Oduro, A., Oostendorp, R., Pattillo, C. Söderbom, M., Teal, F. and Zeuf, A. (2004): "Do African Manufacturing Firms Learn from Exporting?," *The Journal of Development Studies*, Vol. 40(3), pp. 115-141.

Blundell, R. and Bond, S. (1998): "Initial Conditions and Moment Restrictions in Dynamic Panel Data models", *Journal of Econometrics*, Vol. 87, pp. 115-143.

Blundell, R. and Bond, S. (2000): "GMM Estimation with Persistent Panel Data: an Application to Production Function", *Econometric Reviews*, Vol. 19, pp. 321-340.

Bond, S., Hoeffler, A. and Temple, J. (2001): "GMM Estimation of Empirical Growth Models", *CEPR Working Paper* N. 3048, Centre for Economic Policy Research (CEPR), London.

Celasun, M. (1994): "Trade and Industrialization in Turkey: Initial Conditions, Policy and Performance in the 1980s", in Helleiner, G.K (eds): "*Trade Policy and Industrialization in Turbulent Times*", Routledge, London, pp. 453-484.

Chennells, L. and Van Reenen, J. (1999): "Has Technology Hurt Less Skilled Workers? An econometric survey of the effects of technical change on the structure of pay and jobs", *IFS Working Paper*, N. 27, Institute for Fiscal Studies (IFS), London.

Conte, A. and Vivarelli, M. (2007): "Globalization and Employment: Imported Skill Biased Technological Change in Developing Countries", *IZA Discussion Paper*, N. 2797, Institute for the Study of Labor (IZA), Bonn.

Deardorff, A.V. (1998): "Technology, Trade, and Increasing Inequality: Does the Cause Matter for the Cure?", *Journal of International Economic Law*, Vol. 1, pp. 353-376.

Doms, M., Dunne, T., Troske, K. (1997): "Workers, Wages and Technology", *Quarterly Journal of Economics*, Vol. 112, pp. 253–290.

Epifani, P. (2003): "Trade liberalization, firm performance, and labor market outcomes in the developing world: What can we learn from micro-level data?", *Policy Research Working Paper Series* No. 3063, World Bank, Washington, DC.

Evenson, R. and Westphal, L. (1995): "Technological Change and Technology Strategy", in Srinivasan, T. N. and Behrman, J. (eds.) *Handbook of Development Economics,* North Holland Publishing Company, Amsterdam: Vol. 3.

Fajnzylber, P. and Fernandes, A. (2004): "International Economic Activities and the Demand for Skilled Labor: Evidence from Brazil and China," *Policy Research Working Paper Series* N.3426, The World Bank.

Feenstra, R.C. and Hanson, G.H. (1996): "Globalization, Outsourcing, and Wage Inequality", *American Economic Review*, Vol. 86, pp. 240-245.

Feenstra, R.C. and Hanson, G.H. (1997): "Foreign Direct Investment and Relative Wages: Evidence from Mexico's Maquiladoras", *Journal of International Economics*, Vol. 42, pp. 371-393.

Feenstra, R.C and Hanson, G.H. (2001): "Global Production Sharing and Rising Inequality: A Survey of Trade and Wages", *NBER Working Paper* N. 8372, National Bureau of Economic Research, Cambridge (Mass.)

Foster, L., Haltiwanger, J. and Krizan, C.J. (2001): “Aggregate Productivity Growth: Lessons from Microeconomic Evidence,” in Dean, E., Harper, M. and Hulten, C. (eds.): “New Directions in Productivity Analysis”, University of Chicago Press, Chicago: Chapter 8.

Fuentes, O. and S. Gilchrist (2005): “Trade Orientation and Labor Market Evolution: Evidence from Chilean Plant-level Data”, in *Labor Markets and Institutions*, edited by J. Restrepo and A. Tokman, Central Bank of Chile.

Görg, H. and Strobl, E. (2002): "Relative Wages, Openness and Skill-Biased Technological Change", *IZA Discussion Papers* N. 596, Institute for the Study of Labor (IZA), Bonn.

Griliches, Z. (1969): “Capital-skill Complementarity”, *Review of Economics and Statistics*, Vol. 51, pp. 465-468.

Hanson, G. and Harrison, A. (1999): “Trade and Wage Inequality in Mexico,” *Industrial and Labor Relations Review*, Vol. 52, pp. 271-288.

Haskel, J.E. and Heden, Y. (1999): “Computers and the Demand for Skilled Labour: Industry and Establishment-level Evidence for the UK”, *Economic Journal*, Vol. 109, pp. C68-C79.

Katz, L.F. and Murphy, K.M. (1992): “Changes in Relative Wages, 1963-1987: Supply and Demand Factors.” *Quarterly Journal of Economics*, Vol. 107, pp. 35-78.

Keller, W. (2004): “International Technology Diffusion”, *Journal of Economic Literature*, Vol. 42, pp. 752-782.

Krugman, P.R. (1979): “A Model of Innovation, Technology Transfer, and the World Distribution of Income”, *Journal of Political Economy*, Vol. 87, pp. 253-266.

Krugman, P.R. and Lawrence, R. (1993): "Trade, Jobs, and Wages," *NBER Working Papers*, N. 4478, National Bureau of Economic Research.

Lall, S. (2004): “The Employment Impact of Globalization in Developing Countries”, in Lee, E. and Vivarelli, M. (2004) (eds) “*Understanding Globalization, Employment and Poverty Reduction*”, Palgrave Macmillan, New York: pp. 73-101.

Leamer, E. (1994): “Trade, Wages and Revolving Doors Ideas”, *NBER Working Paper* N. 4716, National Bureau of Economic Research, Cambridge (Mass.).

Leamer, E. (1998): “In Search of Stolper-Samuelson Effects on US Wages”, in Collins, S. (eds). “*Imports, Exports and the American Worker”,* Brookings Institution Press, Washington D.C.: pp. 141-214.

Lee, E. and Vivarelli, M. (2004) (eds.): “*Understanding Globalization, Employment and Poverty Reduction***”,** Palgrave Macmillan, New York.

Lee, E. and Vivarelli, M. (2006): “The Social Impact of Globalization in the Developing Countries, *International Labour Review***,** Vol.145, pp. 167-184.

Machin, S. and Van Reenen, J. (1998): “Technology and Changes in Skill Structure: Evidence from Seven OECD Countries,” *Quarterly Journal of Economics,* Vol. 113, pp. 1215–1244.

Mazumdar, J. and Quispe-Agnoli, M. (2002): "Trade and the Skill Premium in Developing Countries: the Role of Intermediate Goods and some Evidence from Peru," Working Paper 11, Federal Reserve Bank of Atlanta.

Meschi, E. and Vivarelli, M. (2009): "Trade and Income Inequality in Developing Countries", *World Development*, Vol. 37 (2), pp. 287-302.

Pavcnik, N. (2003): "What Explains Skill Upgrading in Less Developed Countries?", *Journal of Development Economics*, Vol.71, pp.311-328.

Piva, M. (2003): "The Impact of Technology Transfer on Employment and Income Distribution in Developing Countries: a Survey of Theoretical Models and Empirical Studies", *International Policy Group Working Paper* N.15, International Labour Office (ILO), Geneva.

Piva, M., Santarelli, E. and Vivarelli, M. (2005): "The Skill Bias Effect of Technological and Organisational Change: Evidence and Policy Implications", *Research Policy*, Vol. 34, pp. 141-157.

Piva, M. and Vivarelli, M. (2005): "Innovation and Employment: Evidence from Italian Microdata", *Journal of Economics*, Vol. 86, pp. 65-83.

Robbins, D. (2003): "The Impact of Trade Liberalization upon Inequality in Developing Countries - A Review of Theory and Evidence", *ILO Working Paper,* n.13, International Labour Organization (ILO), Geneva.

Roodman, D. (2006): "How to do xtabond2: An introduction to "Difference" and "System" GMM in Stata", *CGD working paper* n. 103, Center for Global Development (CGD), Washington DC.

Senses, F. (1994): "The Stabilization and Structural Adjustment Program and the Process of Turkish Industrialization: Main Policies and their Impact", in Senses (eds.): "*Recent industrialization experience of Turkey in a global context*", Westport CT. Greenwood Press, London: pp. 51-73.

Taymaz, E. and Lenger, A. (2006): "To Innovate or to Transfer? A Study on Spillovers and Foreign Firms in Turkey", *Journal of Evolutionary Economics*, Vol. 16, pp. 137-153.

Taymaz, E. and Yilmaz, K. (2007): "Productivity and Trade Orientation: Turkish Manufacturing Industry before and after the Custom Union", *Journal of International Trade and Diplomacy*, Vol. 1, pp. 127-154

Vivarelli, M. (2004): "Globalization, Skills and Within-Country Income Inequality in Developing Countries" in Lee, E. and Vivarelli, M. (2004) (eds): "*Understanding Globalization, Employment and Poverty Reduction*"*,* Palgrave Macmillan, New York: pp: 211-243.

White, H. (1980) "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity", *Econometrica*, Vol. 48, pp. 817-838

Wood, A. (1994): "North-South Trade, Employment, and Inequality: Changing Fortunes in a Skill-driven World", Clarendon Press, Oxford.

Yeaple, S. R. (2005): "A simple model of firm heterogeneity, international trade and wages", *Journal of International Economics*, Vol. 65, pp. 1–20.

Yeldan, E. (2000): "The Impact of Financial Liberalization and the Rise of Financial Rents on Income Inequality: the Case of Turkey", *UNU/WIDER Working Papers* N. 206, UNU/WIDER, Helsinki.