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Trade Liberalization, Technology Transfer, and Employment in Middle and Low Income Countries

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Anno Accademico 2012/2013

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To my father, my mother, and Sonia

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INTRODUCTION

In the 1980's many developing countries (DCs) and least developed countries (LDCs) underwent structural changes, where they moved from import substitution economic policies to liberalization and export-oriented strategies. Opening their doors to international trade, these countries were faced with two major growth effects. The first was a static effect pertaining to inter-sectoral transfer of resources, mainly due to changes in the relative price structure. More importantly, liberalization led to a second dynamic effect that emerges from productivity growth due to increased exposure of local industries and firms to competition (both foreign and domestic), increased technological imports embodied in capital and intermediate goods, and to the transfer of knowledge through licensing, patents and other rights (see Rodrik, 1995).

However, these productivity gains were coupled with a growing gap between the employment of skilled and unskilled workers. This has raised concerns regarding increasing income inequality, where in fact within-country inequality in DCs was increasing during that period. Attributing these increasing disparities in developing countries to trade liberalization is a controversial idea among economists. On the one hand, the standard Heckscher Ohlin and Stopler Samuelson (HOSS) theoretical model predicts that trade liberalization would actually lead to egalitarian effects in developing countries. Several extension to the HOSS model showed that such predictions cannot be generalized as they depend on the weights and directions of trade flows. In this respect, theoretical and empirical literature shows that the skill-biased technological change (SBTC) hypothesis is better able to describe the reality of shifting relative employment demand towards more skilled labor.

The present work falls within this area of economic research and looks into the employment impact of trade liberalization and technological upgrading in developing and least developed countries. It is organized into three chapters.

The first chapter provides an overview of the relevant literature. It is divided into three main sections. The first section discusses the quantitative employment effect of technology, namely the "compensation theory", and its empirical applications. The second section moves to shedding light on the qualitative employment effect of technology, through discussing the skill biased technological change phenomenon, its theoretical underpinnings and empirical applications. The third and last section of this chapter focuses on developing countries and the intertwined relationship between employment, technology and trade liberalization in those countries. It looks into the channels through which DCs with open trade can acquire new technologies, and it discusses the HOSS and SBTC models in that context. The section also looks into empirical evidence from DCs, which seems to support the theory of SBTC rather than HOSS.

The second chapter takes the case of a developing country and explores the existence of skill-biased employment differentials within the Turkish manufacturing sector. It studies the determinants of skill bias of employment over time, in both relative and absolute terms using manufacturing survey data for the period 1980 - 2001. Within this context, the conjecture is that technological change, especially skill-enhancing technological import, plays a significant role in raising demand for skilled workers, and thus contributes to increasing the employment gap between skilled and unskilled labor.

Turkey presents itself as a suitable candidate for testing the argument of skill-biased technological change. During the period of the data studied, Turkey was is a middle-income country[1] with significant trade flows with developed countries, especially the EU; therefore, it relied on technology import as a main source for technological upgrading. In addition, during the 1980's Turkey underwent a process of trade liberalization, and shifted from its prior protectionist model of heavy state intervention, whereby it transformed from a rather closed (import-substitution) economy to a much more open (export-oriented) economy. According to the openness indicator of the World Bank Development Indicators, Turkey's openness increased from around 10% in the 1960's to about 40% in the period between 1980 and 2000 and has remained since on a level of about 50% (Elitok and Straubhaar, 2010).

The novelty of the study in this chapter in comparison with previous empirical literature on the subject is that it is performed at firm level within a dynamic framework using a two-equation model that depicts the employment trends for skilled and unskilled workers separately. More specifically, it allows for understanding the forces driving the movements in employment of both types of workers. In fact, a positive shift of the skill-ratio could be the result of the reduction in unskilled workers only, the increase in skilled workers only, a faster increase in the number of skilled workers, or a combination of these movements. A single equation framework cannot capture these different dynamics; therefore, having two equations can provide a more thorough understanding of the nature of the skill-bias. In particular, the System Generalized Method of Moments (GMM-SYS) procedure is applied to a detailed panel of Turkish manufacturing firms (Annual Manufacturing Industry Statistics by the Turkish Statistical Institute, TurkStat), comprised of 17,462 firms over the period between 1980 and 2001.

[1] Today, Turkey is considered an upper-middle-income economy according to the World Development Indicator of 2014.

Chapter three moves to analyze the effect of globalization and technology transfer on manufacturing employment in a LDC, as well as investigate the existence of skill biased technological change. In particular, the study takes the case of the Ethiopian manufacturing sector for the period 1996 - 2004. Ethiopia is one of the least developed countries in the world today. In 1991 it adopted a national structural adjustment program and moved away from an import-substitution strategy adopting an open trade system. Therefore, it provides a suitable setting for studying the effect of globalization on employment and to test the hypothesis of a possible diffusion of the skill bias among the LDCs.

It is important to note here that a large amount of literature has studied the role of technology in changing the structures and dynamics of labor markets in developed countries, the leaders of technological innovation. Developing countries, viewed as followers in terms of technology and innovation, have also had a significant share of studies where focus has been mainly on the effect of technology transfers on employment and skill distribution. However, little research has looked into the impact of technology on labor in the least developed countries (LDCs) that have liberalized their trade and opened their economies to direct technological imports or embodied technological transfers. Technological development is very low in LDCs, and most of them rank lowest according to various international technology and innovation indices such as the Technological Achievement Index, and the Innovation Capability Index (UNCTAD, 2007). However, as many of these countries have adopted trade liberalization policies over the past 20 years, they face a major challenge in how to increase the knowledge and technology intensity of their economies in order to be able to compete in national and international markets. In a study on technology transfer and skill accumulation in LDCs, Mayer (2000) shows that, overall, technological integration of LDCs has increased, though the disparities between the different countries are quite significant. However, he argues that LDCs need human capital to absorb and integrate the improved access to technology, as well as adequate economic policies and supporting institutions that encourage the amounts and types of modern technology that LDCs can import.

There are three are the main research novelties in this chapter. First, it is one of the few studies looking into the impact of trade openness and technology transfer in a LDC. Second to my knowledge – it is the first study investigating these issues in the Ethiopian context. Third, as in the case of Turkey, it adopts an econometric setting which can jointly assess the quantitative and qualitative (both absolute and relative skill bias) impact of globalization and technology transfer.

Finally, the last section concludes with a summary of the main findings, and a comparative analysis between the two cases of Turkey and Ethiopia. Some final remarks and possible future research directions are also mentioned in this last section.

CHAPTER 1

CHAPTER1: LITERATURE REVIEW

Economic theory, with its numerous branches and ramifications, acknowledges the immense role played by technology in stimulating economic progress and development. However, the consequences of technological advancement, and its direct and indirect impact on the dynamics of labor markets and economic institutions remains a matter of debate.

Historically, technological advancement has been accompanied by fear of unemployment resulting from the laborsaving nature of technology, known as technological unemployment. In this respect, Vivarelli (2011) mentions an example of the English workers during the first industrial revolution who, led by Ned Ludd and Captain Swing, were destroying machines in the industrial areas and country side (see Hobsbawm, 1968; and Hobsbawm and Rudé, 1969). However, economic theory has always argued that there exist economic forces that can compensate for the adverse effect of technological unemployment. David Ricardo was among the most prominent proponents of these compensation forces,

"I have before observed, too, that the increase of net incomes, estimated in commodities, which is always the consequence of improved machinery, will lead to new saving and accumulation" (Ricardo, 1951: 396).

This economic debate has been carried to our present times, with different schools of economic thought supporting varying views on the relationship between innovation, technology and employment.

The classical "theory of compensation" continued as the basis of the neo-classical conceptualization of technology and innovation. Technological progress in neo-classical theory leads to higher levels of growth and employment; however, it is considered as an exogenous factor that does not have a long-term effect on unemployment for which only endogenous factors could be responsible. Therefore, the introduction of laborsaving technologies, in this context, is counterbalanced by these "compensation" mechanisms that bring the economy back to full-employment.

In general, Keynesian economists acknowledge the existence of some but not all compensation mechanisms put forward by neo-classical theory. They are skeptical about the capacity of these mechanisms to ensure return to full employment, and stress the importance of government intervention in the form of monetary or fiscal policies (Ansal and Karaomerlioglu, 1999).

Keynesian tradition manifested in theories such as the early growth theory also considers technology as an exogenous factor that opens up investment opportunities through which output, income and employment all increase. A new technology can have a capital and labor saving effect, resulting in a lower capital-output ratio and faster potential growth rate (Pianta, 2005). This view of technological advancement was in line with Schumpeter's analysis on the matter. In Schumpeter's theory, the ability and initiative of entrepreneurs, drawing upon the discoveries of scientists and inventors, create entirely new opportunities for investment, growth and employment (Schumpeter, 1939).

However, the Keynesian and Schumpeterian frameworks differ in that the Keynesian framework revolves around the management of demand, while Schumpeter focuses on autonomous investment, embodying new technical innovation which lies at the basis of economic development (Freeman, 1982). In this context, Freeman (1982) continues to explain that economic growth should be viewed mainly as a process of reallocation of resources between industries, which leads to structural changes and disequilibrium due to the uneven rate of technical change between the various industries. In fact, economic growth is not only accompanied with fast growing and expanding industries, it first and foremost depends on that expansion.

A major contribution of non-mainstream economic approaches is their consideration of institutional circumstances that can have a significant impact on the relationship between technology and employment. Luigi Pasinetti's structural approach, and Christopher Freeman's long run approach are among the major contributions in this respect.

Pasinetti (1981), within his analysis of the dynamic process of modern capitalist economies, describes technological progress as involving an increase in average labor productivity, which should be contrasted to the diffusion of new products and the fast evolution in demand via the compensation mechanisms of price and income (discussed in the next section). The most important difference between Pasinetti's approach and the mainstream approach is that the final outcome of all the complex interactions between innovation and employment does not assure full employment. Pasinetti notes that the structural dynamics of the economic system would lead to technological unemployment; however, at the same time, these dynamics can generate counterbalancing effects that can bring *"macro-economic condition … towards fulfillment, but not automatically"* (Pasinetti 1981: 90). According to Pasinetti, the introduction of new products and/or the institutional changes, such as a decrease in per-capita working time can act as compensation mechanisms. In fact, prior to Pasinetti, Keynes (1981) had suggested that reducing working hours could be a way of avoiding technological unemployment.

Neo-Schumpeterian economists (such as Freeman *et al.*, 1982; Freeman and Soete, 1987; and Perez 1983) also heed the importance of historical and institutional contexts and provide a theoretical framework that combines between short term economic analysis and long term outlook, or the long cycles. In this view, the Kondratiev new long waves[2] emerge from the diffusion of clusters of product innovations introduced and tried out during the final phase of the former cycle. These innovations are expansionary, and contribute substantially to job creation. When the long cycle reaches its maturity, the exhaustion of technological opportunities, generated by the dominant technological paradigm (Dosi, 1982, 1988), together with the saturation effects on the demand side, lead to a downswing that becomes evident through harsh competition and crosscutting technological change. This is when process innovation becomes dominant.

Modern theories such as the new growth theory introduce a crucial change to the way technology is modeled, where technological change began to be viewed as an endogenous factor that drives economic growth and affects employment levels and composition. Models developed by Nordhaus (1969) and Shell (1973) cited by (Aghion and Howitt, 1998) treated technological change as resulting from deliberate economic choices. A series of AK type models use several definitions of innovation (technology, learning by doing, educational variables, knowledge, R&D) as endogenous factors underlying the growth process in an economy (see Romer, 1986; Jones, 1995, Grossman and Helpman, 1995). However, in his analysis of these models, Pianta (2005) notes that the essentially dis-equilibrating nature of technological change is usually treated in a context which remains to assume general equilibrium of markets, meaning that all output is met with its demand, and all workers ready to work on the current wage will find employment. In addition,

[2] Economists generally refer to these long-cycle theories as Kondratiev cycles or Kondratiev long waves after the Russian economist who perished with many others in Siberia in the 1930s. Before his premature death, Kondratiev did more than anyone else to analyze and popularize the idea of long cycles. However, it is true that he was not the originator of the Idea. There were many others who even before the First World War pointed to an apparent tendency for long-term series of prices, interest rates and trade to follow a cyclical half century pattern. Among them were Pareto, Parvus, and the Dutch Marxist Van Geldern (Barr, 1979).

technological change is restricted to process type innovations, and new product innovation is absent in such models. When losses in employment appear in the results of such studies, they are rarely considered as structural unemployment, but rather lead to downward adjustments in wages so that the jobless are returned to work. The lack of flexibility in labor markets is usually used to explain a possible divergence of these models from the reality of labor markets. Pianta suggests that a more adequate approach to study innovation and its effects on the labor market is one that addresses from the beginning the disequilibrium nature of technological change. This view has actually been developed by the neo-Schumpeterian perspectives, Kaldorian, structural, and evolutionary approaches, all discussed above.

Against this background, this chapter delves deeper in the literature that takes interest in the employment impact of technology on an economy. The chapter is divided into three main sections. The first section discusses the quantitative impact of technology, namely the elements of compensation theory and sheds light on empirical studies at the macroeconomic, sectoral, and firm levels. The second section discusses the qualitative employment impact of technology, and the concept of skill biased technological change, as well the empirical studies in this area of research. The third section introduces trade to the technology-employment analysis, and focuses on the effects of technology on employment within the context of developing countries that have liberalized their trade within the past decades. This last section also discusses the channels of technology transfer in these countries, and provides empirical evidence that is mostly in support of the skill biased technological change phenomenon.

1.1. Technology and employment: the quantitative impact

1.1.1. Compensation mechanisms

According to economic theory, technological change allows for the production of the same amount of output with a lower amount of production factors, namely capital and labor. However, what economic textbooks represent as technological change is only the "direct" effect of innovation. Indeed, the economic discipline - since its foundation - has tried to dispel the concerns about the direct harmful effects of technological change by pointing out the market mechanisms that are able to counterbalance the direct impact of process innovation[3] (for an extensive analysis, see also Vivarelli, 1995, chaps.2 and 3; Petit, 1995; Vivarelli and Pianta, 2000, chap. 2; Pianta, 2005; Vivarelli, 2013). These mechanisms came to be known as the "compensation theory", using the terminology presented by Marx in his discussions on large-scale industry and the introduction of machinery (see Marx 1961: Chap. 15). Marx and a group of classical economists were not proponents of compensation theory and argued that compensation can only be partial, especially when the dominant orientation of innovation is of the laborsaving process innovation type. Consequently, it was argued that technological unemployment is a relevant concern that is not limited to the short run, but can persist into the long run.

In what follows, the debate about the validity of the six market compensation mechanisms is presented through defining these mechanisms and shedding light on their critiques.

[3] The result of a process innovation is a reduction in the firm's total cost, while the result of a product innovation is a new product to introduce to the market.

Compensation through additional employment in the capital goods sector. This mechanism is also known as "compensation via new machines". It suggests that although new technologies most often have a labor saving nature, they can create new jobs in the capital goods sector where they; i.e. the new machines, are being produced. Say (1964), an advocate of this type of compensation argues that the new production of machines requires considerable labor; therefore, this process *"gives occupation to the hands they throw out of employ"* (Say, 1964: 87).

This mechanism was heavily criticized by Marx, which placed serious doubts concerning its validity. He states that

"(...) the machine can only be employed profitably, if it … is the (annual) product of far fewer men than it replaces" (Marx, 1969: 552).

Stemming from his theory of value, he contends that compensation must be partial because the value of work in the new machine should be lower than the displaced work in order for this substitution between capital and labor to be profitable. In addition, production of capital goods would also entail laborsaving technologies, so compensation can be totally inexistent and be rather replaced by additional unemployment (Marx, 1969).

Furthermore, new capital goods are often introduced by firms only through scrapping, i.e. the replacement of the old machines with new ones without any net investment; consequently, there is only a substitution of the production lines of the old machines with the new ones, and compensation does not take place at all (Tancioni and Simonetti, 2002).

Compensation through decrease in prices. New technologies lead to lower prices because they reduce total production costs. This, in a neoclassical context, stimulates demand and leads to an increase in production output, which in turn requires additional labor, and allows for the recovery of jobs lost due to the technological innovations. Clark (1907), Pigou (1962), and Steuart (1966) were all supporters of this mechanism. The classical leading critics of the price mechanism were Malthus (1964), Sismondi (1971) and Mill (1976). These economists note that the laborsaving nature of technology first leads to a decrease in aggregate demand since workers who had just lost their jobs would have a lower purchasing power. Besides the immediate drop in demand, Sismondi (1971) discusses this mechanism using Keynesian effective demand that if saturated, does not necessarily translate to higher demand when prices go down. Therefore, Say's law of increased supply creating its own demand, on which this mechanism is based, does not work since it does not take into consideration such demand constraints. Furthermore, the proper functioning of this mechanism is contingent on the existence of a perfect competition setting, for in the case of an oligopolistic market, cost saving need not necessarily lead to lower prices (Sylos Labini, 1969).

Compensation through new investment. It is often attributed to Ricardo (1951) to have put forward this mechanism, but he later also presented some doubts regarding its validity. It operates through the extra profits the innovating firms gain when prices decrease and demand increases due to technological innovation. It suggests that these firms use these profits as investments for expanding their production capacity, which leads to the creation of additional employment.

This mechanism was adopted by marginalists such as Marshall (1961), and Douglas (1930). For instance, Marshall (1961: 254) says that

"…an increase in the power and willingness to save will cause the services of waiting [capital] to be pushed constantly further; and will prevent it from obtaining employment at as a high a rate of interest as before. That is, the rate of interest will

constantly fall, unless indeed invention opens new advantageous uses of roundabout methods of production. But this growth of capital will increase the national dividend; open out new and rich fields for the employment of labor in other directions; and will thus more than compensate for the partial displacement of the services of labor by those of waiting."

Nonetheless, compensation through new investments has been heavily criticized by Keynesian economists who argue that additional profits do not translate immediately into effective demand (see Pasinetti, 1981). This discussion again springs from the applicability of Say's law, where, in the context of this mechanism, profits should be transformed into investments in the same period during which technological upgrading allows for lower costs and higher profits (Vivarelli, 1995). Should this notion be dismissed, profits can be put aside rather than invested and so compensation does not take place. In addition, Marx (1961) argues that the intrinsic nature of the investments plays a significant role in determining the degree of compensation. In fact, if the new investments are capital-intensive and laborsaving, compensation can only be partial or even absent.

Compensation through decrease in wages. This mechanism functions through the substitution between capital and labor. Neo-classical tradition suggests that unemployment can be reduced through price adjustment mechanisms, so a decrease in wages leads to an increase in demand for labor. Wicksell (1961) was the first economist to apply the same logic to technological unemployment. Through a maximization mathematical exercise, he shows that a decrease in wages drives producers to return to older labor-intensive techniques and thus increase labor demand.

This mechanism however conflicts with Keynesian effective demand since the decrease in aggregate demand can lower firms' expectations and they would be discouraged from hiring additional labor (Vivarelli, 2011). A second criticism of this mechanism emerges when one considers the cumulative[4] irreversible (see Dosi, 1982) and localized[5] (see Stiglitz, 1987) nature of modern technology. When *"localized technical progress"* occurs along a *"technological trajectory"* (Freeman and Soete 1987: 42), it can give rise to "*locked in*" technologies (Stiglitz 1987: 128). Within this context, science and technology follow their own rules, and the hypothesis of perfect substitutability between capital and labor that neo-classical models build on ceases to be relevant. Thus, technological change introduces a situation where a decrease in wages does not affect the choice of technology. In his analysis of this line of criticism, Vivarelli (2014) points out to an explanation from (Freeman and Soete 1987: 46) that:

"there is inherent plausibility in the Hicks inducement theory, biasing the long term direction of technical change in a laborsaving direction. Attempts to generate a reversal of this trend by temporary small reductions in the relative price of labor are extremely unlikely to be effective."

Compensation through increase in income. This mechanism follows an opposite logic to the previous one, and follows Keynesian reasoning. It suggests that unions play a role in distributing gains from innovation and achieving a permanent increase in real wages. In this respect, cost saving that results from the introduction of new technologies leads to higher incomes and higher levels of consumption. Increased demand induces higher production and employment (see Pasinetti, 1981).

[4] Dosi (1982) defines technological trajectories as "the movement of multi-dimensional trade-offs among technological variables", within a given technological paradigm. Progress is then described as the improvements of these trade-offs, and it has cumulative features, where the probability of future advances is related to one's current position with respect to the existing technological frontier.

[5] Localized technological progress was first introduced by Atkinson and Stiglitz (1969), who argued that changes that affect one technology (i.e. production method), will have limited effects on other technologies.

Then again, the validity of this mechanism is strongest within a Fordist institutional setup where wage is not only a cost, but also a key determinant of consumption and effective demand (Boyer, 1988). However, there is evidence that new institutional frameworks follow the lines of a competitive wage labor nexus, where the compensation via increased incomes is not as relevant (for a more detailed analysis see Boyer, 1988).

Compensation through new products. Technological change leads to the creation of new products, new economic activities, and new markets, and thus generates new branches of employment. This mechanism differs from the rest of the mechanisms in that it is not related to market forces triggered by technological advancement, but is rather a result of the nature of technological change through product innovations. Even Marx, the leading critic of compensation theory, acknowledged the expansionary effects of this type of technological change.

However, most innovative firms introduce both product (labor-augmenting) and process (laborsaving) innovations at the same time (Pianta, 2005); consequently, the labor saving and labor friendly process operate simultaneously, leaving the final employment outcome uncertain. In fact, as Dosi (1982) explains, the technological paradigms in which the production process takes place are composed of varying clusters of new products, which may have varying effects on employment. For example, the introduction of the automobile in the 1950s and 1960s, which was intensive in unskilled labor in particular, had a much larger labor-intensive effect that the spread of home computers in the 1980s and 1990s. The latter also required intensive-skilled-labor; however, at the same time the spread of ICT represented a laborsaving process innovation for user manufacturing sectors and many service sectors (Vivarelli, 2014).

The effectiveness and efficiency of the compensation mechanisms has long been a subject of debate among economists; therefore, economic theory does not provide explicit answers as to the final employment impact of innovation. Between the optimistic view of some economists and the pessimistic view of the critics, one can only conclude that the relationship between technology and employment is an intricate one, where numerous economic, social, and institutional factors are at play, and where both technological unemployment and compensation mechanisms can in fact coexist.

Within this context, resorting to empirical evidence provides a clearer idea about the operation and validity of these mechanisms at the macroeconomic level. However, before moving to these empirical results, it is worth nothing that such an analysis has its limitations. Firstly, technological change and innovation are hard to measure since variables used to measure them are not often available at the national aggregate level. Secondly, the employment impact of technological change is dependent on an array of economic and institutional mechanisms that are difficult to encompass and control for empirically.

1.1.2. Empirical evidence

This sub-section discusses the empirical evidence pertaining to the quantitative employment effect of technological changes, first at the macroeconomic level, then at the sector level, and finally at the micro - firm level.

1.1.2.1. Employment effect at the macroeconomic level

Empirical macroeconomic level studies operate within partial or general equilibrium frameworks. Sinclair (1981) presents a model with four submodels with different assumptions about labor[6]. He shows that the demand elasticity and elasticity of factor substitution determine the degree of compensation. If these elasticities are sufficiently high, positive employment can in fact take place, more specifically, through the "decrease in wages" mechanism. Using data from the US he also shows that *"… the behavior of aggregate demand, and the demand and supply of money, point however to a disappointingly weak stimulus to employment brought about by downward pressure in the price level"* (Sinclair, 1981: 17), indicating the mechanism "via decrease in prices" is not working.

Layard and Nickell (1985) conduct their analysis using a structural macroeconomic model focused on the labor market, and explain the NAIRU (non-accelerating inflation rate of unemployment) as well as deviations from it. They conclude that technological change can increase labor productivity given the adequate elasticity of labor demand. They calculate this elasticity to be 0.9 for the UK.

Similarly, Nickell and Kong (1989) estimate a three-equation structural system (production, pricing and demand) across nine UK manufacturing sectors over the period 1974 and 1985. They propose a price equation where cost-saving due to process innovation was translated to lower prices , i.e. compensation "via decrease in prices" mechanism. The find that only two sectors (bricks and glass, and textile) did not exhibit a positive employment impact as a result. The majority of the sectors exhibited a high demand elasticity that allowed for the technical change to have a labor-augmenting impact.

Vivarelli (1995: Chapters 7, 8 and 9) develops a macroeconomic model with the purpose of specifying the final employment impact related to the initial

6 The four different assumptions Sinclair (1981) makes regarding wages are :(1) the real wage rate per hour is fixed, (2) the wage share of output is fixed, (3) the money wage rate is fixed, (4) the money wage rate is log-linear in the price level.

technological upgrading in the economy, and evaluating the full or partial development of the various market mechanisms generated by this technological advancement. He tests the model using Italian data over the period 1960 - 1988, and US data over the period 1961- 1988. He runs 3SLS (three stage least squares) regressions and shows that the most effective compensation mechanism in both countries is of that of "decrease in prices". Furthermore, Vivarelli finds that the US economy is more product-oriented than the Italian economy. Therefore, the US thus exhibited a positive relation between technology and employment, while in Italy the various compensation mechanisms could not offset the laborsaving effect of the process type innovation.

1.1.2.2. Employment effect at sector level

In addition to the macroeconomic level, studying the employment impact of technology at the sectoral or industry level also provides valuable insight into some of the dynamics of the compensation mechanisms discussed above. Analysis at this level can concentrate on the indirect employment effects pertaining to the evolution of demand resulting from lower prices due to innovation, that is, "compensation through decrease in prices" mechanism. The "compensation through new products" mechanism can also be studied in this context, and some studies have showed that technological innovation causes a shift from the manufacturing to the services sector (see Evangelista and Perani 1998, and Evangelista and Savona, 1998). Furthermore, structural change is crucial when studying the employment impact of technological change. In this respect, the competitive redistribution of jobs and output, i.e. the gains of innovators and the losses of non-innovators, is an aspect of indirect employment effects that cannot be captured at firm level, and requires sectoral type of analysis. While it is usually expected for employment to grow in expanding sectors and shrink in declining ones, the dynamics of employment reveal different elasticities relative to changes in production (Pianta *et al.*, 1996).

The empirical evidence shows that overall, the employment effect is positive in both, manufacturing and services sectors that experience high demand growth and follow development paths towards product and/or service innovation. Process innovations however lead to job losses (Pianta, 2005). The following is an overview of some empirical studies and their major findings.

Although the major focus of their paper was the effect of introducing high tech capital on skill structure in the U.S., Berndt *et al.* (1992) observe that introducing such technological capital has an overall positive effect on employment intensity. They use 2-digit US SIC manufacturing for the period 1968- 1986 merging several databases together. Clark (1987) contests such results and finds that the expansionary effects of innovative investments prevailed until the mid-1960's, after which the rationalization effects that are created mainly through the purchase of investment goods with R&D content (Meyer and Krahmer, 1992) began to outweigh the expansionary ones.

Pianta *et al.*(1996) show evidence for an overall positive relation between employment growth and variables such as value added, investment and patents when conducting a cross-country analysis of six OECD countries (US, Japan, Germany, France, UK, and Italy) for the period 1980 - 1992. However, they also find that some European countries, especially Italy, who are *"less present in the most dynamic sectors of the world"* (p.86) find it more difficult to benefit from the positive link between technology, employment and growth, yet they tend to endure the laborsaving negative impact of process innovations. Taking the case of Italy, Vivarelli *et al.* (1996) depict an overall negative employment impact of technological change, where process innovations and product innovations have opposite effects on labor demand.

Pianta (2000 and 2001) took the case of five European countries (Denmark, Germany, Italy, the Netherlands, and Norway) for the period of 1989 - 1993 and studied the relationship between technological change and employment using 21 manufacturing industries. He finds generally negative results for the impact of innovation in these countries.

In addition to the manufacturing sector, some studies have also considered the services sector - separately or jointly with manufacturing. The empirical results suggest that no generalization can be made regarding the innovation effect in this sector. Evangelista and Savona (2002) study the employment impact of innovation in the Italian services sector using a panel dataset from the Italian innovation survey covering the period 1993 - 1995. They find a positive impact in the most innovative sectors that are knowledge-intensive, while they observe a negative impact in financial-related, capital-intensive, and more traditional sectors. The major difference between the sectors exhibiting positive employment effects and those facing negative ones is that the former tend to be the sectors producing, adopting and disseminating new ICT, while the second group uses mostly process innovations to rationalize production. The authors suggest that the overall negative results in Italy are due to the fact that the Italian services sector is concentrated in the most traditional branches. Bogliacino and Pianta (2010) consider the manufacturing and services sectors simultaneously for eight European countries (Germany, France, Italy, Norway, Netherlands, Portugal, Spain and UK) during the period 1994 - 2004. They observe different dynamics between different industries; however, the overarching observation is the positive employment impact of product innovations and the negative impact of process innovations. Similarly, Bogliacino and Vivarelli (2010) study the manufacturing and services sectors of 16 European countries over the period 1996 - 2005. They show that technological change, proxied by R&D

expenditures and thus referring mainly to product type innovations, is positively related to increasing employment.

1.1.2.3. Employment effect at firm level

In addition to sector level studies, an increasing amount of literature has been studying the employment impact of technology and innovation at the microeconomic level. The empirical evidence shows an overall tendency of technology to have a positive impact on employment levels. In other words, firms that introduce product and/or process innovations tend to grow faster and enlarge their employment base compared to firms who do not introduce innovations, irrespectively of their size, sector or other firm-specific factors (Pianta, 2005).

Firm-level studies are quite convenient and can be very informative because they overcome many of the methodological problematic issues that macroeconomic and sectoral studies face. For instance, it is difficult for macroeconomic studies to measure innovation due to: (1) lack of adequate data on R&D activities and patents, and (2) the inability to capture aspects of the embodied technological change through which many SME's (small and medium enterprises) upgrade their production processes. In contrast, firm-level studies can fully benefit from the micro-data on R&D expenditures, investment levels, product and process innovations, and can directly link them to the firms' employment trends (Vivarelli, 2011). Moreover, firm-level studies overcome the difficulties pertaining to the fact that national employment trends are affected by a large set of macroeconomic and institutional factors that are complex to capture. They are able to investigate the dynamics of job creation through product innovations, or job destruction through laborsaving process innovations, in isolation of institutional mechanisms, cyclical conditions, labor market dynamics, and other such trends.

Even so, analysis at the microeconomic level has its limitations and shortcomings that make its conclusions difficult to extend to other countries or generalize. More specifically, firm-level studies cannot indicate whether the gains from innovation are having a negative impact on the firms' competitors. In this sense, they are portraying "positive bias" (Vivarelli, 2011), where the employment creating process is generated by the firm that had gained market shares and expanded its production; however, the competitors are crowded out by the innovating firms and the final employment effect may actually be negative. This phenomenon is better known as the "business stealing effect" or "creative destruction". Additionally, the indirect compensation mechanisms (discussed above) cannot be manifested at the firm level due to their dependence on sectoral inter-play and macroeconomic factors and dynamics. Following is a review of some of these studies that portray the different nuances that the analysis in this field has taken.

The first studies conducted at firm level used cross-sectional data and mostly took European countries as case studies. Entorf and Pohlmeier (1990) study a cross-sectional database of firms in West Germany in 1984. They find that product innovations have a positive impact on employment. Blanchflower *et al.*(1991) studied 948 British establishments for the same year 1984. Controlling for age, unions, demand, and ownership, they find positive and significant relation between the introduction of new ICT technology and employment. Machin and Wadhwani (1991) reach the same conclusions when studying the same dataset. In contrast, Zimmermann (1991) studies German firms in 16 industries and finds a negative relationship between technological process innovations and employment. Brouwer *et al.*(1993) also do not find a significant effect of R&D intensity on the employment levels of Dutch firms.

A positive employment effect was observed when only product innovations and R&D in IT were considered. Similarly, Ross and Zimmermann (1993) find a negative employment effect innovation when they studied a cross-sectional dataset of 5,011 German manufacturing firms for the year 1980. In the US, Doms *et al.* (1995) show evidence for a positive relation between employment and the introduction of advanced manufacturing technologies in manufacturing plants for the period of 1987-1991.

An important number of studies showed that product innovations -as opposed to process innovations- are the only type of technological development that affects employment. Leo and Steiner (1994) find positive effects of technology on Austrian firms (400 firms for the period 1990-1992) only when considering the lagged effect of product innovations. Konig *et al.* (1995) also find supporting evidence for the positive effect only of product innovations using the Mannheim Innovation Panel and Mannheim Enterprise of 3000 German firms. Smolny (1998) finds a significant positive effect of product innovations when studying an unbalanced panel of around 16,000 firms in West German manufacturing sector for the period 1980-1992. He also finds that product innovations have a significant negative impact on employment at industry level due to rivalry. Contrary to most studies, Klette and Forre (1998) do not find significant evidence supporting the positive employment impact of technology. Using a database of 4,333 Norwegian firms over the period 1982 - 1992, the authors do not detect a positive relation between net increase in employment and R&D intensity.

Using more sophisticated econometric techniques, Van Reenen (1997) applied a dynamic employment growth model (OLD and GMM-DIFF) to a panel of 598 British firms for the period 1976 - 1982. He also finds that product innovations have significant positive effects on employment. However, the effect of patents was not robust after controlling for firm fixed effects. Using a similar methodology, Blanchflower and Burgess (1998) study two panel datasets including 831 UK plants, and 888 Australian plants, and find a positive and significant results for the British firms, and positive but weakly significant positive results in the Australian case. Greenan and Guellec (2000) explore the dynamics of employment and technological innovation in the French industrial sector. Using a sample of 15,186 firms for the period 1986 - 1990, they observe that innovating firms create more jobs over the medium run. Process innovations have a higher job creating effect than product innovations at firm level; however, the trend is reversed at the sector level. The authors attribute this opposite employment impact to "creative destruction" effects. Piva and Vivarelli (2004 and 2005) control for these effects in their study of 575 Italian manufacturing firms over the period 1992 - 1997, and still find evidence supporting the positive effect of technological innovation on employment. Also taking the case of Italian manufacturing firms, Hall *et al.* (2008) take a more recent timeframe 1995 - 2003, and also show a positive relation between innovation and employment. They distinguish between product and process innovations, and show that product innovations contribute to augmenting employment, and process innovations do not cause displacement. Following a similar approach of studying the employment effect of product and process innovations separately, Harrison *et al.* (2008) consider four European countries (Germany, France, UK, and Spain). The authors show that while product innovations contribute to creating jobs, process innovations tend to displace employment. In addition to product and process innovations, Lachenmaier and Rottmann (2011), distinguish between innovation input and innovation output when studying a panel dataset of German firms over the period 1982 - 2002. They put forward evidence for the positive impact of innovation on employment, including the innovation input and output variables. Interestingly, they find that the impact of process innovations is stronger than that of product innovations.

Overall, despite their methodological shortcomings, firm-level empirical studies support the positive relation between employment and technological innovations. The distinction between product and process innovations shows that product innovations tend to be more labor-friendly, while process innovations have negative or no effect on employment levels. Business stealing or creative destruction are also considered and controlled for in some studies, but the results remain to show a positive relation between employment and technology, which further asserts the validity and strength of this relation.

1.2. Technology and employment: the qualitative impact

Apart from the quantitative impact of technology on employment, a stream of literature has shown that the relationship between technology and employment also has a qualitative aspect, giving rise to the notion of Skill Biased Technological Change (SBTC). This section sheds light on this phenomenon and presents empirical studies that have tested for the presence of SBTC in a number of countries.

1.2.1. Skill-biased technological change: definition and origins

The main idea of the SBTC hypothesis is that employers' increased demand for skilled workers is driven by new technologies that are penetrating into modernized industries, and which only workers with a higher level of skill can operate (Machin, 2003). The definition of SBTC does not necessitate an absolute shift from unskilled to skilled labor. It implies that an exogenous adoption of a new technology results in a relative shift in employment from unskilled labor to skilled labor, which leads to a rise in both relative wages and levels of employment (Conte and Vivarelli, 2011).

The first to develop the SBTC concept and formalize the hypothesis of capital-skill compelmentarity was Griliches (1969) who provided evidence for the premise that "skill" or "schooled" labor is more complementary with capital than unskilled, or "raw" labor[7]. Another early contribution was made by Welch (1970), who studied the increasing returns to education in the US, and also concluded that production processes have become more complicated over time and necessitate an increasing level of skill.

The foundations of SBTC can be traced to three major observations (Violante, 2008). First, the decline in relative prices of investment in equipment and physical capital is said to have driven the increase in demand for skilled labor due to capital-skill complementarity in the production processes. As Krusell *et al.* (2000: 1030) explain,

"SBTC reflects the rapid growth of the stock of equipment, combined with the different ways equipment interacts with different types of labor in the production technology".

Second, SBTC as viewed from a human capital perspective (see Nelson and Phelps, 1966), suggests that workers with higher education are more capable and learn faster; therefore, they are more adequate in operating and implementing new technologies that are being adopted by innovating firms. The third argument supporting SBTC is related to changes in the organizational design of firms (see Milgrom and Roberts, 1990, and Garicano and Rossi, 2004). This line of reasoning suggests that the introduction of new technologies, especially ICT, brings about more efficient organizational design in firms and this requires more skilled workers who can adapt fast and multi-task (Violante, 2008).

[7] In his study, he uses two different datasets for the US manufacturing sector in 1954 and 1960

The rapid diffusion of ICT is said to have instigated a process of substitution of unskilled workers for skilled ones. In fact, a number of studies have documented a decline in the relative wages of unskilled workers in several developed countries, and have attributed this decline to the spread of information technology and computers.

In terms of its impact on overall employment, Vivarelli (2011) argues that SBTC leads to unemployment among the unskilled labor even if the compensation mechanisms function at their full capacity. He explains that SBTC is most often accompanied with laborsaving process innovation, and skilled labor is more scarce in comparison to unskilled labor; therefore, the new equilibrium reached after the increased demand for skilled labor is always at a lower level of demand for unskilled labor. This is also known as the "human resource constraint" (see Amendola and Gaffard, 1988).

1.2.2. Empirical Evidence

Many empirical studies indicate that SBTC has gained momentum during the past three decades due to the surge in information technology and spread in computers (Pianta, 2005). The first to explore SBTC were Berman *et al.* (1994) who provided evidence for the existence of strong correlations between within industry skill upgrading and increased investment in both computer technology and R&D in the U.S. manufacturing sector between 1979 and 1989. They concluded that technological change explains the shift to non-production, or skilled workers. Autor *et al.* (1998) also show that the spread of computer technology in the US since 1970 can in fact explain as much as 30 to 50 percent of the increase in the growth rate of relative demand for skilled labor. Empirical studies supporting SBTC were conducted for several other countries like the UK, France, Germany, Italy, and Spain (see Table 1.1). Moreover, Machin and Van Reenen (1998) provide evidence of SBTC in performing a cross-country study. They consider seven OECD countries (US, UK, France, Germany, Denmark, Sweden and Japan) and assert a positive relation between R&D expenditure and relative demand for skilled workers. They observe that most shifts from unskilled to skilled labor seem to occur within rather than between industries, which further asserts the hypothesis that SBTC is in fact the main driving force behind the shift in relative demand for labor.

Table 10.1: List of studies measuring the employment impact of technological change in developed countries

Author	Country	Period	Data	Methodology	Results
Machin (1996)	United Kingdom	1984- 1990 / 1979-1990	Firm level and Sector level	Derives econometric specifications from production cost function. Dependent variable: share of non-manual wages to total wages. Technology related regressors: computer usage for firm level data, and R&D intensity and count of innovations for industry-level data.	Firm level: significant and positive results indicating firms indeed increase the non-manual employment shares with increased technology adoption. Increased computer usage is associated with reduction in shares of unskilled workers. Majority of shifts towards non-manual labor have been within firms and industries. Industry level: Similar positive and significant results.
Haskel and Heden (1999)	United Kingdom	1972 – 1992	Firm level (app. 15,000 establishment per year)	Skilled labor demand regression. Dependent variable: change in wage bill share of non-manual workers. Technology related independent variable: ratio of computer investment to total investment.	Positive and significant relation between computer investment and increased demand for skilled workers. Computerization reduced the demand for manual (unskilled) workers. This result was statistically significant even when controlling for endogeneity and human capital upgrading.
Mairesse, Greenan, and Topiol-Bensaid (2001)	France	1986, 1990 and 1994	Firm level (about 3,000 medium and large firms)	Cross-sectional and time-series regressions. Proxies used: ratio of value of assets in office and computing equipment to value of total physical assets, and several shares of total employees to different types of specialized workers (computer staff, electronics staff, R&D staff, analytical staff)	Significant and robust evidence of positive impact of IT capital on firm productivity, skill performance and employment in the cross-section dimension. The time-series dimension does not exhibit similar positive impact.

Author	Country	Period	Data	Methodology	Results
Goux and Maurin (2000)	France	1970, 1977, 1985, 1987, 1993	Sector level (34 sectors, 2-digit SIC system)	Regression with dependent variable: difference between impact of employment shifts on wage bill and growth rates. Independent variables: dissemination of computers and new technologies, and various types of occupation	Technical progress has a small impact on labor demand composition (around 15%). The decrease in unskilled workers is mainly due to slackness in the domestic demand.
Aguirregabiria and Alonso-Borrego (2001)	Spain	1986 – 1991	Firm level (1,080 firms)	GMM estimator. Dependent variable: labor input. Technology related independent variables: R&D capital and technological capital	Introduction of technological capital leads to significant changes in the occupational structure favoring skilled labor. R&D does not have a significant effect since it does not necessarily reflect the introduction of successful innovations.

1.3. Technology, employment, and international trade

This section introduces trade into the discussion of the employment impact of technological advancement. The issue of trade is particularly relevant in the case of developing countries, as their major source for obtaining modern technology is in fact their trade activity with the more developed countries. Before moving to the contesting theories on the effect of technology on employment within a trade liberalization dynamic setting, I want to shed some light on the overall effects of trade liberalization on developing countries.

The past three decades have witnessed a great deal of DCs moving from protectionist economies regimes to trade liberalization policies. This shift has always been advocated by the developed countries and major international organizations with the argument that trade liberalization is a necessary condition for sustained economic development (Thirlwall, 2012). A large number of studies have looked into the relationship between trade liberalization and growth performance. The results of these studies have been mixed. Edwards (1998) uses a set of 93 countries to analyze the strength of the relationship between trade openness and total factor production (TFP) growth. His results show a positive relationship between the outward orientation of countries and their growth performance. However, he mentions in his conclusions that further understanding of the economics of innovation and productivity growth is required, especially at country level. The results of Edwards have been criticized by Rodriguez and Rodrik (2001) mainly due to methodological issues pertaining to the robustness of the results. Dollar and Kraay (2004) looked into the effect of globalization on growth and poverty. They identify groups of developing countries that had become "globalizers" as of 1980, and show that these countries have shown accelerating growth rates. In contrast, the rich world and the rest of the developing world have shown decelerating growth from the 1970s to the 1980s and the 1990s. Dollar and Kraay's work was criticized by Dowrick and Golley (2004) who argued that the faster growth of the "globalizing" sample of Dollar and Kraay was in fact due to the fast growth of China and India.

Given that the final effect of trade liberalization on DCs is not quite clear cut, its interplay with technology and their effect on employment also becomes quite an intricate matter to analyze.

SBTC introduced in the earlier section is also known as the “technology-based” explanation for the widening gap between demand for skilled and unskilled labor and the growing wage inequality between them. Some scholars have followed a different approach in explaining this phenomenon, which is the “trade-based” explanation, at the heart of which is the Heckscher-Ohlin theory and the Stopler-Samuelson theorem.

1.3.1. The Heckscher - Ohlin, Stopler-Samuelson theory

The primary theory discussing trade and its distributional effects is the Heckscher-Ohlin (HO) model and the Stolper-Samuelson (SS) theorem that is also known as the HOSS model. Starting from a Ricardian comparative advantage setting, the HO model postulates that a country will specialize in the production of the good whose manufacturing requires intensive use of the relatively abundant factor in that country. Therefore, it will export this good and import the good whose manufacturing requires intensive use of its relatively scarce, and thus more expensive, factor of production. The standard model is a 2x2x2 trade model and assumes two countries, each producing two goods, where each good requires two factors of production. The two countries are identical with the exception of their relative factor endowments.

It is perhaps most illustrative for the purpose of this study to use the HO specification of Wood (1994) who used skilled and unskilled labor as the factors of production, and North (developed) and South (developing) as the two countries in the model. The standard assumptions of this model that are mentioned in Francois and Nelson (1998) are: (1) Behavioral/institutional assumptions, where (a) households and firms have rational behavior, (b) markets are complete and perfectly competitive, (c) there is balanced trade between both countries. (2) Both countries have identical tastes that are represented by identical systems of homothetic community indifference curves. (3) A set of assumptions about production factors, (a) the quality of both production factors is uniform, (b) there is perfect mobility between sectors, and (c) there is complete immobility between countries. (4) A set of assumptions about the production function, (a) both countries have the same technologies, (b) both goods require positive inputs of both production factors, (c) the production functions are linear homogenous, twice differentiable, and strictly concave. (5) Machinery is more skill-intensive at all factor prices. (6) The North is relatively better endowed with skilled labor than the South, and endowments are fixed and in-elastically supplied. Finally, (7) there are no trade costs.

In this context and under these assumptions, HO theory concludes that since the South is relatively abundant in low-skilled labor, it will have a comparative advantage in the production of the low-skill-intensive good. The opposite is valid for the North countries. In fact, following trade liberalization the South should specialize in and export low-skill-intensive goods, and should experience a contraction of the production of skill-intensive goods that are substituted by imports.

An important extension to the HO model is the Stopler Samuelson (SS) theorem that links prices of products to the returns on factors of production. The SS theorem focuses on the exogenous changes in the prices of international goods, or in tariffs that change the relative prices of goods that domestic producers face. It argues that, under fixed technology, these price changes will change the relative factor prices, and so when the relative price of a good rises, the return of the factor used intensively to produce that good will rise, while the return on the other factor will fall. This analysis is possible namely due to the fixed technology assumption, which implies that the relationship between output and input factors is fixed. In a trade liberalization context, this means that in a developed country, the price of unskilled -labor - intensive goods will decrease and the wages of unskilled workers will decrease relative to those of skilled workers. In developing countries, the opposite is expected to happen, i.e. liberalization would raise the relative price of unskilled-labor-intensive goods and the relative wages of unskilled workers will rise. This implies that developed countries will witness a widening inequality gap between skilled and unskilled labor. Along the same lines, HOSS predicts that trade-liberalization will reduce inequality in DCs (Davis and Mishra, 2007).

There is evidence that HOSS does indeed depict the experience of developed countries. These countries have witnessed considerable increases in imports of low-skill-intensive goods for developing countries, especially since the 1980's when many DCs liberalized their trade regimes. During this period, empirical studies show that developed countries also witnessed a rise in the relative wages of skilled labor and a growing income inequality gap. Burtless (1995), Freeman (1995), and Wood (2000) among others mainly attribute the increased inequality in developed countries to increasing liberalization and expanding international trade.

Looking at DCs, the HOSS optimistic predictions for developing countries that undergo trade liberalizations has been often used by institutions such as the World Bank and the International Monetary Fund to validate their support for trade liberalization programs in such countries. They argue that liberalizing trade would lead to economic growth and a better distribution of wages and income. However, the HOSS predictions have not been quite consistent with empirical evidence from developing countries, where trade liberalization was in fact accompanied with an increased demand for skilled workers, and higher levels of wage inequality (see for example, Wood, 2000; Slaughter, 2000).

HOSS is often challenged because of the restrictive assumptions it makes, which render it far from applicable to reality. In this respect, several extensions were made to the basic HOSS model, which attempt to relax some of its more restrictive assumptions and allow it to operate in a more realistic framework. Wood (1994) divided workers into three categories: non-educated, basic educated, and skilled workers. The division of workers does not change the predictions of the SS theory, but it allowed for observing different within-country inequality trends resulting from international trade, especially in low and middle income countries. To illustrate this point, consider a DC with a comparative advantage in manufacturing. Trade liberalization should lead to lower inequality since the country would increase its production and export of labor-intensive goods and increase its demand for basic-educated workers relative to skilled workers. However, this would lead basic-educated workers to have relatively higher wages than the non-educated workers, which would increase income inequality. Wood solves this issue by arguing that *"because countries with a lot of non-educated workers usually do not have comparative advantages in manufacturing, the net effect of more exports of manufactures is likely to be a reduction in inequality"* (Wood, 1994: 245).

Davis (1996) extended the analysis from a North- South framework into several country groups, which he called *"cones of diversification"*, where the factor of abundance is assessed in relation to these groups of countries that have similar endowments and produce similar goods, rather than to the world. Therefore, the model stresses the relative position of a given country with respect to other countries within its cone. Davis proposes a model with two cones of diversification, one for developed and another for developing countries. Within this framework, a country that is considered very unskilled labor abundant compared to the global economy, can be categorized as skill abundant when compared to the countries within its cone. This could change the expected outcomes of the standard HOSS model. On the one hand, liberalization could lead to higher demand for skilled labor in a DC as long as it is within its cone of diversification, where it has relatively high supply of skilled labor. On the other hand, a developed country can witness a reduction in its inequality gap if it has relatively more unskilled workers compared to other countries within its cone.

Dornbusch *et al* (1980) proposed a model with a continuum of goods that are ranked according to their relative capital intensity, which can be interpreted as their embodied technological content. This analysis enabled the authors to study the changes in prices and wages within the country rather than only the relative changes between countries.

Finally, Feenstra and Hanson (1996) bring intermediate goods and outsourcing activities into the analysis as opposed to only final goods. They argue that moving non-skill intensive productions abroad leads to a shift in employment towards more skilled workers within local industries. Their model consists of a continuum of goods ordered by the degree of skill intensity, and assumes that the production of a final good requires a continuum of intermediary goods with varying proportions of skilled and unskilled labor. They also assume, as other models do, that developed countries have a comparative advantage in skilled-labor intensive goods and developing countries have a comparative advantage in unskilled-labor intensive goods. Trade liberalization, through FDI and other trade channels, would shift the production of intermediate goods from developed to developing countries. While such products would be characterized as unskilled-labor-intensive from the point of view of a developed country, they are considered as skilled-labor-intensive goods from the point of view of a developing country. This implies that the demand for skilled labor would increase in both North and South, thus leading to a higher skill premium in both regions.

The main conclusion of these departures from the standard HOSS framework is that international trade may lead to different within-country inequality trends, especially in low and middle-income countries, which are not consistent with the predictions of HOSS. Despite the changes that these models introduced, they remained to operate within the same HOSS framework, where returns to factors of production are conditional on their relative distribution among countries (Arbache, 2001).

1.3.2. Technological change in developing countries

One of the main restrictions of the HOSS theory is the assumption that all countries have identical levels of technology and so analysis within this framework does not allow for studying the dynamic effects of trade. The skill-biased technological change (SBTC) approach makes this drastic break from HOSS and drops the assumption of technological homogeneity among countries. This in turn allows for the assessment of the effect of technology transfer in developing countries on their levels of inequality (Acemoglu, 1998) and the changing structure and composition of their labor markets. A standard assumption would be that the developed countries have higher levels of technology than developing countries, and that trade openness acts as a catalyst for the transfer of technology from the more developed to the less developed countries. Therefore, the final employment impact of trade would be highly dependent on the skill-intensity embodied in the transferred technology. Even though developed countries do not usually transfer their best state-of-the-art technologies, it remains safe to assume that they do bring about significant relative upgrading to the traditional modes of production of local industries in DCs. Since R&D activities are quite limited in DCs, they rely on these technological transfers as their primary means of technological upgrading. Trade liberalization plays a crucial role in this respect and can most often lead to an increased demand for skilled labor in DCs.

The distributive effects of technological transfer can take several forms. The remainder of this section sheds light on these effects.

SET hypothesis

The term "skill-enhancing trade" (SET) hypothesis was put forward by Robbins (1996 and 2003). The basic idea is that trade liberalization accelerates the flow of capital and embodied technology from the developed countries to the developing ones, which causes these latter countries to enter into a phase of adaptation to the new skill-intensive technologies that they have received (Robbins, 1996). Therefore, the more developing countries import capital and technology, the higher the degree of skill-intensity will be in the various sectors of these countries. This would induce an overall higher relative demand for skilled labor, even if resources shift to unskilled-labor-intensive sector as HOSS would predict. This could in turn result in an increased wage dispersion in these countries, and thus higher levels of inequality.

It is important to note here that even if the technology is not considered as skill-intensive in the developed country, it could be considered as skill-intensive in the developing country, indicating that technology can be skill biased in relative terms. This concept was also noted in Feenstra and Hanson (1996) - that was discussed earlier in the section- where outsourcing involves a relative skill biased technological transfer, namely because the activities that are being transferred from the North to the South are considered as skilled intensive only in the South countries. Zhu and Trefler (2005) have extended the Feenstra and Hanson model and incorporate the effect of technological catching-up that could take place in developing countries. They conclude that it is not the process of technological catch-up itself that raises inequality, but rather the higher level of export shares of the DC's most skill-intensive goods. Therefore, the effect of technological catch-up is an indirect one. Zhu and Trefler (2005) also show that the faster a DC's catch-up rate is, the greater the rate at which export shares will shift towards the more skill intensive goods will be, and the greater the growth of inequality will become.

Skill intensive learning activity

Pissarides (1997) adds to the discourse on the distributional effects of trade liberalization by arguing that transfer of technology is biased in favor of skilled labor. The basic idea of Pissarides is that trade allows developing countries to benefit from opportunities of profitable imitation of technologies produced in the developed world because it increases the exposure of the developing countries to a new range of technological innovations. In fact, when a developing country liberalizes its trade, it intensifies the process of technology transfer and the key assumption here is that transfer of technology requires more skilled labor, namely because learning is a skill-intensive activity. Therefore, when a developing country opens its trade, it reallocates skilled labor from production to other activities such as reverse engineering or R&D, which would lead to a rise in the relative earnings of skilled labor. However, according to Pissarides, this phenomenon is only temporary and lasts only until the workers learn the new technologies. Once the learning period is completed, the proportion of skilled workers employed in the imitation activities would decrease and so will the returns to skills. Nonetheless, if the technology transferred is skill biased then the relative increase in demand for skilled labor could be permanent.

Skill based technological transfer

So far I have looked into the ways trade integration and technology adoption can affect the demand for skilled labor and the skill premium, even if the skill bias of the technology does not change. The mere transfer of technologies implies the use of more skilled labor since the new technologies obtained by developing counties are more intensive than the ones that had been used in those countries. Nevertheless, technologies transferred to the developing world could be skill-biased in absolute terms, which would render their effect on the demand for skilled labor even larger.

As mentioned earlier, the rapid diffusion of technologies in developing countries, especially ICT technology, has caused a significant substitution of unskilled workers for skilled ones. There is a wide debate in the literature that pertains to the importance of SBTC in the context of developing countries in terms of explaining the rising inequality between skilled and unskilled workers. If trade were the main driver of the increased demand for skilled workers, it should be expected that labor reallocation would take place across sectors. In fact, HOSS predicts that skill-intensive sectors should grow and expand as a result of trade with DCs. In contrast, the skill intensity within each industry should decrease. If SBTC were the main driver of this increased demand for skills, it should be expected to observe a within-industry skill upgrading.

1.3.3. Channels of technology transfer

R&D activities are limited in DCs; therefore, they mainly rely on developed countries to pass their technologies on to them through the major channels of trade and FDI. In what follows is a brief depiction of the various channels of technology transfer in DCs and the direct and indirect mechanisms through which they can affect the growth of these countries and their employment levels. (for a detailed discussion see Piva, 2003; Keller, 2004).

Imports of intermediate and capital goods.

The higher level of capital goods flows that come along with trade liberalization can facilitate the process of technological upgrading, when these capital goods incorporate new technologies. When DCs increase their imports of more technologically advanced machinery and equipment, it helps in diffusing technology in these countries and raises the relative demand for skilled labor (Acemoglu, 2003). Therefore, import of intermediate and capital goods from developed countries can contribute to capital upgrading through increasing knowledge and expanding potential applications (Xu and Wang, 2000). Incorporating imported foreign intermediate goods into the production process involves the implicit utilization of the innovation that was created with the R&D investment of the foreign inventor; therefore, the importer benefits from the technological knowledge that is embodied in the intermediate good. This kind of technology transfer is sometimes referred to as passive technological spillover (Keller, 2001), and allows for the process of "reverse engineering". A large body of literature has studied the effect of import flows on technological upgrading in importing countries.

Coe and Helpman (1995), using a sample of OECD countries, show that foreign knowledge - defined as the sum of the R&D stocks of trading partners weighted by the bilateral trade shares - that is embodied in traded goods has a positive impact on TFP (total factor productivity) in the importing countries. Similar positive results appear in studies that looked into the case of DCs. Coe *et al.* (1997) and Mayer (2000), find that imports of intermediate goods raises the TFP in DCs.

It is important to note here that the type of technological imports can affect the scope of their impact. On the one hand, a developing country can implement embodied technological change (ETC) through the importation of “mature” machineries (including second-hand capital goods, see Barba Navaretti *et al*. 1998) from more industrialized countries. On the other hand, a lagged DC can enjoy the “last comer” benefit of jumping directly on a relatively new technology (see Perkins and Neumayer, 2005). An example of the latter could be the diffusion of mobile telecommunications in Sub-Saharan Africa in countries where the traditional telephone networks are limited to few urban areas. This focus on the quality of the imported technology was empirically studied by Barba Navaretti and Soloaga (2002). They look at the role of imported machinery in transferring embodied technological progress from the EU to a number of neighboring developing and transition countries in Central-Eastern Europe and Southern Mediterranean. Their results show that imported machinery has a positive impact on TFP and that higher impact is associated with a higher level of technological complexity of the imported machinery. In a later study by Barba Navaretti *et al.* (2006), the same countries are studied and the authors calculate the gap between the technology purchased and the technological frontier (defined by the US), by comparing the unit values of machinery imported by each country with the unit values of machinery imported by the US. Their results show a persistent gap, and in some cases even increasing, which leads them to conclude that the productivity growth in manufacturing depends on the types of imported machinery (quality) and rather than on its share out of total investment (quantity).

Exports

For firms in DCs, exports can be another channel for technological transfer through "learning by exporting" (Keller, 2001), which gives rise to efficiency gains, and acquiring knowledge of international best practices (Vivarelli, 2011). Moreover, foreign clients may provide their suppliers in DCs with technical assistance, and transmit to local firms some relevant expertise, in order to improve the quality of imported goods (Epifani, 2003). Bernard and Jensen (1997) argue that a large percent of the increased wage inequality in the US is due to skill upgrading within the exporting plants. They further explain that trade-induced demand shifts have caused a reallocation of resources across plants towards exporting firms.

In terms of its employment effect, Yeaple (2005) demonstrated that exporting firms increase their demand for skilled labor because the adoption of new technologies is more profitable for them, which is in line with the SBTC notion. Bustos (2011), in her study on the effects of free regional trade agreements on the demand for skill in Argentina, finds that trade liberalization reduces variable export costs, increasing exporting revenues and inducing more firms to enter the export market, which makes the introduction of new technologies beneficial for more firms.

On another front, Verhoogen (2008) proposes a model where increased trade with more developed countries can stimulate exporters in DCs to increase the quality of their products, which would lead to higher demand for more skilled workers. He finds that a devaluation in Mexico induced the most productive firms to raise the export share of sales and wages relative to less productive plants. Goldberg and Pavcnik (2004) explain that the changes in the composition of production inputs as a response to liberalization induce a reallocation of both capital and labor towards "higher quality" firms, where this quality could be reflecting "firm productivity" or "product quality". However, and regardless of what leads to this improved quality, these "higher quality" firms hire a higher share of skilled labor.

FDI

Another important channel for technology transfer is FDI. One of the first to articulate this was Hymer (1976), who suggested that FDI is not merely a transfer of capital, but a transmission of an entire "package" of capital, management, and new technology. In fact, new technology can be embodied within capital goods, and/or transferred through best practices and know-how that investing firms provide their counterparts with.

During the 1990's increasing FDI flows to DCs formed a fundamental part of their development strategies (Piva, 2003). The major reason why developing countries try to attract FDI is to acquire modern foreign technologies. They invite multinational companies (MNC's) to invest in their industries so that they can benefit from technological spillovers to the local firms. There are four main types of spills that can occur (Piva, 2003): (1) *demonstration*, which takes places when local firms obtain technologies through imitation or reverse engineering (see Findlay, 1978; Blomström and Kokko,.1998; Saggi, 2002), (2) *labor turnover*, which takes place when workers are trained by transnational firms and can transfer acquired technological know-how to their local firms or use this knowledge to start-up their own businesses (Kinoshita, 2000), (3) *competition effects*, which occur when competitive pressures lead FDI affiliates to necessitate their local partners to introduce technological upgrading, and (4) *vertical spillovers*, which refer to the backward and forward linkages with international firms that lead to technological upgrading between industries.

However, the degree to which FDI can have a positive impact on the technological advancement of the host countries is associated with the "absorptive capacity" of that country (Cohen and Levinthal, 1989) and the availability of a certain quality of human capital (Borenzstein *et al.,* 1998). Regarding the employment effects of FDI, MNC subsidiaries generally create employment (Görg, 2000), and pay higher wages than local firms in developing countries (Lipsey and Sjöholm, 2004). The direct employment effect is manifested through the fact that the MNCs themselves employ workers. The indirect effect is that the operation of MNCs in the country increases demand for local suppliers' products and thus could contribute to increasing employment in local firms as well (Dunning and Fontanier, 2007).

Licensing

Obtaining a license usually provides technology in a more accessible way than FDI; therefore, many countries such as Brazil, China, India, Mexico, and Japan have preferred it as a channel for technology transfer (Piva, 2003). It usually includes a contractual transfer of know-how and technology between firms. However, since licensed companies can become competitors to the innovating MNC's, or leak the licensed technologies, MNCs have tended to consider this mode of technology transfer as riskier than FDI. Therefore, they are inclined to use licensing to transfer their older technologies, while they use FDI for the newer innovations (De Ferranti *et al.*, 2003).

"Defensive innovation"

Although local R&D activity in DCs is not a major source of technological upgrading, this is not to say that is does not exist at all. Some DCs might attempt to introduce R&D into their processes as a response to trade openness. This is what Wood (1995) called "defensive innovation". Wood suggests that intensified competition that comes along with opening trade can instigate firms in DCs to engage in R&D activities in order to benefit from new existing technologies that they may have has little incentive to adopt and develop prior to liberalization. This theory was further developed by Thoenig and Verdier (2003). However, as Goldberg and Pavcnik (2004) rightfully observe, this argument seems more adequate for middle-income developing countries such as Brazil and Colombia, rather than low-income countries. They continue to note that a common implication of this hypothesis is that in the short and medium terms, SBTC should be more evident in the sectors that have witnessed a higher level of liberalization. Attanasio *et al.*(2004) indeed show that during 1984-1998, the increase in demand for skilled workers in Colombia was highest in the sectors that witnessed the largest tariff cuts.

Since technology transfer in DCs involves mostly labor saving process innovations, it could have harmful effects on the local employment levels in DCs that might not be balanced through the compensation mechanisms. Vivarelli (2011) discusses the additional difficulties the DCs face with regards to the functionality of the compensation mechanisms.

The mechanisms operating through decreases in prices and/or wages operate best in highly competitive market settings. Therefore, they can be hampered by the typically low degrees of competition at the local markets in DCs. In addition, the new investment mechanisms can be hindered by the tendencies of local investors to invest abroad. Furthermore, the compensation through higher incomes can be slowed down by the tendency of consumers to spend additional income on imported luxury goods. Finally, R&D activity in DCs is quite rare; therefore, compensation through production innovations that are labor-friendly is not likely to occur.

1.3.4. Trade, poverty, and inequality in developing countries

The evidence in support of the SBTC phenomenon taking place in developing countries is large. This leads one to look deeper into the effect of trade liberalization on inequality and poverty in developing countries since SBTC could be a major cause of an increasing inequality between skilled and unskilled labor, thus leading to increasing poverty among the unskilled workers in DCs.

Advocates of trade liberalization continue to assert that the freeing of trade will help alleviate poverty and move people out of it. Winters *et al.* (2004) examine whether developing countries who undergo trade liberalization witness increased or reduced poverty levels. They suggest that theory provides a strong belief in that liberalization of trade will have a poverty alleviating effect in the long run on average, and that empirical evidence broadly supports this presumption, or at least *"lends no support to the position that trade liberalization generally has an adverse impact"* (Winters *et al.* 2004: 106). Thirlwall (2012) disagrees with these conclusions and suggests that the impact of trade liberalization on poverty actually depends on its effects on employment and prices, and it can in fact cause poverty by throwing people out of work.

Another thorough study of this issue is the empirical study of Ravallion (2006), who takes a sample of 75 countries where there have been at least two household surveys on poverty, and measures the relationship between percentage change in poverty rate and the percentage change in the ratio of trade to GDP as a proxy for trade liberalization. He finds that there is a significant negative relation between them; however, the correlation shows to be weak, where for example, controlling for initial conditions renders the coefficient insignificant. Ravallion concludes that *"it is hard to maintain the view that expanding trade, in general, is a powerful force for poverty reduction in developing countries".*

Goldberg and Pavcnik (2007) discuss some empirical research on the effect of globalization on income inequality in developing countries. They suggest that there is a *"contemporaneous increase in globalization and inequality in most developing countries".* The authors examine the various channels through which globalization may affect inequality, and point to the increasing gap between skilled and unskilled workers; a manifestation of SBTC.

Milanovic (2005a) studies the impact of openness, measured by the trade to GDP ratio, and FDI on relative income shares of low and high deciles of income. The dataset that Milanovic uses consists of 321 household surveys in 95 countries in 1988, and 113 countries in 1993 and 1998, and with this, his research covers 90% of the world population. The results show that at very low income level, the rich (top two deciles) are that ones who benefit from openness. As income level rises, i.e. for countries with survey-incomes between $4000 and $7000 at international prices, the relative income of the poor and middle-class households rises compared to the rich. Therefore, Milanovic concludes that openness seems to make income distribution worse off before moving to make it better, so that the effect of trade openness on a country's income distribution is dependent on its initial income level. In addition, he does not find any effect of FDI on income distribution. Therefore, Milanovic concludes that

"increased trade seems to result in greater inequality, that is reduced income share of the poorest deciles in poor countries. Those who, according to economic theory and according to policy prescription of international organizations, should benefit the most from increased trade appear, on the contrary, to be losers in relative terms." (p.32).

Similarly, Barro (2000), in his study on the relationship between income inequality and rates of growth and investment shows, through econometric analysis on a broad panel of countries, that the positive relationship between openness and inequality is most evident in poor countries. The estimated relation weakens as countries get richer, and reaches zero when GDP per capita rises to about $13,000 (1985 USD).

Contrary to the above results, Dollar and Kraay (2002) take a panel of 92 countries and show that growth spurred by open trade benefits the poor as much as it benefits the typical average household, and conclude that openness to international trade should lie at the core of poverty reduction strategies. However, Thirlwall (2012) notes that the variable definitions of Dollar and Kraay are "unusual" since they measure trade in nominal USD, while they measure GDP at purchasing power parity (PPP). This would lead to an understatement of the ratio of trade to GDO since GDP at PPP is much higher than in nominal terms.

1.3.5. Empirical evidence on the employment impact of technology in developing countries

In this section, I turn my attention to the empirical literature studying the employment impact of technology on developing and underdeveloped countries, with a focus on the phenomenon of SBTC in those countries.

Matusz and Tarr (1999) survey studies carried out before 1995 that look into the impact of globalization on employment in developing countries. They conclude that trade and FDI liberalization have had a positive effect on employment, with the exception of the transition countries of eastern Europe. Ghose (2000) takes the case of manufacturing employment when analyzing the employment effect of globalization and trade liberalization. His study concludes that growth of trade manufactured products has a strong labor augmenting effect within the manufacturing sectors of the countries under study. Lall (2004) also finds that globalization can provide many benefits to developing countries, especially in the form of increased export activity and employment growth. However, he continues to suggest that these effects may not be valid of any "typical" developing country. For instance, rapid exposure to market forces within a framework of increasingly lower transaction costs, may actually reduce employment and freeze comparative advantage in stagnant or low-return activities. In addition, even if a shift to labor-intensive activities occurs, it may not lead to higher overall net employment if it also destroys local firms without encouraging the growth of new, more efficient enterprises.

Coe *et al.* (1997) have looked into the impact of foreign knowledge embodied in traded goods on total factor productivity (TFP) in DCs. They show that the import of intermediate goods raises TFP in DCs just as does in more developed countries (as Coe and Helpman (1995) had shown for OECD countries). Mayer (2000) defines import shares as the import of machinery when looking into the effect of trade liberalization on low-income countries. The dataset included 46 countries with per-capita income under $800 (1995 US Dollars). His results show that "*improved access to technology imports appears not to have improved labor productivity and the demand for skilled labor in many low-income countries.*"

Therefore, he concludes that these countries need to raise the skill level of the domestic labor force in order to be able to reap the potential benefits of globalization. Schiff and Wang (2006) consider not only the quantity of imported technology, but its quality as well. They stress the fact that a country can increase its exposure to technology though trade, or through improved knowledge of that trade. Taylor (2004) argues that the final employment effect depends on the balance between gains in labor productivity and output growth stimulated by domestic demand, trade and FDI. He shows that in seven out of eleven DCs, growth of output per capita in traded goods sectors was slower than growth of labor productivity, thus leading to losses of jobs.

While a large number of works have documented the relevance of the SBTC hypothesis for advanced countries, the evidence for DCs is less abundant, and it is almost absent in the case of the least developed countries (LDCs). An increase in the demand for skilled labor in DCs has been empirically documented, and studies using cross-country analysis have found evidence in support of SBTC. This invalidates the HOSS predictions regarding the egalitarian effects of trade in those groups of countries (Revegna, 1997). Berman and Machin (2000 and 2004) investigate SBTC in the manufacturing sectors of middle income countries. They observe that the industries that upgraded their technologies and increased their demand for skilled labor in the developing countries during the 1980s are the same industries that underwent this process in the US during the '60s and '70s; they conclude that technologies are being transferred from developed to developing countries where they are having the same skill-upgrading effect. Meschi and Vivarelli (2009) study the impact of trade on within-country income inequality in a sample of 70 DCs over the 1980-1999 period; their results suggest that total aggregate trade flows are weakly related with income inequality; however, once they disaggregate total trade flows according to their areas of origin/destination, they find that trade with high income countries worsens income distribution in middle income DCs, both through imports and exports. Their findings provide a preliminary support to the hypothesis that technological differentials between trading partners are important in shaping the distributive effects of trade openness. By the same token, Conte and Vivarelli (2011) report evidence of a positive relationship between the import of embodied technology and increased demand for skilled labor in low and middle-income countries. They show that the skill-enhancing trade - measured through imports of industrial machinery, equipment, and ICT capital goods - plays a key role in diverging labor demand towards the more skilled and away from the unskilled. Their empirical study was based on panel data covering the manufacturing sectors of 23 low and middle-income countries over the period of 1980 – 1991. Almeida (2009) reaches similar conclusions when studying 8 countries in East Asia; however, she did not find evidence supporting SBTC in low-income countries or China.

Moving from cross-country analysis, to country specific studies, there is also significant evidence that supports the presence of SBTC in DCs. Robbins and Grindling (1999) observe bias towards skilled workers in post liberalization Costa Rica. They conclude that the bias is emerging from the higher import of capital goods that is instigated by liberalization, where capital goods embody a bias towards skilled labor.

Fajnzylber and Fernandes (2009) study the effects of international integration on a cross-section of manufacturing plants in Brazil and China. They find that the use of imported inputs, exports and FDI are associated with higher demand for skilled workers in Brazil; however, the same is not true for China, where specialization in unskilled labor intensive productions turns out to compensate for the access to skill-biased technologies. Giovanetti and Menezes-Filho (2006) also looked into the evolution of skilled labor in Brazil over the period 1990 - 1998. They showed evidence for an increase in the share of skilled labor, which was entirely caused by the "within industry" effect; however, the "between-industry" effect showed to be negative. They also tested the SET hypothesis through econometric analysis, and found that tariffs were negatively related to skill upgrading. This indicates that lower tariffs lead to increased import of technologically advanced inputs, which are expected to raise demand for skilled labor. A more recent paper by Araújo *et al.* (2011) that also takes the case of Brazil using a panel of manufacturing firms over the period of 1997 – 2005, reaches similar conclusions that support the hypothesis of skill-enhancing trade and the fact that technology has played a significant role in up-skilling manufacturing labor in Brazil.

Pavcnik (2003) investigated skill upgrading in Chile for the period 1976 - 1986, but did not find significant evidence supporting SBTC. However, later research on Chile conducted by Fuentes and Gilchrist, (2005) on Chile who expanded the study period to 1995, did find a significant relation between the adoption of foreign technology and increased relative demand for skilled labor.

Feenstra and Hanson (1997) use data from Mexican industries and they find a positive relation between FDI and demand for skilled labor. More specifically, they find that the outsourcing of production through FDI from the US to Mexico implies that plants that were relatively unskilled-labor-intensive in the US were relatively skill-intensive in Mexico. This asserts an earlier remark that what is not skill-intensive in a developed country can be considered as skill-intensive in a developing country, and thus shifting production to the developing country through FDI and/or export /import trade can lead to increasing inequality in both countries. Hanson and Harrison (1999) further study the case of Mexico and conclude that indeed FDI, licensing agreements, and imports are all channels of technology transfer and lead to higher demand for skilled labor.

Birchenall (2001) also attributes increased inequality in Colombia to SBTC resulting from trade liberalization and increased openness of the economy. Görg and Strobl (2002) show that using technologically upgraded foreign machinery in Ghana has led to an increase in the demand for skilled labor. However, they do not find that export activity has a skill bias effect. Finally, Meschi *et al.* (2011) study the effect of trade openness on inequality in Turkey. They conclude that both imports and exports contribute to raising inequality between skilled and unskilled workers due to the skill-biased nature of the technologies that are being imported and used in industries with export orientations.

CHAPTER 2

CHAPTER 2: THE CASE OF TURKEY

After a thorough discussion of the theoretical and empirical literature pertaining to the relationship between liberalization and globalization from one side, and employment and skills from the other side, this chapter moves to an empirical application within the context of developing countries. It explores the existence of skill-based employment differentials within economies that are technologically advancing and being increasingly integrated with the world markets. It takes the Turkish manufacturing sector as a case study to discuss this issue through examining the determinants of skill bias of employment over time, in both relative and absolute terms.

Turkey proves to be an interesting case to study. It is a middle-income country with significant trade flows with developed countries, especially the EU; therefore, it relies on technology import as its main source for technological upgrading. In addition, during the 1980's Turkey underwent a process of trade liberalization, and shifted from its prior protectionist model of heavy state intervention, whereby it transformed from a rather closed (import-substitution) economy to a much more open (export-oriented) economy. The series of institutional and legal changes accompanied this structural adjustment; all had serious impacts on the growth and development of the Turkish economy (Taymaz, 1999). Undoubtedly, these structural changes had implications on the labor market trends, imports, exports, FDI levels, and other economic aspects, whose dynamics are of interest to the present research.

The empirical analysis is performed at firm level within a dynamic framework using a two-equation model that depicts the employment trends for skilled and unskilled workers separately.

The results confirm the theoretical postulation discussed earlier that, contrary to traditional trade theory expectations, developing countries face the phenomenon of skill-biased technological change and skill-enhancing technology import, which leads to increasing the employment gap between skilled and unskilled workers.

The chapter is organized into 4 main sections. The next section discusses the data used for the purpose of this research. Section 2.2 presents provides some information regarding the structural adjustment program in Turkey, the state of manufacturing employment, and the technological upgrading that the country has undergone. In section 2.3, I present the empirical model, some econometric specifications. Section 2.4 presents and discusses the results obtain. Finally, I conclude with a number of remarks.

2.1. The data

The data used in this chapter is from the Turkish "Annual Manufacturing Industry Survey" conducted by the National Turkish Statistical Institute, TurkStat. The survey covers a total of 17,462 firms from 1980 to 2001. The survey includes private firms having at least 10 employees as well as public ones, representing around 90% of the Turkish manufacturing output, within the formal sector. They are classified by their type of activity according to the "International Standard Classification", ISIC Rev.2.

Table 2.1: Distribution of firms according to size and skill division

ISIC industry	Total labor	Skilled labor	Unskilled labor
Food, beverages and tobacco	18.5%	21.6%	17.6%
Textile, wearing Apparel and leather industries	29.4%	19.8%	32.2%
Wood and wood products including furniture	2.2%	1.8%	2.3%
Paper and paper products printing and publishing	3.5%	5.0%	3.0%
Chemicals and chemical, petroleum, coal, rubber and plastic	9.6%	14.6%	8.3%
Non-metallic mineral products, except products of petroleum & coal	7.1%	6.7%	7.3%
Basic metal industries	7.4%	7.4%	7.4%
Fabricated metal products petroleum, coal, rubber and plastic	21.6%	22.5%	21.3%
Other manufacturing industries	0.6%	0.5%	0.6%
Total	100%	100.0%	100.0%

Source: Own elaborations from Annual Manufacturing Industry Survey, TurkStat

The database provides a wide range of information on each firm including the economic activity of the firm, its employees and their wages, the firm's purchases of input, its volume of sales and output, its investment activities, and the status of its assets and capital. All monetary variables are expressed in 1994 Turkish Lira, using sector-specific deflators.

Employment is measured as the number of workers per year. Workers are divided into two broad categories: (1) production workers, including technical personnel, foremen, supervisors and unskilled workers, and (2) administrative workers, including management and administration employees, and office personnel. This categorization is used in the empirical analysis to distinguish between white collar (skilled) workers proxied by the administrative workers, and blue collar (unskilled) workers proxied by the production workers. The decision to categorize skilled and unskilled labor based on this division stems from the fact that this approach has been used in literature and has shown satisfactory results (see for example, Berman *et al.* 1994; Leamer, 1998). Although the ideal categorization for skilled and unskilled workers would be one based on educational attainment or a further disaggregation by working tasks, the adopted categorization is the only workable within our dataset. In fact, the database does contain a more detailed description of workers' tasks; however, it does not contain corresponding wage data, so it could not be used in the empirical analysis.

2.2. Descriptive analysis

This section presents the factors that led to the opening up of the Turkish economy in the 1980's and the changes that followed its integration with the world market. It also sheds light on employment in the Turkish manufacturing sector, as well as on trends in the R&D activities within this sector.

2.2.1. Structural adjustment and trade liberalization in Turkey

The Turkish economy achieved significantly high growth rates during the 1960s and 1970s under the import substitution (IS) industrialization strategy; however, these rates showed to be unsustainable in the late 1970's when the country fell in a severe balance of payments crisis. In 1980, Turkey launched a stabilization program, which entailed a set of policies that aimed at, as Senses (1991) explains, *"changing the system of incentives from archetypal import substitution, with its heavy state intervention and widespread rent-seeking, toward export orientation with an overall emphasis on market-oriented policies".*

Under the protectionist economic policies, the state represented the locomotive of the economy (Saracoglu, 1987), where vigorous public investment led to expanding the domestic production capacity in heavy manufacturing and capital goods, such as machinery, petrochemical and basic intermediates (Metin-Ozcan *et al.* 2001). The state played a dual role of an investing and producing agent with State Economic Enterprises (SEEs) serving as the major tools for achieving the industrialization targets (Metin-Ozcan *et al.*, 2001). Consequently, a large industrial base was established in the country, and Turkey was able to achieve significant rates of growth in the manufacturing output during the period 1965- 1980 (an annual average of 7.5 percent) (Senses, 1994).

Nonetheless, the protectionist policies had some major limitations that rendered the system unsustainable. In the mid 1970's Turkey faced deterioration in its economic environment mainly due to its failure to adjust and adapt to external changes in the world economy (such as increase in oil prices in 1974, and recession in the industrialized countries) (Saracoglu, 1987). The IS strategy began to reach its limits when financing the balance of payments and industrial investments became increasingly difficult (Metin-Ozcan *et al,*2001). Furthermore, pushing the pace of industrialization beyond the available resources led to serious macroeconomic instabilities (Senses, 1994). By 1979, Turkey stood in the midst of a severe foreign exchange crisis, where it was unable to import even essential items, its inflation accelerated, and unemployment was widespread (Saracoglu, 1987).

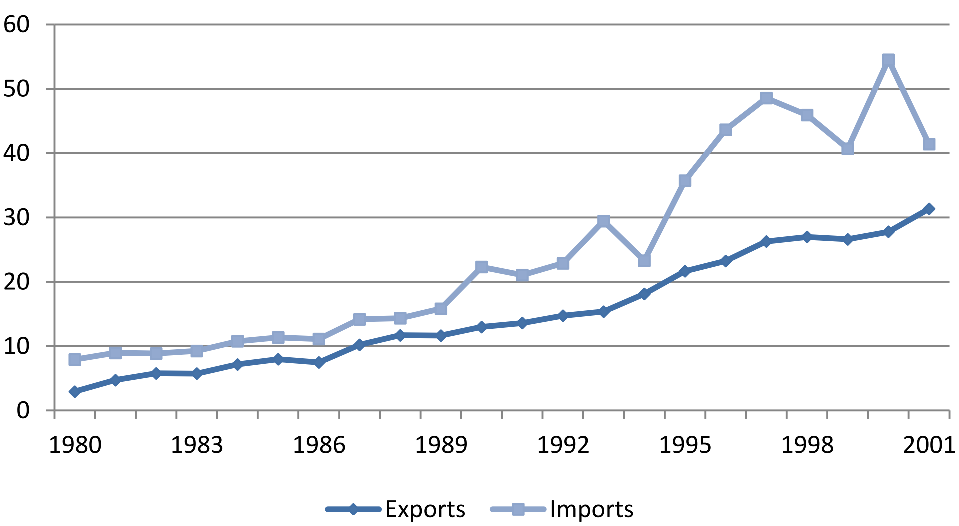
In January of 1980, Turkey launched a comprehensive structural adjustment reform program under the auspices of the IMF and the World Bank. The Stabilization and Structural Adjustment Program (SSAP) was based on an "outward oriented trade" strategy and foreign trade, where product, and later, capital markets were liberalized to a large extent (Taymaz, 1999). The new program abolished import substitution as the major strategy for economic growth (Saracoglu, 1987) and firmly established a new regime centered on an export-led growth strategy (Taymaz, 1999).

The first phase of structural adjustment operated under the grand title of export promotion, but still under a regulated foreign exchange system and controls over capital inflows. Integration with world market during this phase was realized mainly through commodity trade liberalization (Boratav *et al*, 2001)[8]. This phase however witnessed severe erosion of wage incomes through hostile measures against organized labor. The restraint of wages played a significant role in lowering production costs and squeezing the domestic absorption capacity (Metin-Ozcan, *et al*, 2004). This mode of surplus creation reached its economic and political limits by 1988, and as a result, financial markets were completely deregulated (Boratav *et al*, 2001). The country opened up its domestic and asset markets to international competition with the declaration of the convertibility of the Turkish Lira in 1989 (Boratav *et al*., 2001). In 1996

[8] In the period between 1980 and 1983, the major reform emphasis was on encouraging exports through export tax rebates, preferential export credits, foreign exchange allocation, and duty-free access to imports (Taymaz and Yilmaz, 2007). During this period, the total subsidy rate received by manufactured goods exporters reached 20-23 percent (Milanovic, 1986). The subsidies were particularly high for exports channeled through foreign trade companies (Celasun, 1994). Later, after 1984 the import regime underwent fundamental reforms, where a large number of commodities were allowed to be imported without any prior permission and quantitative restrictions were eliminated (Taymaz and Yilmaz, 2007).

Turkey signed the Custom Union agreement with the European Union (EU)[9]. It also endorsed Free Trade Agreements (FTAs) with the European Free Trade countries, Central and Eastern European countries, and Israel. These changes led to significant increases in both imports and exports (see figure 2.1 below). The import penetration ratio for manufacturing increased from 15 percent in 1980 to 22 percent in 1984 and continued to fluctuate around this rate during the 90s to reach 30% in 2000 (Taymaz and Yilmaz, 2007). The export to output ratio in the manufacturing sector increased from about 16% in 1984 to 20% in 1989 and exceeded 30% in the year 2000.

Figure 2.1: Trade volumes in Bil. USD

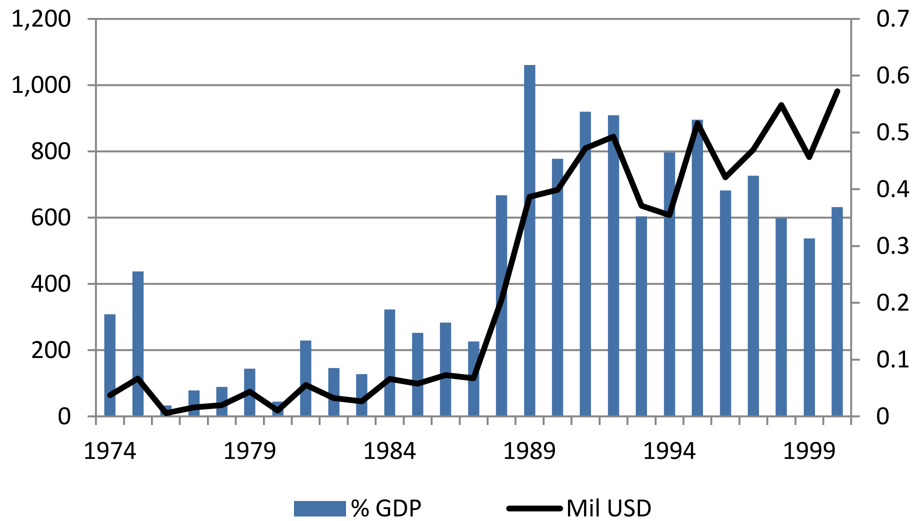


Source: TurkStat, Foreign Trade Statistics

The levels of FDI also increased dramatically with the opening of the country. As Figure 2.2 below shows, FDI levels were low during the 1970s, i.e. before the launching of the SSAP, and began to increase during the 1980s to surge in 1989 with the full liberalization of capital accounts.

[9] This agreement entailed the free circulation of all industrial goods between EU and Turkey. In addition, Turkey adopted the EU's common external tariff for industrial products and the industrial elements of processed agricultural products.

Figure 2.2: FDI inflows

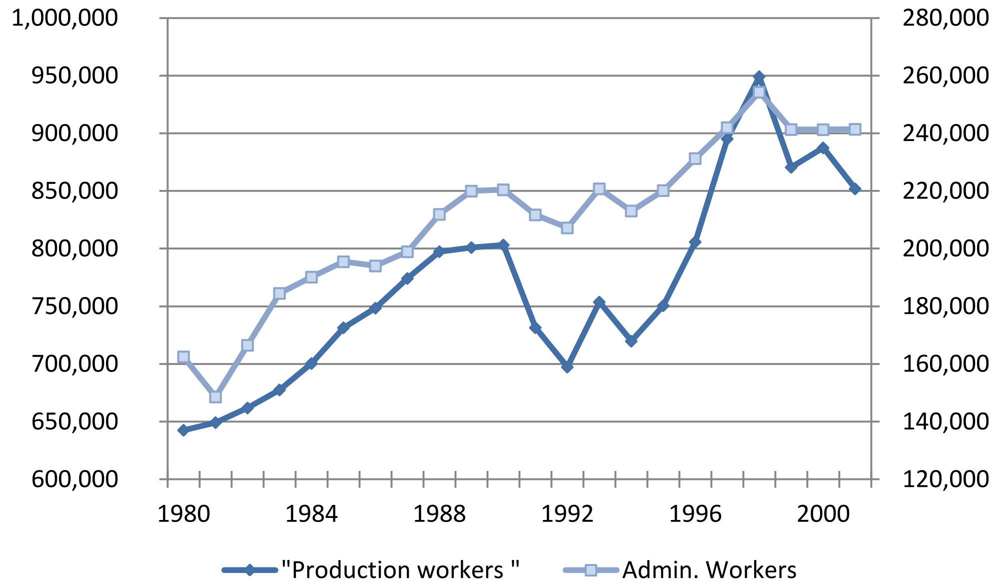


Source : World Development Indicators / The World Bank

2.2.2. Employment in the manufacturing sector

There has been a continuous significant shift of the Turkish workforce away from agriculture and into the services sector in the first place, followed by industry and construction. The share of workforce in the industrial sector has increased from 14% in 1975 to 18% in 2000 (Tunali, 2003). Looking at the structure of manufacturing labor force in more detail through our data, one can observe that overall employment has been increasing for both production and administrative workers (Figure 2.3). Production workers seem to face higher fluctuations while the increase in administrative workers has been fairly steady. The average ratio of administrative to production workers is 0.27 over the period 1980- 2001, where it was 0.25 in 1980 and reached 0.28 in 2001.

Figure 2.3: Employment of production and admin workers

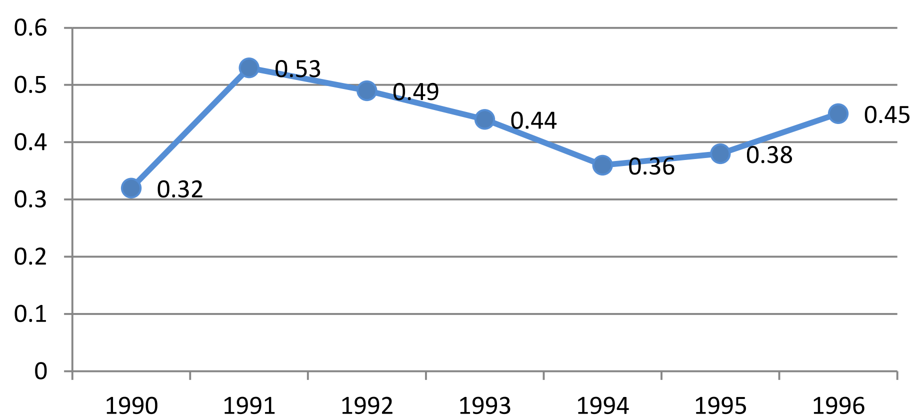


Source: Own elaborations from Annual Manufacturing Industry Survey, TurkStat

2.2.3. Technological upgrading in Turkey

Although Turkey enjoys a relatively dynamic and active manufacturing sector relatively to other DCs, the intensity of local R&D activities remains low. Figure 2.4 below shows the gross domestic expenditure on R&D to GDP ratio. The ratio has been improving, with fluctuations, over time; however, it continues to fall much lower than the OECD average.

Figure 2.4: Expenditure on R&D to GDP ratio



Source: Elci, 2003. "Innovation Policy in Seven Candidate Countries". ADE, March 2003

Although the business sector's share of funding R&D had increased from 27% in 1990 to 42% in 1999; however, the OECD average is as high as 63% (Pamukcu, 2003). The largest portion of businesses spending on R&D are within the manufacturing sector: 92% in 1995 (Erdilek, 2005). The government remains to fund more than half R&D expenditure in the country, and most of public funded R&D activities are performed in universities (Pamukcu, 2003). In fact, around two thirds of R&D in Turkey is produced by higher education institutions (Erdilek, 2005), which raises concerns about the actual benefit of these research activities for the business sector. Indeed, Pack (2000) points out that government-funded institutions in DCs often tend favor self-sufficiency in technology generation at the expense of technology imports that remain essential for industrial development in these countries. Table 2.2 below shows the total share of firms who perform R&D in the manufacturing sector, as well as the share of private and public firms. The share of public R&D performers remains higher than that of private performers, namely due to the fact that most R&D funding is public.

Table 2.2: R&D performers in the Turkish manufacturing sector

Year	Total R&D performing firms	Private R&D performers	Public R&D performers
1992	8.3%	8.1%	14.8%
1993	12.5%	12.4%	14.4%
1994	14.8%	14.8%	15.0%
1995	16.0%	15.9%	18.2%
1996	13.9%	13.9%	16.0%
1997	13.3%	13.2%	15.8%
1998	13.6%	13.5%	19.7%
1999	14.5%	14.4%	19.3%
2000	15.1%	14.8%	26.2%
2001	12.1%	11.9%	21.3%

Source: Own elaborations from Annual Manufacturing Industry Survey, TurkStat

The establishment of the Technology Development Foundation of Turkey (TTGV) in 1991 and the launching of R&D support programs in the 1990s formed a major step towards institutionalizing innovation activities in Turkey. It has been providing R&D support in the form of interest-free "R&D loans" since 1992. The Technology Monitoring and Evaluation Board of the Scientific and Technical Research Council of Turkey (TIDEB of TUBITAK, in Turkish acronyms) is the other major R&D supporter in Turkey. R&D support rate depends the share of the products (produced through R&D) in total sales, employment of PhD researchers, R&D services obtained from universities, R&D performed within techno-parks, and projects undertaken in priority areas, among other factors (Özçelik and Taymaz, 2002). A study on the effectiveness of these public support systems (Özçelik and Taymaz, 2008) showed that public R&D support tends to also stimulate private R&D activities, especially within smaller firms.

On the whole, it can be concluded that technological upgrading in Turkey is likely to be mainly implemented through imported capital goods; nevertheless, the domestic R&D activities are not negligible and should be taken into account in the empirical analysis.

2.3. The Empirical model

In this section I specify the empirical model that I used for the study, and I discuss in detail the choice of the econometric approach that I use, namely the System-GMM method.

2.3.1. Model specification

Consistently with the previous empirical literature studying the employment effects of technological change and assuming a perfect competition setting (see Van Reenen, 1997), the labor demand equation is derived using a constant elasticity of substitution (CES) production function of the following form:

$$Y = T\,[\,(AL)^{(\sigma-1)/\sigma} + (BK)^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)} \qquad (1)$$

where Y is output, L and K are the standard inputs of labor and capital respectively; T is a Hicks-neutral technology parameter (movements in T leave the capital-labor ratio constant), A is labor augmenting Harrod-neutral technology, and B is capital augmenting Solow-neutral technical change. By setting real wages equal to the marginal productivity of labor, the following first order condition equation for labor is obtained.

$$\ln L = \ln Y - \sigma \ln W + (\sigma - 1) \ln A \quad (2)$$

σ measures the elasticity of substitution between capital and labor (Van Reenen, 1997), and W represents real wages. This setting is further extended by including some proxy variables for the unobserved labor-augmenting technology component A.

Since the present model separates between unskilled and skilled workers, the above equation can be expressed for each labor category separately.

$$\ln USL = \ln Y - \sigma_{USL} \ln USW + (\sigma_{USL} - 1) \ln A_{USL} \quad (3)$$

$$\ln SL = \ln Y - \sigma_{SL} \ln SW + (\sigma_{SL} - 1) \ln A_{SL} \quad (4)$$

where USW and SW are the real wages for unskilled and skilled workers respectively. Costs of labor adjustments call for transforming the model from a static to a dynamic one, in order to take into account firm's attrition and delays in hiring/firing workers (see Lachenmaier and Rottmann, 2011); therefore, a lagged employment variable is added to the equations. Moreover, the specification is extended to include proxies for the various factors related to trade and technology. The final estimating equations are the following:

$$USL_{it} = \alpha + \beta USL_{it-1} + \delta USW_{it} + \gamma Y_{it} + \eta TECH + \mu EXP_{it} + \lambda INV_{it} + (u_{it} + \varepsilon_i) \quad (5)$$

$$SL_{it} = \alpha + \beta SL_{it-1} + \delta SW_{it} + \gamma Y_{it} + \eta TECH_{it} + \mu EXP_{it} + \lambda INV_{it} + (u_{it} + \varepsilon_i) \quad (6)$$

All variables are expressed in natural logarithms. USL and SL are respectively the numbers of unskilled and skilled workers of sector i at time t. USW and SW are the wages of each labor category. Y is the output variable that reflects the impact of firms' sales and also controls for possible business cycle fluctuations that can affect demand for the different types of labor. $TECH$ is a vector composed of two dummy variables representing domestic and imported technology: namely, the presence of internal R&D expenditures ($R\&D$) and the obtained availability of a foreign patent or other appropriability devices developed abroad (PAT). EXP is a dummy that takes the value of one when the firm is an exporter and zero if it does not export. INV represents firms' net investment. Finally, standard to panel data analysis, the error term is composed by the idiosyncratic error component (u_{it}) and the time invariant firm fixed effect component (ε_i).

Therefore, equations (5) and (6) can be seen as a twofold dynamic labor demand, where employment depends on output, investment and wages as traditionally assumed, but also on additional drivers such as domestic technology, imported technology and "learning by exporting".

The most commonly used method for studying the skill employment gap is through estimating a sole relative demand for labor equation, where changes in the share of skilled workers would provide evidence for the existence of an up-skilling trend within the labor force. However, this one-equation setting does not permit the researcher to go a step further into investigating the relative versus absolute skill bias. Indeed, the advantage of the present two-equation setting is that is allows for this type of analysis, whereby absolute skill bias would manifest itself when the considered variables have a positive coefficient for the skilled workers and a negative coefficient for the unskilled workers, while relative skill bias would appear when the coefficients for both skilled and unskilled workers are positive but differ in statistical significance and/or in magnitude, with the coefficients for the unskilled workers being less significant and/or lower. In addition, this setting is more accurate in exploring the autoregressive dynamics of blue collar sand white collars workers separately.

However, a possible drawback of this two-equation setting is that the equations are not entirely independent, and this could be translated into a correlation between the error terms of the two regression equations. To mitigate this issue, I begin with the specification in equation (3) and use the ratio of skilled to unskilled workers as the dependent variable. The following equation is used in the estimation:

$$(\frac{SL}{USL})_{it} = \alpha + \beta(\frac{SL}{USL})_{it-1} + \delta W_{it} + \gamma Y_{it} + \eta TECH_{it} + \mu EXP_{it} + \lambda INV_{it} + (u_{it} + \varepsilon_i) \quad (7)$$

All variables are expressed in natural logarithms, and they follow the definitions presented in the summary table below.

Table 2.3: The variables and their definitions

Variable	Definition
USL	Number of unskilled employees engaged in production activities
SL	Number of skilled employee engaged in non-production activities
W	Real total wages
BCW	Real wages of unskilled labor
WCW	Real wages of skilled labor
Y	Real output of the firm (sales)
R&D	Dummy variable for existence of R&D activities
PAT	Dummy variable for obtaining foreign royalties, patents, know-how and other property rights
EXP	Dummy variable for export activities
INV	Net investment of the firm
Source	The Annual Manufacturing Industry Survey for the Republic of Turkey, TurkStat
Years	Annual observations for the period 1980 – 2001

2.4. Econometric issues

The presence of firm-specific effects creates a correlation between the lagged dependent variable USL_{it-1} (and SL_{it-1}) and the individual fixed effect ε_i . Therefore, the dynamic specification implies a violation of the assumption of strict exogeneity of the estimators. In this context, the use of least squares will lead to inconsistent and upwardly biased estimates for the coefficient of the lagged dependent variable (Hsiao, 1986). The firm effects can be eliminated through the within-group estimator (or fixed effects estimator, FE). However, this leads to a downward bias of the estimated parameter of the lagged dependent variable (Nickell, 1981).

Extensive econometric research has been done in order to obtain consistent and efficient estimators of the parameters in dynamic panel models. Almost all approaches include first transforming the original equations to eliminate the fixed effects and then applying instrumental variables estimations for the lagged endogenous variable (Halaby, 2004). Anderson and Hsiao (1982) developed a formulation for obtaining consistent FE-IV (fixed effects – instrumental variables) estimators by resorting to first differencing in order to eliminate the unobserved fixed effects, and then using two lags and beyond to instrument the lagged dependent variable.

Efficiency improvements have been made to the Anderson and Hsiao model through the utilization of the GMM (Generalized Method of Moments) technique. Arellano and Bond (1991) first resorted to GMM by using an instrument matrix that includes all previous values of the lagged dependent variable, so obtaining the GMM-DIFF estimator. However, The GMM-DIFF estimator has been found to be weak when (1) there is strong persistence in the time series, and/or (2) the time dimension and time variability of the panel is small compared with its cross-section dimension and variability (Bond *et al.*, 2001). Blundell and Bond (1998) have performed an efficiency improvement to the GMM-DIFF by using additional level moment conditions and obtaining the system GMM or GMM-SYS model. Through these added moment conditions, the GMM-SYS uses all the information available in the data based on the assumption that $E(\Delta u_{it}\varepsilon_i) = 0$ (Blundell and Bond, 1998; Bond, 2002). Since our panel dataset is characterized by both the above conditions (1) and (2), we adopted a GMM-SYS model.

Time persistence was tested through computing AR (1) using ordinary least squares (OLS) in levels and the obtained outcome – showing strong and highly significant persistence.

Table 2.4: Time persistence test

	(1) Unskilled labor	(2) Skilled labor
AR (1)	0.979***	0.550***
	(0.0005)	(0.0013)

Notes: Standard errors in brackets. *** Significant at 1%

Secondly, the presence of a lagged dependent variable required running an OLS regression to determine the upper bound for the value of the coefficient obtained in the GMM-SYS; therefore, the values obtained for the coefficients of USL_{it-1} and SL_{it-1} using OLS would serve as an upper bound for the corresponding values coming out from the estimates obtained using GMM-SYS. Similarly, the FE methodology was applied to provide a lower bound for the value of the estimated coefficient of GMM-SYS, since the fixed effects lead to downward biased results.

It is important to note that all the regressors were considered potentially endogenous, since they are largely dependent on firms' simultaneous decisions. Therefore – to be on the safer side – all variables have been instrumented using the GMM orthogonality conditions.

Thirdly, I inserted time dummies to control for unobserved macroeconomic and cyclical shocks that may affect the variables.

2.5.Results

The OLS outcomes reported in columns (1) and (2) of Table 2.5 below show that the values of the coefficients of the endogenous variables from GMM-SYS (columns 5 and 6) are lower than those obtained from OLS. Also in the case of FE, GMM-SYS results are consistent with the expectations. On the whole, the comparison between GMM-SYS on the one hand and OLS and FE on the other hand is supporting the adequacy of the chosen GMM-SYS methodology. Results are discussed with reference to the preferred GMM-SYS specification, although they are generally consistent across the three methodologies showed in the table.

The positive and highly significant values of the lagged coefficients for both types of workers confirm the persistence of the employment time-series. The remaining explanatory variables are divided into variables that have a significant relationship only with unskilled workers, variables that have a significant relationship only with skilled workers, and variables that are significant for both.

The *real wage* showed to a negative relationship for both skilled and unskilled workers, which is in line with basic supply and demand theory. However, the coefficient was significant for the unskilled workers only. A possible interpretation of this observation is that unskilled workers are more elastic to wages since they are more substitutable. In contrast, skilled workers are hired because of specific competences that they possess, and so their wages are not as essential a factor that affects the employers' decisions of hiring and retaining them. The *output* variable is positive for both skilled and unskilled workers indicating that expansion of production requires higher demand for both types of labor. However, the coefficient for the unskilled workers is slightly higher than that for the skilled workers, where the ratio of unskilled to skilled workers is 1.47. This indicates that firm expansion is in general labor enhancing; however, the effect is stronger for unskilled labor. Consequently, the *output* variable does not present evidence to support SBTC. *Net investment* is positively related only to unskilled workers, while it is not statistically significant for skilled workers. Therefore, *coeteris paribus,* increasing sales and investments does not contribute to an up-skilling trend in Turkish manufacturing.

Turning our attention to the focus of this study, the *R&D* dummy variable (that takes the value of 1 if the firm performs R&D activities and zero if it does not) shows positive and significant impact on the demand for skilled workers, but not for the unskilled. Therefore, innovating firms tend to have an absolute higher demand for skills, and this reflects an absolute skill bias effect for these firms.

Contrary to the R&D variable, which is a proxy for locally developed technologies, the *patent* variable was used to measure international technological transfer through foreign licenses, patent rights and other transfer of know-how. This variable takes the value of 1 if the firm has obtained such rights and zero if it has not. Similarly to the *R&D* variable, *patents* show positive and significant coefficients for skilled workers only; therefore, firms that benefit from this type of imported technology increase their demand for skilled workers and do not increase their demand for unskilled workers. The last variable studied in the regression model is the *export* dummy variable, taking the value of 1 if the firm performs export activities and zero otherwise. As discussed in earlier sections, the possible skill-biased impact of this variable may be related to the so-called "learning by exporting" effect. Indeed, the results support this hypothesis, with the dummy showing a positive and significant coefficient for both skilled and unskilled workers, but with a larger magnitude in the case of the white collars. Hence, engaging in export activities also seems to encourage hiring more skilled than unskilled workers.

The overall results are consistent with the SBTC hypothesis: indeed, both domestic and foreign technologies foster the demand for skilled workers in Turkish manufacturing. The nature of this bias is that of a *absolute* skill-bias for *R&D* and *patents*, where new technologies obtained through local and imported innovation, require a higher number of additional skilled workers and do not seem to require additional skilled workers. The skill bias related to learning by exporting is relative meaning that the indirect channel of technological upgrading that exporting firms are benefiting from is not leading to possible destruction of jobs, but it rather requires a higher number of additional skilled workers compared to unskilled. Furthermore, output and investment did not exhibit evidence for skill bias, indicating that increasing the capacity of production and investments, while keeping the most prominent sources of technological upgrading constant, in fact leads to hiring more unskilled than skilled workers.

A number of tests were performed to test the validity of the estimated model and the robustness of the corresponding results. A Wald test[10] was run to test for the overall joint significance of the independent variables: it always rejects the null hypothesis of insignificant coefficients. The Hansen test for over-identifying restrictions was also performed: the null of adequate instruments was rejected; however, since the Hansen test may over-reject in the case of very large samples (see Blundell and Bond, 1999; Roodman, 2006), the same model was run and the Hansen test performed on a random sub-sample comprising 20% of the original data. The outcome was that the Hansen tests never rejected the null, so reassuring on the validity of the chosen instruments. Finally, the standard Arellano and Bond (AR) tests for autocorrelation support the consistency of the adopted GMM estimators, however only after using t-3 instruments.

[10] It is distributed as a $\chi 2$ where the degrees of freedom equate the number of restricted coefficients.

Table 2.5: Employment equations of unskilled and skilled workers

	OLS		FE		SYS-GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Lagged unskilled workers	0.849***		0.401***		0.512***	
	(0.0016)		(0.0032)		(0.0206)	
Unskilled real wage	-0.0940***		-0.131***		-0.192***	
	(0.0023)		(0.0035)		(0.0097)	
Lagged skilled workers		0.718***		0.263***		0.384***
		(0.0021)		(0.0033)		(0.0140)
Skilled real wage		-0.0712***		-0.178***		-0.00108
		(0.0024)		(0.0033)		(0.0103)
Real output	0.0885***	0.145***	0.222***	0.186***	0.280***	0.190***
	(0.0011)	(0.0016)	(0.0023)	(0.0031)	(0.0139)	(0.0130)
R&D dummy	0.00519	0.0629***	0.0122***	0.0251***	0.00184	0.129***
	(0.0034)	(0.0046)	(0.0037)	(0.0049)	(0.0056)	(0.0086)
Patent dummy	0.00633	0.133***	0.0194	0.0379**	0.0196	0.472***
	(0.0083)	(0.0110)	(0.0137)	(0.0176)	(0.0230)	(0.0322)
Net investment	0.00763***	0.0105***	0.00437***	0.00689***	0.00839***	0.00188
	(0.0003)	(0.0004)	(0.0004)	(0.0005)	(0.0023)	(0.0028)
Exporter dummy	0.00952***	0.0214***	0.00847**	0.0376***	0.0190*	0.171***
	(0.0031)	(0.0042)	(0.0040)	(0.0052)	(0.0105)	(0.0136)
Constant	-0.0333***	-0.638***	0.332***	0.363***	-0.517***	-0.741***
	(0.0106)	(0.0153)	(0.0269)	(0.0348)	(0.0700)	(0.1020)
Observations	77,302	69,125	77,302	69,125	77,302	69,125
R-squared	0.905	0.863	0.377	0.229		
Wald test					29904***	16440***
AR(1)					-23.57***	-27.33***
AR(2)					1.481	3.546***
AR(3)					-1.06	1.218
Hansen					76.13	106.1
Hansen p-value					0	0

Notes: 1. Robust standard errors in brackets. 2.***, **, and * indicate statistical significance at the 1%, 5%, and 10%, respectively.

Finally, since some of our key results depict the existence of a relative skill bias effect, the significance of the differences in the coefficients obtained for skilled and unskilled workers was tested (see Table 2.6). As can be seen, the relative skill-bias effects of both and expansionary climate and of technological advances (both domestic- and foreign-based) are strongly confirmed. In contrast, the relative skill bias impact of being an exporter is only weakly confirmed by the test.

Table 2.6: t -statistic for comparing coefficients of the two equations

Variable	t - value	Significance level (2 -tailed)
Output	t= -4.73	ρ= 0.001
Exporter	t= 8.84	ρ= 0.001

The second part of the results section turns to the alternative model I consider; one equation regression with the ratio of skilled to unskilled workers as the dependent variable. The table 2.7 reports the results obtained from the SYS-GMM regression.

The overall results assert the conclusions reached in the previous two-equation setting. Both output and net investment showed not to have a significant effect on the skill composition of firms' labor. Therefore, although output and investment can have overall labor augmenting effects, they do not play a significant role in the skill structure within this additional labor demand that they create.

In contrast, *R&D* activities, *patents*, and *exporting* activities all had positive and significant coefficients. Therefore, all these variables are causing an increase in the skill ratio, that is, higher levels of demand for skilled labor compared to unskilled. Firms that perform R&D activities tend to have a skill ratio that is 3.5 percentage points higher than firms who do not perform R&D, that is, having more skilled workers compared to unskilled. Firms that have foreign patents and licenses have skill ratios that are 12.6 percentage points greater than firms that do not have such forms of indirect technology transfers. Exporting firms witness a 3.8 percentage point increase in their skilled to unskilled ratio of labor, compared to firms that do not export. This confirms that firms involved in export activities are benefitting from the indirect technology transfer that this channel provides. The highest impact on skill ratio stems from the possession of patents, licenses and other similar know-how, indicating that such a direct contact with foreign firms is the one that leads to the highest increase in demand for skilled labor

Table 2.7: SYS-GMM with dependent variable "Skilled to Unskilled ratio"

VARIABLES	Skilled/Unskilled
Lagged Skilled/Unskilled	0.300***
	(0.0316)
Wage ratio	-0.423***
	(0.157)
Real output	0.00371
	(0.00711)
R&D dummy	0.0355***
	(0.00363)
Patent dummy	0.126***
	(0.0137)
Net investment	0.000684
	(0.00186)
Exporter dummy	0.0383***
	(0.00634)
Constant	0.835***
	(0.14200)
Observations	68,893
Wald test	2280***
AR(1)	-5.292***
AR(2)	1.074
Hansen	101.6
Hansen p-value	0.000

Notes: 1. Robust standard errors in brackets.
2.***, **, and * indicate statistical significance at the 1%, 5%, and 10%, respectively.

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The series of robustness tests shows that the model is performing well overall. The Wald test is highly significant. The Arellano bond test failed to reject the null hypothesis of no autocorrelation at t-2 instruments. The Hansen test rejected the hypothesis of adequate instruments was rejected; however, as mentioned earlier, this test tends to over-reject when the sample is large; therefore, its results are not reliable in our case of large sample with 68,893 observations.

Concluding remarks

This chapter has empirically explored the possible roles of trade and technology in affecting the skill-based employment gap within the Turkish manufacturing sector over the two decades of the '80s and '90s.

Since the results did not show any variables having negative and significant coefficients, one can conclude that both technology and trade have a positive contribution to the creation of employment, and there is no clear evidence for any job destruction phenomenon taking place. Therefore, no negative quantitative effects are detectable as a consequence of technological change and globalization.

However, both technology-related variables (R&D and patents) as well as the trade variable (exports) show strong evidence for skill bias. Both domestic and imported technologies increase the demand for skilled labor, while they do not have a statistically significant effect on unskilled labor, indicating an *absolute* skill bias effect. Export activities exhibit a *relative* skill bias effect, where they contribute to the increase in demand for both types of labor, but the demand for skilled labor is around 8 times more than that of unskilled labor. This evidence offers a strong support to the skill biased technological change hypothesis and points out the key role that the skill-enhancing-trade may play in shaping the demand for labor in a developing.

This evidence is further asserted when looking at the effect of technology and trade on the skill ratio within the employment forces of the Turkish manufacturing sector. The factors that lead to an increase in the ratio of skilled to unskilled workers are the R&D activities performed by the manufacturing enterprises, the patents and licenses that they have, and their export activities.

The fact that technology and globalization imply an obvious skill-bias calls for economic policies in DCs able to couple trade liberalization with education and training policies addressed to increase the supply of skilled labor.

ANNEX I: TECHNICAL NOTE ON EMPIRICAL WORK IN TURKEY

Adjusting the variables of the model

The original specification of the regression equations was set prior to actually seeing the data; therefore, some adjustments to the variables and their specifications was an inevitable. The following is a summary of the changes that were made to the original regression equations to reach the final specification of the model. The original set of equations was:

$$USL_{it} = \alpha + \beta USL_{it-1} + \delta USW_{it} + \gamma SAL_{it} + \eta R\&D + \mu INVD_{it} + \lambda INVI_{it} + \xi PAT + \pi SECT + (u_{it} + \varepsilon_i) \quad (8)$$

$$SL_{it} = \alpha + \beta SL_{it-1} + \delta SW_{it} + \gamma SAL_{it} + \eta R\&D + \mu INVD_{it} + \lambda INVI_{it} + \xi PAT + \pi SECT + (u_{it} + \varepsilon_i) \quad (9)$$

The dependent variables are USL_{it} and SL_{it} representing unskilled and skilled workers respectively in firm i at time t. USW and SW are the wages of each type of labor. *SAL* indicates the volume of sales of the firms. *R&D* is set as a dummy variables indicating the existence of R&D activities. *INVD* indicates investment in machinery and equipment purchased from the domestic market, while *INVI* represents investment in imported machinery and equipment. *PAT* is another dummy variable that looks at whether the firm has obtained royalties, patents, know-how or other rights to utilization of foreign technology.

Replacing Sales with Output

The "sales" variable was initially set as a proxy for the firms' manufacturing output. There were three sales variables in the data that could be used:

1. Sales of manufactured products
2. Sales of commercial products that firms purchase in order to sell

3. Sales of manufacturing products under subcontracting from other firms

However, the data contained an *output* variable defined as: sales adjusted by changes in output inventories. This variable was also used by Turkstat to calculate value added (value added = output - input). I tried the model with both variables, and the real value of the *output* variable proved more adequate and gave the most robust results, so it was the one that I adopted in the model.

Adjustments to the Investment variables

The original model specified two investment variables: (1) investment in machinery and equipment purchased from the domestic market, and (2) investment in imported machinery and equipment. The idea behind this differentiation in the origin of the investment was to distinguish between domestic and imported embodied technological change. However, after looking at the mentioned variables in the raw data, they proved to be inadequate for a number of reasons:

1. They included investment in machinery and transportation equipment.
2. The coverage and detail of these variables changes overtime due to changes in the questionnaire. For example, the variable for imported machinery was missing for some years
3. The signal - to -noise ratio decreases for detailed categories; therefore, it is better to aggregate the investment-related variables into one variable rather than split them into several variables.
4. In an attempt to distinguish between domestic and foreign machinery using another method, I tried to use real capital stock and foreign capital stock as proxies in the regression model. However, they gave results opposite to the ones I had expected because of measurement errors or because they were also considered together with transportation. In addition, since I am using R&D as a

dummy and not as a stock, it would not be quite strategic to use capital stocks. This is when I decided to abandon the distinction between domestic and foreign machinery.

After deciding to use only one investment variable, I had several options to choose from since I had several investment variables in the dataset.

1. Total investment in machinery, (without specifying if domestic or foreign).
2. Investment in software , both foreign and domestic. However this variable is available after 1995 and it does not seem to be of good quality since it has many missing values.
3. Total gross investment
4. Total net investment

After consulting with my supervising professors, we decided to make attempts with both gross and net total investment variables. Gross investment in principle should be more adequate since new technologies also come about through scrapping.

Adding an export dummy

After a more detailed review of the literature on the various channels for technology transfer to the developing countries, export orientation appeared as an important feature of the firm that would increase its chances of upgrading its technology and facing the phenomenon of SBTC. For this reason, I decided to look into the export variable available in the Turkish dataset. I used its a dummy variable that takes the value of 1 if the firm is export oriented and zero if it is not. In fact, the variable showed to be significant and so it was kept in the final specification of the regression model.

Regression methods

The main econometric methodology used is the GMM-SYS approach using the *xtabond2* Stata command; however, other regression methodologies were also applied in order to verify the accuracy of the present model and its robustness. In addition, trials with other variations of the GMM were used in order to test the validity of the model and to explore whether other GMM specifications give better results.

Running OLS and LSDV

The presence of a lagged dependent variable required running an OLS to determine the upper bound for the value of the coefficient obtained from the GMM-SYS. In the presence of firm specific effects and a dynamic specification, the OLS is known to result in upward biased estimates; therefore, the value obtained using OLS would serve as an upper bound for the value of the estimate obtained in GMM-SYS. Incorporating the fixed effects, the least square dummy variable (LSDV) method was also applied and gave very similar results. The OLS was reported in the paper and indeed the value of the coefficient of the endogenous variable in GMM-SYS is lower than that obtained in OLS.

Running Fixed Effects model

In the presence of an endogenous variable, namely the lagged dependent variable in this case, applying the fixed effects methodology leads to downward biased results. Therefore, the FE method was applied to provide a lower bound for the value of the estimated coefficient of GMM-SYS. Due to the presence of the endogenous variable, the *xtivreg* command was used in Stata to apply the FE model. The results of this estimation are presented in the paper and they show that the value of the GMM-SYS estimate for the endogenous variable are higher than that of the FE.

The GMM-DIFF model

The GMM-DIFF model developed by Arellano and Bond (1991) was also applied. It forms an efficiency improvement to the Fixed effects - instrumental variable model of Anderson and Hsiao (1982), but it is weak in cases where there is time-persistence in the time series. In the present case, a test for time-persistence showed that the dependent variables are significantly correlated with their lagged values; however, as shown in the table below the values for the production workers' equation was higher than that of the administrative workers. Therefore, to check if time persistence really poses an issue or not, I ran the GMM-DIFF to check if it will give better results.

Annex table 1: OLS for testing time persistence

	Skilled	**Unskilled**
AR(1)	0.550***	0.979***
	(0.00135)	(0.00058)

The results from this regression are not reported in the paper because they did not give significantly better results than the GMM-SYS indicating that time persistence did indeed play a role in the model and using GMM-SYS is more appropriate.

The two-step GMM-SYS

The literature sometimes uses a two-step GMM regression rather than a one-step estimation. The two-step estimation leads to asymptotically more efficient standard errors than the one-step estimation. This procedure is applicable in cases of samples larger than 1,000 observations. Usually, it is accompanied by a Windmeijer correction for the small-sample variance (Windmeijer, 2000), which eliminates the possible downward bias. Since the sample used in this paper is rather large, this correction was not included in the estimation process. The *robust* option was also not used in this case because the sample is large enough. The results of this estimation are also reported in the paper.

Diagnostic tests

Several tests had to be performed in order to verify the significance of the results, their robustness, and their reliability.

The Wald test

The Wald test was run to test for the overall significance of the independent variables . It is distributed as a $\chi 2$ where the degrees of freedom equate the number of restricted coefficients. It always rejects the null hypothesis of insignificant coefficients. The results of this test affirmed the robustness of the results since the variables were jointly significant in all the cases.

The Sargan and Hansen tests

The Sargan test of overidentifying restrictions was performed. This test is used to verify the overall validity of the GMM instruments where the null hypothesis suggests that the instruments are uncorrelated with some set of residuals. In the set of regressions that I performed the null hypothesis was rejected; however, after some research on the nature of this test and the reliability of its results, I concluded that the failure of this test was not something to be overly concerned with.

1. As Roodman (2006) suggests, the Sargan tests "*should not be relied upon too faithfully, as it is prone to weakness*" (Roodman, 2006: 12). He further explains that intuitively speaking, when GMM is applied, the aim is to drive the vector of empirical moments close to zero, and then the Sargan tests whether it is close to zero. *"Counter-intuitively, however, the test actually grows weaker the more moment conditions there are and, seemingly, the harder it should be to come close to satisfying them all"* (Roodman, 2006: 13).
2. Blundell and Bond (2000) observe in their Monte Carlo experiments "some tendency for this test statistic to reject a valid null hypothesis too often" and that

"this tendency is greater at higher values of the autoregressive parameter"(Blundell and Bond, 2000: 329)

3. A very large number of observations increases the likelihood of obtaining a significant Sargan. I confirmed this observation by testing it with a random subsample of the dataset (20%). Indeed the Sargan ceased to be significant in the cases where I used the subsample and I increased the laglimits of the lagged dependent variable to (4 5) laglimits.

The Hansen test is another test for testing the validity of the GMM instruments. It is actually the one reported in the paper because it tends to replace the Sargan test. Conte and Vivarelli (2011) rely on the Hansen test because the Sargan statistic in both one-step GMM robust estimation and two-step GMM estimation is not robust to either heteroskedasticity or autocorrelation.

This test also failed when applied to the large sample and ceased to be significant when a random subsample of 20% of the original dataset was used.

The AR test

The Arellano - Bond (AR) test was performed to test for autocorrelation. It is a Lagrange multiplier based test which is applied to the residuals of the first-difference question in order to drop the time-invariant fixed effect (Arellano and Bond, 1991). This test has a normal distribution under the null hypothesis of no autocorrelation. It provides strong evidence of AR(1) in first differences because of the autocorrelation between the first differences of the errors Δu_{it} and Δu_{it-1} due to the common termu_{it}. The absence of AR(2) supports the consistency of the GMM estimator.

In my regression, AR(1) was indeed significant; however, AR(2) was also significant. I solved this problem by using older instruments. When I used t-3 rather than t-2 instruments the AR(3) failed to be significant.

Trials and Combinations with Variables

After discussing all the steps pertaining to the choice of variables, the regression techniques and the diagnostic tests, this section presents the results of the several attempts and trials made to reach the final model presented in the paper. The dependents variables are: *lprod* , the log-transformed number of production workers, and *ladmin*, the log-transformed number of administrative workers. The aim of these regressions was to determine the best investment variable to use and whether to include the export dummy or not.

Annex table 2: Using net investment and no export dummy

	NET INVESTMENT											
	OLS		LSDV		FE		SYS GMM		DIFF GMM		2-STEP GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	lprod	ladmin	lprod	Ladmin	Lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin
Constant	-0.0382***	-0.650***	-0.01260	-0.664***	0.329***	0.351***	-0.0465**	-1.045***			-0.0540**	-2.159***
	(0.0105)	(0.0151)	(0.0121)	(0.0156)	(0.0269)	(0.0348)	(0.0232)	(0.0826)			(0.02190)	(0.0812)
Lagged lprod	0.850***		0.851***		0.402***		0.722***		0.393***		0.721***	
	(0.00163)		(0.00163)		(0.00322)		(0.02140)		(0.02870)		(0.01830)	
Real wage prod	-0.0942***		-0.0977***		-0.131***		-0.138***		-0.162***		-0.137***	
	(0.00233)		(0.00254)		(0.00346)		(0.00503)		(0.00748)		(0.00495)	
Lagged ladmin		0.719***		0.719***		0.263***		0.561***		0.260***		0.377***
		(0.0021)		(0.0021)		(0.0033)		(0.0237)		(0.0201)		(0.0208)
Real wage admin		-0.0712***		-0.0700***		-0.178***		-0.109***		-0.205***		0.145***
		(0.0024)		(0.0026)		(0.0033)		(0.0054)		(0.0060)		(0.0116)
Real output	0.0889***	0.146***	0.0887***	0.146***	0.222***	0.188***	0.153***	0.230***	0.181***	0.119***	0.154***	0.272***
	(0.00112)	(0.0016)	(0.00112)	(0.0016)	(0.00232)	(0.0031)	(0.00889)	(0.0109)	(0.00510)	(0.0059)	(0.00767)	(0.0094)
R&D dummy	0.00563*	0.0638***	0.00614*	0.0636***	0.0123***	0.0257***	0.0123***	0.0663***	0.00851*	0.0171***	0.0117***	0.0734***
	(0.00335)	(0.0046)	(0.00333)	(0.0046)	(0.00373)	(0.0049)	(0.00417)	(0.0064)	(0.00451)	(0.0063)	(0.00414)	(0.0067)
Patents	0.00704	0.134***	0.01030	0.133***	0.01930	0.0376**	0.0404***	0.220***	0.02630	0.0033	0.0432***	0.219***
	(0.00826)	(0.0110)	(0.00821)	(0.0110)	(0.01370)	(0.0176)	(0.01400)	(0.0200)	(0.02210)	(0.0275)	(0.01380)	(0.0241)
Net investment	0.00774***	0.0107***	0.00740***	0.0106***	0.00441***	0.00708***	0.00645***	0.0107***	0.00224***	0.00398***	0.00640***	0.0111***
	(0.00032)	(0.0004)	(0.00032)	(0.0004)	(0.00039)	(0.0005)	(0.00048)	(0.0007)	(0.00051)	(0.0007)	(0.00046)	(0.0007)
year dummies			*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	77,302	69,125	77,302	69,125	77,302	69,125	77,302	69,125	59,359	51,985	77,302	68,932
Number of firms					16,115	14,743	16,115	14,743	13,221		16,115	
R-squared	0.905	0.863	0.907	0.863	0.377	0.228						
Wald test (time							1142.98***	55.43***	1334.45***	396.89***	1215.54***	404.07***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wald test (overall)							142761***	78810***	3504***	1978***	144966***	46505***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(1)							-24.69***	-23.46***	-15.93***	-18.48***	-26.24***	-25.35***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(2)							2.326***	5.074***	0.40	1.971**	2.359**	2.905***
							(0.0200)	(0.0000)	(0.6920)	(0.0487)	(0.0183)	(0.0036)
Hansen							109***	47.67***	13.43	25.88**	109***	36.68***
							(0.000)	(0.000)	(0.339)	(0.011)	(0.000)	(0.0087)

Annex table 3: Using net investment with export dummy

	NET INVESTMENT + EXPORT DUMMY											
	OLS		LSDV		FE		SYS GMM		DIFF GMM		2-STEP GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin
Constant	-0.0551***	-0.659***	-0.0915***	-0.660***	1.044***	1.261***	-0.104***	-0.676***			-0.0799***	-2.349***
	(0.0162)	(0.0231)	(0.0163)	(0.0234)	(0.0454)	(0.0583)	(0.0285)	(0.1240)			(0.0265)	(0.1810)
Lagged lprod	0.841***		0.842***		0.202***		0.788***		0.399***		0.827***	
	(0.0023)		(0.0023)		(0.0054)		(0.0252)		(0.0413)		(0.0219)	
Real wage prod	-0.0942***		-0.0964***		-0.159***		-0.136***		-0.186***		-0.134***	
	(0.0035)		(0.0035)		(0.0054)		(0.0062)		(0.0102)		(0.0061)	
Lagged ladmin		0.710***		0.710***		0.0715***		0.660***		0.275***		0.359***
		(0.0029)		(0.0029)		(0.0052)		(0.0336)		(0.0290)		(0.0456)
Real wage admin		-0.0701***		-0.0713***		-0.191***		-0.120***		-0.215***		0.132***
		(0.0037)		(0.0037)		(0.0050)		(0.0075)		(0.0096)		(0.0164)
Real output	0.0922***	0.147***	0.0921***	0.147***	0.227***	0.155***	0.127***	0.181***	0.197***	0.117***	0.111***	0.280***
	(0.0016)	(0.0023)	(0.0016)	(0.0023)	(0.0037)	(0.0051)	(0.0105)	(0.0154)	(0.0077)	(0.0084)	(0.0092)	(0.0203)
R&D dummy	0.00999**	0.0654***	0.0077	0.0651***	0.0200***	0.0143*	0.0134**	0.0520***	0.0148**	0.0053	0.0117**	0.0732***
	(0.0048)	(0.0067)	(0.0047)	(0.0067)	(0.0056)	(0.0074)	(0.0058)	(0.0094)	(0.0068)	(0.0099)	(0.0058)	(0.0101)
Patent	-0.0023	0.143***	0.0012	0.144***	0.0458*	0.0706**	0.0085	0.193***	0.0090	0.0409	0.0009	0.256***
	(0.012)	(0.016)	(0.012)	(0.0160)	(0.0266)	(0.0339)	(0.0149)	(0.0244)	(0.0331)	(0.0450)	(0.0147)	(0.0347)
Net invetsment	0.00721***	0.0109***	0.00706***	0.0109***	0.00439***	0.00468***	0.00606***	0.00955***	0.00321***	0.00281**	0.00579***	0.0119***
	(0.0005)	(0.0007)	(0.0005)	(0.0007)	(0.0006)	(0.0008)	(0.0006)	(0.0010)	(0.0008)	(0.0012)	(0.0006)	(0.0011)
Export dummy	0.0121***	0.0227***	0.0156***	0.0227***	0.00943*	0.0204***	0.0143***	0.0262***	0.0054	0.0149*	0.0105**	0.0432***
	(0.0037)	(0.0052)	(0.0037)	(0.0052)	(0.0048)	(0.0064)	(0.0055)	(0.0067)	(0.0061)	(0.0081)	(0.0053)	(0.0074)
year dummies			*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
R-squared	0.91	0.86	0.91	0.86	0.22	0.10						
Wald test (time							498.46***	35.34***	580.38***	82.25***	536.79***	85.01***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wald test							127370***	76628***	1098***	673.5***	128945***	35995***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(1)							-20.14***	-17.31***	-12.06***	-13.45***	-21.55***	-13.36***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(2)							3.031***	3.666***	1.865*	1.55	3.064***	2.258**
							(0.0024)	(0.0002)	(0.0622)	(0.122)	(0.0022)	(0.024)
Hansen							39.57***	12.02	9.264*	7.13	39.57***	14.10
							(0.0001)	(0.444)	(0.099)	(0.211)	(0.0001)	(0.294)

Annex table 4: Using gross investment with no export dummy

	GROSS INVESTMENT											
	OLS		**LSDV**		**FE**		**SYS GMM**		**DIFF GMM**		**2-STEP GMM**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin
Constant	-0.0401***	-0.651***	(0.0146)	-0.667***	0.296***	0.325***	-0.112***	-1.115***			-0.122***	-2.313***
	(0.0104)	(0.0150)	(0.0120)	(0.0154)	(0.0265)	(0.0342)	(0.0238)	(0.0808)			(0.0219)	(0.0817)
Lagged lprod	0.849***		0.850***		0.404***		0.714***		0.407***		0.709***	
	(0.0016)		(0.0016)		(0.0032)		(0.0210)		(0.0274)		(0.0180)	
Real wage lprod	-0.0939***		-0.0972***		-0.130***		-0.139***		-0.162***		-0.138***	
	(0.0023)		(0.0025)		(0.0034)		(0.0050)		(0.0074)		(0.0049)	
Lagged ladmin		0.719***		0.719***		0.265***		0.535***		0.288***		0.356***
		(0.0020)		(0.0021)		(0.0033)		(0.0226)		(0.0196)		(0.0199)
Real wage ladmin		- 0.0716***		-0.0704***		-0.178***		-0.107***		-0.207***		0.153***
		(0.0024)		(0.0026)		(0.0032)		(0.0053)		(0.0060)		(0.0116)
Real output	0.0890***	0.147***	0.0886***	0.146***	0.224***	0.190***	0.157***	0.242***	0.184***	0.120***	0.159***	0.280***
	(0.0011)	(0.0016)	(0.0011)	(0.0016)	(0.0023)	(0.0030)	(0.0088)	(0.0105)	(0.0050)	(0.0058)	(0.0076)	(0.0090)
R&D dummy	0.00557*	0.0629***	0.00601*	0.0627***	0.0112***	0.0242***	0.0118***	0.0679***	0.00753*	0.0163***	0.0114***	0.0745***
	(0.0033)	(0.0045)	(0.0033)	(0.0045)	(0.0037)	(0.0049)	(0.0042)	(0.0063)	(0.0045)	(0.0063)	(0.0041)	(0.0067)
Patent	0.0058	0.133***	0.0089	0.132***	0.0149	0.0357**	0.0408***	0.230***	0.0248	-0.000997	0.0453***	0.222***
	(0.0082)	(0.0109)	(0.0081)	(0.0109)	(0.0136)	(0.0173)	(0.0142)	(0.0200)	(0.0220)	(0.0276)	(0.0140)	(0.0244)
Gross investment	0.00763***	0.0107***	0.00729***	0.0106***	0.00439***	0.00703***	0.00641***	0.0110***	0.00219***	0.00409***	0.00632***	0.0112***
	(0.0003)	(0.0004)	(0.0003)	(0.0004)	(0.0004)	(0.0005)	(0.0005)	(0.0007)	(0.0005)	(0.0007)	(0.0005)	(0.0007)
year dummies			*yes*	*yes*	*yes*	*yes*	yes	yes	yes	yes	yes	yes
Observations	78,944	70,685	78,944	70,685	78,944	70,685	78,944	70,685	61,598	54,090	78,944	70,484
Wald time dummies							1204.25***	60.44***	1452.21***	412.93***	1283.19***	430.9***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wald test (overall)							136351***	72444***	3738***	2003***	138718***	44087***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(1)							-24.69***	-24.34***	-16.66***	-19.58***	-26.35***	-25.98***
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(2)							2.197**	5.03***	0.323	2.502**	2.224**	2.613***
							(0.028)	(0.000)	(0.747)	(0.0124)	(0.0261)	(0.009)
Hansen							142.5***	60.7***	17.93	26.13***	142.5***	40.39***
							(0.000)	(0.000)	(0.118)	(0.0103)	(0.000)	(0.003)

Annex table 05: Using gross investment and export dummy

	GROSS INVESTMENT + EXPORT DUMMY											
	OLS		LSDV		FE		SYS GMM		DIFF GMM		2-STEP GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin	lprod	ladmin
Constant	-0.0628***	-0.664***	-0.0310*	-0.665***	1.093***	1.224***	-0.110***	-0.691***			-0.0876***	-2.452***
	(0.01610)	(0.02290)	(0.01670)	(0.02310)	(0.04510)	(0.05740)	(0.02830)	(0.11800)			(0.02640)	(0.17300)
Lagged lprod	0.840***		0.841***		0.205***		0.790***		0.416***		0.827***	
	(0.00226)		(0.00225)		(0.00533)		(0.02480)		(0.03930)		(0.02160)	
Real wage lprod	-0.0934***		-0.0955***		-0.159***		-0.136***		-0.188***		-0.134***	
	(0.00345)		(0.00351)		(0.00535)		(0.00610)		(0.01010)		(0.00603)	
Lagged ladmin		0.709***		0.709***		0.0719***		0.654***		0.303***		0.319***
		(0.00288)		(0.00289)		(0.00509)		(0.03210)		(0.02830)		(0.04390)
Real wage ladmin		-0.0703***		-0.0714***		-0.192***		-0.121***		-0.217***		0.146***
		(0.00361)		(0.00365)		(0.00490)		(0.00730)		(0.00958)		(0.01640)
Real output	0.0928***	0.148***	0.0927***	0.148***	0.230***	0.159***	0.126***	0.184***	0.200***	0.120***	0.111***	0.297***
	(0.00160)	(0.00230)	(0.00159)	(0.00231)	(0.00367)	(0.00497)	(0.01040)	(0.01480)	(0.00760)	(0.00836)	(0.00907)	(0.01960)
R&D dummy	0.00994**	0.0641***	0.00767	0.0639***	0.0199***	0.0127*	0.0129**	0.0507***	0.0145**	0.00294	0.0114**	0.0757***
	(0.00472)	(0.00663)	(0.00470)	(0.00663)	(0.00554)	(0.00734)	(0.00578)	(0.00926)	(0.00673)	(0.00983)	(0.00577)	(0.01010)
Patent	(0.00792)	0.144***	(0.00462)	0.145***	0.03950	0.0586*	0.00250	0.195***	0.00191	0.02960	-0.00523	0.271***
	(0.01150)	(0.01580)	(0.01150)	(0.01580)	(0.02640)	(0.03360)	(0.01500)	(0.02390)	(0.03340)	(0.04540)	(0.01480)	(0.03490)
Gross investment	0.00709***	0.0109***	0.00695***	0.0109***	0.00437***	0.00493***	0.00596***	0.00977***	0.00325***	0.00307***	0.00572***	0.0124***
	(0.00045)	(0.00064)	(0.00045)	(0.00064)	(0.00060)	(0.00081)	(0.00061)	(0.00096)	(0.00078)	(0.00117)	(0.00060)	(0.00112)
Export dummy	0.0113***	0.0223***	0.0147***	0.0223***	0.00983**	0.0202***	0.0137**	0.0262***	0.00642	0.0146*	0.00998*	0.0448***
	(0.00365)	(0.00510)	(0.00364)	(0.00511)	(0.00478)	(0.00631)	(0.00546)	(0.00655)	(0.00610)	(0.00803)	(0.00528)	(0.00735)
Observations	39,542	35,001	39,542	35,001	39,542	35,001	39,542	35,001	26,416	22,758	39,542	34,909
Wald time dummies							526.25***	39***	671.4***	109.75***	571.81***	104.77***
							(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald test (overall)							126925***	76623***	1369***	711.1***	128795***	33586***
							(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AR(1)							-20.05***	-17.88***	-12.58***	-14.25***	-21.43***	-13.41***
							(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AR(2)							3.048***	3.891***	1.78*	2.089**	3.083***	1.945*
							(0.0023)	(0.0001)	(0.0751)	(0.0368)	(0.00205)	(0.0517)
Hansen							45.24***	14.27	11.21**	7.153	45.24***	16
							(0.00001)	(0.2849)	(0.0474)	(0.21)	(0.00001)	(0.191)

Looking at tables 2 and 4, I decided to use the net investment variable since it gave slightly better results in terms of the differences between the coefficients of the production workers' equation and administrative workers' equation. The next step was to test the performance of the model through the various diagnostic tests discussed above. The AR test was performed using more lags and it failed to be significant on the third lag as the table below shows.

Annex table 6: AR tests of investment + export dummy model

AR test	Prod	Admin
AR (1)	-22.33***	-21.65***
	(0.000)	(0.000)
AR(2)	2.302***	4.975***
	(0.021)	(0.000)
AR(3)	-0.224	1.536
	(0.823)	(0.124)

The Hansen test, although it remained to fail, it was not worrisome since I had established that it is due to the large sample since it stopped being significant when I ran it with only 20% of the sample. In fact, the GMM-SYS results of the admin equation fail to reject the Hansen test even with the large sample.

CHAPTER 3

CHAPTER 3: THE CASE OF ETHIOPIA

The purpose of this chapter is to look at the impact of technology transfers on employment and skills within the context of a low-income country. As presented in chapter one, a large amount of literature has studied the effect of technological progress on employment in developed countries, the leaders in technological innovation. Developing countries, viewed as followers in terms of technology and innovation, have also had a significant share of studies where focus has been mainly on the effect of technology transfers on employment and skill distribution. However, little research has looked into the impact of technology on labor in the least developed countries (LDCs) that have liberalized their trade and have opened their economies to direct technological imports or embodied technological transfers.

Technological development is very low in LDCs, and most of them rank lowest according to various international technology and innovation indices such as the Technological Achievement Index, and the Innovation Capability Index (UNCTAD, 2007). However, as many of these countries have adopted trade liberalization policies over the past 20 years, they face a major challenge in how to increase the knowledge and technology intensity of their economies in order to be able to compete in national and international markets. In a study on technology transfer and skill accumulation in LDCs, Mayer (2000) shows that, overall, technological integration of LDCs has increased, though the disparities between the different countries are quite significant. However, he argues that LDCs need human capital to absorb and integrate the improved access to technology, as well as adequate economic policies and supporting institutions that encourage the amounts and types of modern technology that LDCs can import.

Against this background, this chapter takes the case of the Ethiopian manufacturing sector for the period 1996 - 2004. Ethiopia is one of the least developed countries in the world today. In 1991 it adopted a national structural adjustment program and moved away from an import-substitution strategy adopting an open trade system. Therefore, it provides a suitable setting for studying the effect of trade openness on employment and to test the hypothesis of a possible diffusion of the skill bias among the LDCs.

The empirical tests put forward in this chapter will investigate the roles of the different channels through which trade openness and technology transfer can affect the quantitative and qualitative employment evolution in an LDC such as Ethiopia. This will be done using firm level micro-data analyzed through the lens of a dynamic demand for labor extended to take into account technology, trade and FDI.

The rest of the chapter is organized into 4 sections. Section 3.1 presents the data used in the empirical analysis. Section 3.2 sheds light on the process of trade liberalization in Ethiopia and presents some descriptive evidence on the manufacturing sector and its employment evolution. In section 3.3 I specify the econometric model for the first regression analysis using total employment as the dependent variable, and I discuss the results obtained. In section 3.4 I extend the econometric analysis to test for the presence of skill bias within the Ethiopian manufacturing sector and I present the results. Finally, several concluding remarks are discussed.

3.1. The data

This chapter relies on data from the Ethiopian "Annual Survey of Manufacturing Industry" conducted by the Central Statistical Authority of Ethiopia. The survey covers 1,940 enterprises, and has a total of 7,050 observations for the period between 1996 and 2004. It includes formal private and public enterprises employing at least 10 employees. The enterprises are classified according to the "International Standard Classification", ISIC Rev.3. Table 3.1 presents the distribution of both public and private firms across the various sectors within the manufacturing industry (two-digit ISIC).

Table 3.1: Distribution of public and private firms by sector

Industry	Private sector	Public sector
Food products and beverages	28.1%	31.4%
Tobacco products	0.0%	0.4%
Textiles	2.4%	12.8%
Wearing apparel; dressing and dyeing of fur	3.6%	3.2%
Tanning and dressing of leather	7.5%	5.5%
Wood and of products of wood and cork	1.6%	6.4%
Paper and paper products	0.7%	1.3%
Publishing, printing and reproduction of recorded media	7.0%	5.1%
Chemicals and chemical products	4.6%	7.6%
Rubber and plastics products	4.0%	2.4%
Other non-metallic mineral products	11.4%	12.4%
Basic metals	0.8%	2.1%
Fabricated metal products, except machinery and equipment	7.2%	3.4%
Machinery and equipment n.e.c.	1.8%	0.2%
Electrical machinery and apparatus n.e.c.	0.1%	0.3%
Motor vehicles, trailers and semi-trailers	1.0%	0.8%
Furniture	18.1%	4.5%
	100.0%	100.0%

Source: Author's calculations from the Annual Survey of Manufacturing Industry

The final sample used in the empirical analysis comprises only private sector firms that have reported to employing both production and administration workers. Firms that were not monitored for at least two consecutive years were also excluded from the final sample, since the main regression methodology relies on lagged values of the regressors for identification purposes[11].

The dataset contains a wide range of information about the enterprises generated from the 8-section survey questionnaire. Information on the type of activity of the enterprises, their employees and wages, inputs and output volumes, investments and

[11] This sample selection criterion has led to a reduction in the final sample size vis-à-vis other studies that have used this dataset, namely, Bigsten *et al.* (2009), and Bigsten and Gebreyeesus (2007).

license fees, and the major problems they face, are included in the dataset. All monetary variables are expressed in 1996 Birr, the Ethiopian currency, and have been deflated using GDP and CPI deflators as appropriate. Employment is measured as the number of workers in each quarter of the Ethiopian year. Total employment was therefore calculated as the annual average of these quarters. Employment is also divided into two categories, "administrative and technical employees" and "production workers". The former is defined as the salaried directors and managers, technicians, superintendents, research workers, draftsmen and designers, engineers, chemists, architects, accountants, book-keepers, office machine operators, receptionists, sales men, delivery personnel, guards and other office staff. As for the production workers, they include workers directly engaged in production, i.e. persons engaged in fabricating, processing, assembling, maintenance, repair, janitorial, record keeping and other associated activities.

3.2. Trade reform and manufacturing in Ethiopia

This section provides background information on the history of trade liberalization in Ethiopia and the main characteristics of its manufacturing sector, which are quite intertwined with the nature of economic policies that have been placed by the various regimes that governed the country. The history of economic policy in Ethiopia can be analyzed in three phases: 1950–74 (the Imperial era), 1974–91 (the Derg era) and the period since 1992 (the post-Derg era).

3.2.1. Trade liberalization in Ethiopia

Ethiopia's economy followed an import-substitution strategy based on private ownership under the Imperial government. Foreign capital played a major role in the process of industrialization during the 1950's up till the 1970's; foreign private (full or majority) ownership reached 52% by 1974 with a total of 143 firms (Shiferaw, 2005). In

1950 the country witnessed its first economic development program, part of which was an attempt to boost industrialization. In this respect, the government introduced a scheme aimed at inducing foreign investment, technology, skills and management in the manufacturing sector. However, as most manufacturing was owned by private foreign nationals, small local enterprises did not benefit from this reform scheme until it was further changed in the 1960's. The changes included assisting local SMEs in both manufacturing and non-manufacturing sectors, where the government provided generous tax incentives, high levels of tariff protection, and easy access to domestic credit for domestic production. Nonetheless, the overall role of the Imperial government can be described as a facilitating rather than a managing role.

The year 1974 marked the end of the monarchy era through a coup d'état, which led to the establishment of a military council called the Derg (Dergue) that adopted Socialist ideology. The regime continued to operate within the import-substitution strategy. The Derg nationalized all large and medium private manufacturing enterprises, thus putting a halt to the earlier private enterprise development initiatives and schemes for attracting foreign investments. The management of the nationalized enterprises was assigned to a small number of corporations that controlled prices and output quantities. Industrialization took place mainly through high tariffs, and the establishment of a few large enterprises that controlled factor markets and allowed state owned enterprises to gain preferential access to credit, foreign exchange and skilled labor. This came in parallel with a weakening of private manufacturing and restricting private investment. According to official numbers from the Central Agency of Statistics (1990), the contribution of the private sector to production and employment in medium and large scale manufacturing in 1988/89 was no more than 4% and 8% respectively.

At the end of the 1980's, Ethiopia began to gradually move away from the communist-inspired controlled economy to a more market-oriented economy. With the new

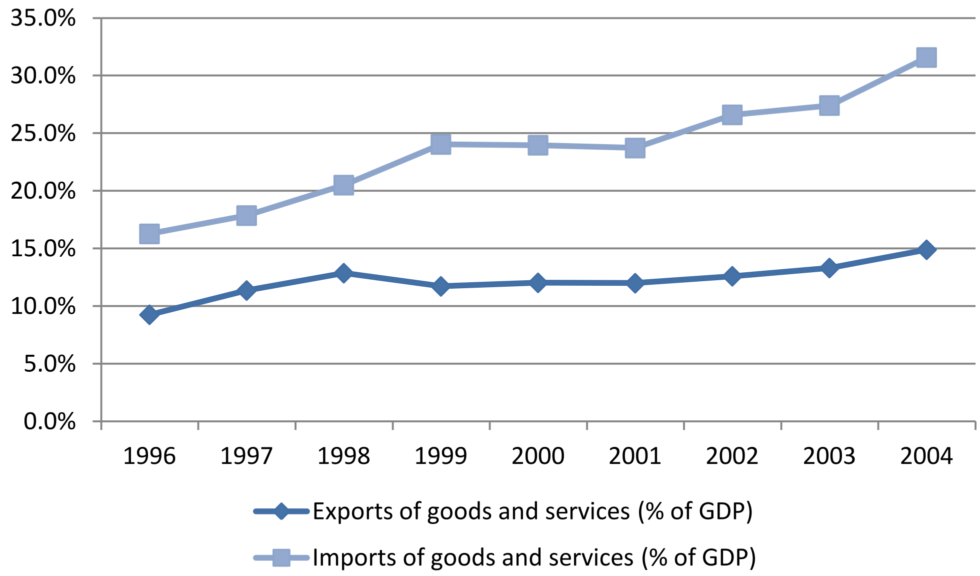
Transitional Government of Ethiopia (TGE) coming to power in 1991, the country's economic structure underwent major transformations vis-à-vis the preceding Derg era. Among the stated objectives of the new government were, reducing macroeconomic imbalances, eliminating structural distortion, improving the country's human capital and infrastructure as well as poverty reduction. The TGE undertook policy reform steps including privatization, trade opening and market deregulation. In 1992 a new investment law was issued (and had subsequent revisions and improvements), which can be best described as part of a new industrial policy for the country. The new policy aimed at increasing private sector participation by allowing entry into sectors that were previously reserved for the state sector. It removed caps on private investment, and provided a number of incentives such as tax holidays for investors within initial capital above a certain threshold. Additionally, the reform policy included the public enterprises reform act (1992) which aimed at instituting managerial autonomy and financial responsibility for public enterprises, thus putting them at par with private sector enterprises.

In June 1993, the government launched a structural adjustment program under the auspices of the World Bank and the African Development Fund. A comprehensive trade reform was set up that aimed at dismantling quantitative restrictions and gradually reducing the levels of import tariffs and export taxes, as well as non-tariff barriers and import licensing requirements. Export promotion schemes were introduced. Custom tariffs were substantially reduced through a six-stage reform implemented between 1993 and 2003. In the first round, the maximum tariff was reduced from 230% to 80%. The next rounds led to a further gradual reduction that reached 35% in 2003 (Bigsten *et al*, 2009). In 2001 the Export Trade Duty Incentive Scheme was established. It included duty draw-backs, vouchers, and bonded manufacturing warehouses, where exporters were refunded 100% of any duty paid on raw materials. To further encourage exporters to acquire foreign technology and expertise, the government also issued directives in 2004 to reduce taxes and other costs on salaries paid to foreign experts (Bigsten and Gebreeyesus, 2007).[12] Even though the post 1991 period witnessed significant economic liberalization, it is important to emphasize that the State has still played a prominent role in the Ethiopian economy over the same period. Land remains public property in Ethiopia; and the State still controls some key sectors of the economy such as telecommunication and IT fully, while it plays a dominant role in other sectors such as banking, insurance and transportation. The prevailing development strategy is also spearheaded by the State. Indeed, the growth performance witnessed in recent years is also driven by extensive public sector investments, particularly in the energy and road transport sectors (see World Bank 2013a and 2013b; IMF 2013).

Figure 3.1 below shows the GDP share of both exports and imports, which have increased as a result of the changes in the country's trade policy. Exports increased from 9.3% of GDP in 1996 to 14.9% in 2004, an increase of around 60%. Imports increased from 16.3% in 1993 to 31.6%, a much a larger increase of 94%, hence the gap between exports and imports is increasing. It is worth noting in this respect that ICT imports' share of total imports has been increasing rapidly, where ICT imports formed 5% of all good imports in 2000 and increased to around 9% in 2004, indicating an increasing demand for high technology communication and computing systems that possibly reflect an upgrading in the production and/or management processes in the various economic sectors in Ethiopia.

[12] It is important to note that the State still plays a major role in post-Derg Ethiopia controlling most economic activities in key sectors such as transportation, communication and IT. Land is also owned by the State and the prevailing developmental paradigm is one of 'Developmental State' led (see World Bank (2013a) and recent Economist commentaries such as http://www.economist.com/news/middle-east-and-africa/21584037-government-expands-mobile-phone-network-tightens-its-grip-out-reach (accessed 31.10.2013)

Figure 3.1: Ethiopia's exports and imports of goods and services as percentage of GDP

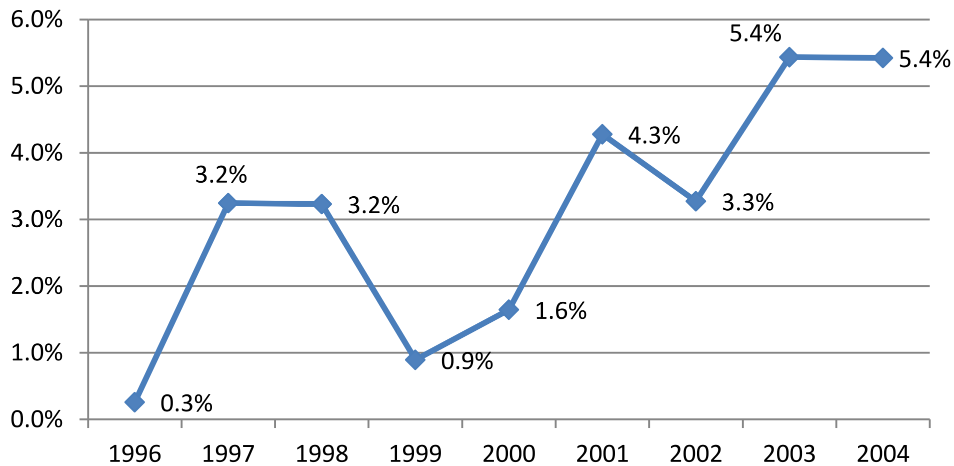


Source: World Development Indicators (WDI) - 2013

Trade liberalization had a major impact on the investment climate in the country, especially FDI. The problems of political instability, and the nationalization of major industries during the Derg era severely discouraged foreign private investment. The government attempted to stimulate FDI through the Joint Venture Proclamation in 1983, which offered a number of incentives such, as a five-year period of income tax relief, import and export duty relief, tariff protection and repatriation of profits and capital. Nonetheless, the proclamation did not succeed in achieving its objectives. In 1989, the government revised the 1983 proclamation by allowing majority foreign ownership in many sectors. It also sought to provide further protection to investors. However, the political instability and the prolonged civil war at the time further discouraged FDI. The political instability got worse and it consequently led to the overthrow of the regime in 1991.

FDI has started to play some role in the country following the 1992 liberalization program, although domestic investments still constitute about 64% of total investment in Ethiopia, (Haile and Assefa, 2006) thus forming the main component of capital formation in the country. The reforms as well as the introduction of investment guarantee schemes helped raise the share of FDI inflows as presented in Figure 3.2 below. There was a drop in these inflows between 1998 and 2000 as a result of the Eritrean - Ethiopian war, but they increased rapidly after the end of the conflict and peaked in 2003-2004 at around $550million[13]. Of the FDI projects licensed by 2003, 46.6% were in manufacturing and processing; 40.7% in trade, hotels and tourism; and 12.7% in agriculture and mining (UNCTAD, 2004).

Figure 3.2: FDI inflows as percentage of GDP (1996 - 2004)



Source: World Development Indicators (WDI) - 2013

According to Ethiopian Investment and Innovation Policy Review (UNCTAD, 2002), the Middle-East accounted for the largest share of the post-1992 FDI projects in the country. This was followed by the European Union as the second largest source of FDI to Ethiopia over the period 1992 to1998. Trade liberalization was also accompanied by financial market liberalization and a large devaluation of the Birr by 141.55 percent, from 2.07 birr per dollar to 5 birr per dollar. Since then, the exchange rate has been increasingly market driven. Most price controls and restrictions on private investments have also been lifted and a large wage of privatization took place. The privatization program was initiated in 1994 as an attempt to increase the role of the private sector in

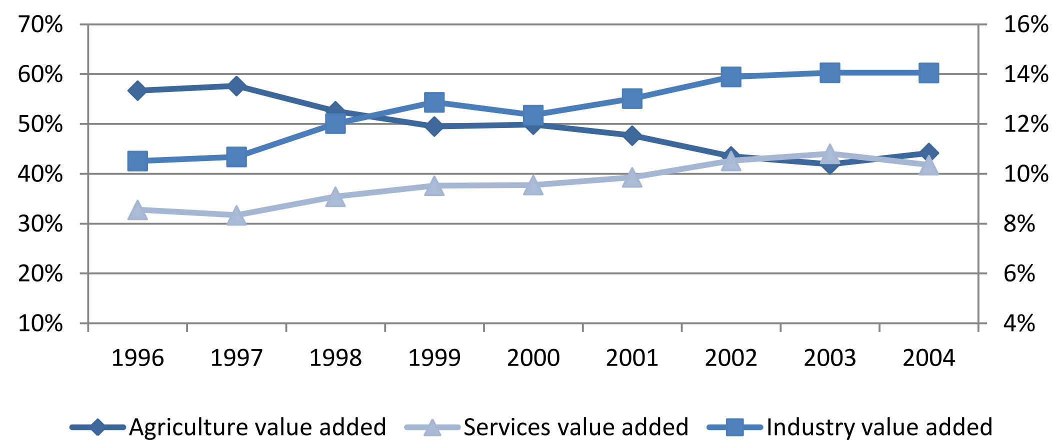
[13] Figure from UNCTAD stat

the economy. The Ethiopian Privatization Agency (EPA) which has the power and duties of transferring state-owned enterprises to private ownership was established. Up till 2003, the government had privatized 200 enterprises to domestic and foreign investors (AFDB, 2003).

3.2.2. The Ethiopian manufacturing sector: size and employment

Ethiopia's industrial base remains to be quite small compared to other developing countries, as well as with respect to other national economic sectors. The GDP share of the industrial sector increased from 10.7 % in 1996 to 14.1 % in 2004 as Figure 3.4 below depicts, which however is still much lower than sub-Saharan African average of 31.8 % (Bigsten and Gebreeyesus, 2009). The share of agriculture in national value added has been decreasing though it still constitutes more than 40% of the country's output value added, while industry and services have been both rising at similar rates.

Figure 3.3: Value added of Ethiopian economic sectors as percentage of GDP (1996 - 2004)



Source: World Development Indicators (WDI), 2013

The share of manufacturing in GDP is another indicator of the country's underdeveloped industry, where it formed an average of only 5.4% of GDP for the period 1996 - 2004, rising from 5.13% in 1996, reaching a peak in 2001 (5.72%), and declining to 5.32% in 2004[14]. Table 3.2 below shows the distribution of firms across the two-digit aggregation of the country's

[14] Figures from WDI, 2013

manufacturing sectors. The highest share of firms is within the food and beverages sector, followed by furniture production. The largest output share is also that of the food products and beverages sector. The food, beverages, and textile sectors make up the largest shares of employment of around 27% each; thus together accounting for more than half of manufacturing employment. Contributing to only 9% of manufacturing output, and containing more than a quarter of employment, the textile sector seems to remain labor intensive. In contrast, the tanning and dressing leather contributes almost the same share of output (8.8%), but contains only 8% of labor; therefore, this sector seems to be moving away from traditional labor-intensive production processes and towards more mechanized systems. Similar analysis can also be made looking at non-metallic mineral products.

Table 3.2: Distribution of forms by 2 digit ISIC

Manufacturing Sector	Total firms	Share of output	Share of employment
Food products and beverages	28.5%	40.2%	27.1%
Tobacco products	0.1%	3.6%	1.1%
Textiles	4.3%	9.0%	27.1%
Wearing apparel; dressing and dyeing of fur	3.5%	0.7%	4.6%
Tanning and dressing of leather	7.1%	8.8%	8.1%
Wood and of products of wood and cork	2.4%	0.6%	1.5%
Paper and paper products	0.9%	2.4%	1.6%
Publishing, printing and reproduction of recorded media	6.6%	2.8%	4.8%
Chemicals and chemical products	5.1%	6.1%	4.4%
Rubber and plastics products	3.8%	5.1%	3.9%
Other non-metallic mineral products	11.5%	8.4%	6.2%
Basic metals	1.0%	4.5%	1.5%
Fabricated metal products, except machinery and equipment	6.6%	1.7%	2.7%
Machinery and equipment	1.5%	0.1%	0.3%
Electrical machinery and apparatus.	0.2%	0.0%	0.1%
Motor vehicles, trailers and semi-trailers	1.0%	4.6%	1.0%
Furniture	15.7%	1.5%	4.1%
Total	100.0%	100.0%	100.0%

Source: Author's calculations from the Annual Survey of Manufacturing Industry

Employment in the manufacturing sector was steadily increasing over the period 1996 - 2004 (Table 3.3), for both skilled and unskilled workers. This was however happening in parallel with a decrease in average employment that reflects a decrease in firm size. This is most likely due to the decrease in the size of the public sector and the proliferation of micro and small enterprises following liberalization.

The ratio of skilled workers witnessed a sharp increase from 27.7% to 35.8% in 1997 and since then followed an overall stable trend, with some fluctuations around this higher share. Therefore, the change in skilled distribution could be indicative of the presence, or to say the least, appearance of skill bias within the manufacturing sector.

Table 3.3: Employment and percentage of skilled workers in manufacturing 1996 – 2004

Year	Total employment	Mean employment	Share of skilled workers
1996	7,281	131.8623	27.7%
1997	13,495	109.6907	35.8%
1998	17,113	114.4901	36.1%
1999	20,459	110.6722	34.5%
2000	25,283	108.5062	33.1%
2001	23,968	103.7757	35.6%
2002	28,028	94.49525	34.4%
2003	29,549	89.61639	35.8%

Source: Author's calculations from the Annual Survey of Manufacturing Industry

Higher levels of total employment seem to be associated with higher shares of foreign ownership in Ethiopian manufacturing enterprises. As Table 3.4 below shows, overall higher shares of foreign ownership are accompanied with higher average number of employees, with the exception of one bracket (40% to 60%). Higher foreign shares are also associated with higher average number of administrative or skilled workers, where they even exceed the average number of production workers at one instance.

Table 3.4: Mean total employment, admin and production workers by foreign share in private firms

Foreign share in paid up capital	Mean number of employees	Mean Admin workers	Mean Product workers
0%	41.4	13.7	27.4
0 to 10%	70.5	29.3	41.2
10 to 20 %	91.9	34.5	57.4
20 to 40 %	121.8	77.8	44.0
40 to 60%	60.0	14.1	45.9
more than 60%	142.2	63.7	78.5

Source: Author's calculations from the Annual Survey of Manufacturing Industry

3.3. Econometric analysis for total employment

The aim of this section is to explore empirically the relationship between employment and trade openness in Ethiopia. More specifically, my aim is to identify the determinants of employment that pertain to trade liberalization and increased globalization in Ethiopia. In developing countries, trade openness unlocks the doors to several direct and indirect technology transfer mechanisms, much of which can be laborsaving. However, if compensation mechanisms were at work, this potential laborsaving effect would soon be offset by market mechanisms and could be even turned into a labor-augmenting effect. Do compensation mechanisms function well in low income countries such as Ethiopia? What is the overall employment effect of the outward looking economic policies within the manufacturing sector of the country? The analysis deploys System Generalized Method of Moments (GMM-SYS) procedure to answer these questions, implementing a dynamic framework that depicts enterprise-level employment trends.

3.3.1. The empirical model

The starting point of the empirical analysis is a perfectly competitive industry that assumes a constant elasticity of substitution (CES) production function of the form[15] mentioned in chapter two (refer to equation 1). The first order condition is obtained by setting real wages equal to the marginal productivity of labor (refer to chapter two, equation 2). In addition, similarly to the methodology in chapter two, relevant costs in labor adjustments and persistence in the employment evolution call for transforming the model from a static to a dynamic one (as standard in the literature, see Arellano and Bond, 1991; for a recent application see Lachenmaier and Rottman, 2011); therefore, a lagged employment variable is added to the equation, and it takes the following final extended form:

[15] The choice of this production function is consistent with previous empirical literature studying the employment effects of technological change and assuming a perfect competition setting (see Van Reenen, 1997, Conte and Vivarelli 2010),

$$EMP_{it} = \alpha + \beta EMP_{it-1} + \delta W_{it} + \gamma Y_{it} + \eta INV_{it} + \mu FOR_{it} + \lambda EXP_{it} + \omega LOC_{it} + (u_{it} + \varepsilon_i) \quad (10)$$

All variables are expressed in natural logarithms. Standard to panel data analysis, the error term is composed of the idiosyncratic error component (u_{it}) and the time invariant firm fixed effects component (ε_i). *EMP* is the number of employed workers in firm i at time t. W represents the real wages of workers, and Y is the real output of each firm. *INV* captures the share of investment out of total output. A positive coefficient of this variable can be an indicator that the mechanism of compensation through investment is indeed at work. *FOR* represents the share of foreign ownership in a given firm at a given time period. It is a measure of the degree of foreign investment that is expected to be a channel of technology transfer through the full or partial involvement of (Multi National Companies) MNCs in the production processes of their partner enterprises. In this way, I will also be able to evaluate the skill-biased impact of FDI. A positive and significant coefficient of this variable would indicate that there is either a direct employment effect manifested through the fact that the MNCs themselves employ workers, or an indirect effect through increased demand for local suppliers' products that could contribute to increasing employment in local firms as well (Dunning and Fontanier, 2007). *EXP* is the export to output ratio. It is used to test whether exporting firms are in fact expanding their production. As mentioned earlier, exporting firms in middle and low income countries can be in fact "learning by exporting" (Keller, 2001), through obtaining efficiency gains, and acquiring knowledge of international best practices (Vivarelli, 2011). Positive and significant results for this variable would indicate that exporters within the Ethiopian manufacturing sector are indeed benefitting from this channel of technology transfer. *LOC* is a dummy variable for location. It takes the value of one if the firm is located in and around Addis Ababa, the capital, and zero if outside of the capital region. It is expected that larger and more technologically advanced firms are located in the capital area that is the business and financial center in the country. Consequently, their location would have an employment enhancing effect, through higher competitiveness. Table 3.5 below provides some descriptive statistics for the variables used in the analysis.

Table 3.5: Descriptive statistics of variables used in regression

Variable	Mean	Std. Dev.	Min	Max
Total employment	47.379	122.074	2.000	2759.000
Total real wage	8.033	0.622	3.468	10.740
Total real output	13.375	1.801	8.206	19.408
Investment/output ratio	0.193	1.941	0.000	91.728
Location dummy	0.644	0.479	0.000	1.000
Foreign share	0.040	0.183	0.000	1.000
Export /output ratio	0.019	0.130	0.000	1.336

Source: Author's calculations from the Annual Survey of Manufacturing Industry

The presence of firm-specific effects causes a correlation between the lagged dependent variable (EMP_{it}) and the individual fixed effect (ε_i). Therefore, using the pooled OLS methodology would lead to upwardly biased and inconsistent coefficients of the lagged dependent variable, with a larger bias as the variance of the unobserved effect increases (Hsiao, 1986). Furthermore, the dynamic specification of the model implies that the assumption of strict exogeneity of the explanatory variables does not hold due to the presence of an endogenous first-order lagged dependent variable. Obtaining consistent and efficient estimators includes first transforming the original equations to eliminate the fixed effects and then applying instrumental variables estimations for the parameter of the lagged endogenous variable (Halaby, 2004). Anderson and Hsiao (1982) have developed a formulation for obtaining consistent FE-IV estimators by resorting to first differencing in order to eliminate the unobserved effect, and then two lags and beyond to instrumentalize the lagged dependent variable. However, more radical efficiency improvements have been obtained by Arellano and Bond (1991), using GMM techniques as an alternative to the Anderson and Hsiao approach. In their model, the instrument matrix includes all previous level values of the lagged dependent variable, where they obtain the GMM-DIFF estimator. However, the GMM-DIFF estimator has been found to be weak in cases when: (1) there is a strong persistence over time, where the instruments are weakly correlated with the first difference variables, and (2) cross-sectional variability dominates time variability (Bond *et al.*, 2001). Blundell and Bond (1998) have then put forward an efficiency improvement to the GMM-DIFF model by using additional moment conditions and obtaining the system GMM or GMM-SYS. In particular, they use moment restrictions of a simultaneous system of first-differenced equations and the equations in level. In the first-differenced equations they use the lagged level values of the variables as instruments (similar to the GMM-DIFF estimator), and in the level equations they use differences as instruments. In the present empirical study, the GMM-SYS will be used due to the fact that it seems to fit best with the characteristics of the panel data and the nature of the empirical model. In particular, our longitudinal data are characterized by a larger cross-sectional (between variance equal to 1.003) than time variability (within variance equal to 0.1144). Moreover, as table 3.6 below depicts, time persistence is obvious for all the three categorizations of employment.

Table 3.6: Time persistence in the employment time series

	Total employment	Unskilled	Skilled
AR (1)	0.896*** (0.000)	0.830*** (0.000)	0.860*** (0.000)

Source: Author's calculations from the Annual Survey of Manufacturing Industry

3.3.2. The results

Table 3.7 presents the OLS, FE and SYS-GMM estimators for the total employment equation. Although OLS is expected to result in upward biased estimates in the presence of firm specific effects and a dynamic specification, it forms an upper bound for the value of the estimate of lagged endogenous variable obtained in SYS-GMM. Similarly, the FE results are presented to provide a lower bound for the value of the mentioned estimator, since the fixed effects regression produces downward biased results. Time and sector dummies were included to control for unobserved shocks that may affect the variables. It is important to note here that all the regressors were considered potentially endogenous, since they are largely dependent on firms' simultaneous decisions. Therefore – to be on the safer side – all variables have been instrumented using the GMM orthoganality conditions.

Looking at the last column of table 3.7, the SYS-GMM shows a positive and significant value of lagged total employment coefficient, further asserting the persistence in the time series. The magnitude of this coefficient correctly lies within the upper and lower bounds set by the OLS and FE estimators respectively. The total wage coefficient shows a negative and significant value, which is in line with the expected sign indicating a negative relationship between labor demand and wages.

The rest of the variables show positive coefficients reflecting employment-enhancing effects to varying levels of significance. The *output* explanatory variable shows that an expansion in output requires higher levels of employment. Similarly, the positive sign of the *investment* variable indicates that as the share of investment from total output increases, the demand for labor rises. This is a manifestation that at least part of firms' profits are being used for expanding their production capacity, thus the compensation channel via new investments might be at work in the manufacturing sector of Ethiopia. The *location* dummy variable shows that firms located in the capital region are those firms that hire more workers. The *Foreign ownership* variable also shows a positive and significant relation with total employment, indicating that firms with higher foreign share have higher expansion tendencies. The last studied variable is the *export* ratio variable, which also exhibits an employment enhancing effect.

In terms of relative magnitude, it appears that the export variable has the highest impact since its coefficient if of the highest magnitude. On average, when firms are exporters, their labor demand increases by 116.5 percentage points. However, this effect is weakly (10%) significant. The location dummy has the second highest coefficient and is significant at 1%. Demand for labor of firms located in the capital region is found to increase by 19 percentage points.

Table 3.7: Regression results using OLS, FE and SYS-GMM for total employment equation

Dependent variable: Total employment	**OLS**	**FE**	**SYS-GMM**
Lagged total employment	0.710***	0.160***	0.352***
	(0.0112)	(0.0191)	(0.0653)
total wage	-0.144***	-0.313***	-0.262*
	(0.0171)	(0.0223)	(0.1450)
Real output	0.177***	0.184***	0.372***
	(0.0076)	(0.0114)	(0.0593)
investment / output ratio	0.00814	-0.0146**	0.0241***
	(0.0071)	(0.0074)	(0.0064)
Location dummy	0.0608***	0.0521	0.188***
	(0.0174)	0.0795)	(0.0484)
Foreign ownership share	0.0879**	-0.0236	0.170*
	(0.0412)	(0.0537)	(0.0996)
Export / output ratio	0.0161	-0.123	1.165*
	(0.0626)	(0.1700)	(0.5970)
Constant	-0.417***	2.751***	-1.054
	(0.1150)	(0.2240)	(0.9290)
time dummies	*yes*	*yes*	*yes*
sector dummies	*yes*	*no*	*yes*
Observations	2,816	2,816	2,816
Number of firms		865	865
R-squared	0.855	0.693	
Adjusted R-squared	0.853		
AR(1)			-7.51***
AR(2)			0.896
Wald test chi2			2131***
Hansen test			102.5

Notes: 1. Robust standard errors in brackets.
2. ***, **, and * indicate the statistical significance at the 1%, 5%, and 10%, respectively.

A number of validity tests have been conducted to check the performance of the model and robustness of the results. The Wald test[16] was used to test the overall significance of the independent variables. It rejected the null hypothesis of insignificant coefficients, thus confirming the joint significance of the variables and the robustness of the overall results. The Hansen test for over-identifying restrictions, where the null hypothesis is that of adequate instruments, failed to reject the null, thus confirming the adequacy of the instruments used. In addition, the Arellano and Bond (AR) test for autocorrelation was performed, which is found to support the consistency of the GMM estimators using t-2 instruments

To sum up, the results show that all tested variables pertaining to the effect of trade and technology-transfer on total manufacturing employment, showed positive and significant coefficients, indicating a labor-augmenting effect. Therefore, no negative quantitative effects are evident as a consequence of technological change and globalization.

3.4. Econometric analysis for skill categories

Another question that this chapter attempts to address is how the employment enhancing effect of the variables is being allocated between skilled and unskilled labor. Therefore, this section of the chapter looks into the phenomenon of skill bias within the Ethiopian manufacturing sector. The empirical model of section 3.3 is extended to capture this effect, if present. The analysis is still performed at firm level within a dynamic framework using System-GMM; however, the model is transformed into a two-equation model that depicts the employment trends for skilled and unskilled workers separately. This setting is in fact quite similar to the setting used for the Turkish case in Chapter 2.

[16] It is distributed as a $\chi 2$ where the degrees of freedom equate the number of restricted coefficients

Although the two equation setting has quite a number of advantages, it also has certain drawbacks pertaining to the possible correlation between the error terms of the two equations. Therefore, another alteration to the model is performed, where I use one equation, with the ratio of skilled to unskilled workers as the dependent variable.

3.4.1. Extension of the econometric model

Two labor demand equations are defined, one for each group of skilled and unskilled workers. Equation (2) is therefore expressed for both types of labor of the following form:

$$\ln USL = \ln Y - \sigma_{USL} \ln USW + (\sigma_{USL} - 1) \ln A_{USL} \quad (11)$$

$$\ln SL = \ln Y - \sigma_{SL} \ln SW + (\sigma_{SL} - 1) \ln A_{SL} \quad (12)$$

where USL and SL are the numbers of unskilled labor and skilled labor, respectively measured by the amounts of production *vs* administrative workers. USW and SW are the real wages of unskilled and skilled labor.

As in the case of equation (10), equations (11) and (12) are extended to include the proxies for the various factors affecting labor-augmenting technologies within a dynamic specification:

$$USL_{it} = \alpha + \beta USL_{it-1} + \delta USW_{it} + \gamma Y_{it} + \eta INV_{it} + \mu FOR_{it} + \lambda EXP_{it} + \omega LOC_{it} + (u_{it} + \varepsilon_{it}) \quad (13)$$

$$SL_{it} = \alpha + \beta SL_{it-1} + \delta SW_{it} + \gamma Y_{it} + \eta INV_{it} + \mu FOR_{it} + \lambda EXP_{it} + \omega LOC_{it} + (u_{it} + \varepsilon_{it}) \quad (14)$$

All variables are expressed in natural logarithms, and they follow the definitions mentioned earlier in the section.

The main advantage of using a two-equation setting rather than the standard cost share unique equation is that it allows for studying relative versus absolute skill bias.

Absolute skill bias would appear when technology and openness related variables have a positive coefficient for skilled workers and negative coefficients for unskilled workers, while relative skill bias would appear when the coefficients for both skilled and unskilled workers are positive but differ in magnitude, with the coefficients for unskilled workers being lower. In addition, this setting is more informative in exploring the employment dynamics of the different categories of workers separately.

However, a possible drawback of this two-equation setting is that the equations are not entirely independent, and this could be translated into a correlation between the error terms of the two regression equations. To mitigate this issue, I use the specification in equation (10) and use the ratio of skilled to unskilled workers as the dependent variable. The following equation is used in the estimation

$$(\frac{SL}{USL})_{it} = \alpha + \beta EMP_{it-1} + \delta W_{it} + \gamma Y_{it} + \eta INV_{it} + \mu FOR_{it} + \lambda EXP_{it} + \omega LOC_{it} + (u_{it} + \varepsilon_i) \qquad (15)$$

All variables are expressed in natural logarithms, and they follow the definitions mentioned earlier.

3.4.2. Results

Table 3.8 shows the results of the second set of regressions, where the demand for labor was studied for skilled labor and unskilled labor separately. Looking at the SYS-GMM results for both unskilled and skilled workers, the lagged employment variable is positive and significant for both types of workers. This, as in the case of total employment, affirms the time persistence of the series. In addition, the coefficients of both variables lie within the bounds set by OLS and FE results. The wage explanatory variables are also significant and in line with the expected negative sign. It is worth noting here that in terms of magnitude, the coefficient of unskilled workers is higher than that of skilled workers. A possible explanation for this observation might be that the demand for unskilled workers is more elastic given the ease with which such workers can be substituted vis-à-vis their skilled counterparts.

The coefficient of the *output* variable is positive and significant for both types of workers, with a slightly higher magnitude for skilled workers. The difference between these two coefficients however proved not statistically significant (refer to Table 3.9). Therefore, no conclusion regarding the presence of a relative skill bias can be asserted here. The *investment* variable shows similar results, positive and significant for both skilled and unskilled labor, with a higher magnitude for skilled labor. However, also in this case, the t-test for the significance of the difference between the two values is not significant (see Table 3.9, second row).

The difference between the magnitudes of the *location* dummy variable is instead significant (see Table 3.9, third row). Therefore, location does exhibit a relative skill bias effect in that firms located in the capital and its vicinity not only hire more workers, but they have the tendency to hire more skilled workers. A proximity to the capital leads to an increase of 31.2 percentage points in demand for skilled labor as opposed to only 16.1 percentage points increase in the demand for unskilled workers (with both the coefficients highly significant).

The share of foreign ownership is found to have significant effects only for skilled workers. Therefore, the employment enhancing effect observed in the total employment equation stems mostly from the effect on the demand for skilled labor[17]. This leads us to the conclusion that firms with higher shares of foreign ownership exhibit an absolute skill bias effect, indicating that the FDI channel of technology transfer is at work in Ethiopia.

[17] The fact that the t-test for the difference between the two coefficients of this variable is not significant is a consequence of the fact that the coefficient for unskilled labor is not significant.

The export variable, contrary to our expectations pertaining a possible skill bias, is found to be barely significant for unskilled labor but not for skilled labor. This is to say that the positive effect on total employment observed earlier originates mainly from higher demand for unskilled rather than skilled labor. Therefore, the process of "learning by exporting" is not obvious in Ethiopia, at least not for the time period considered, that was still characterized by a dominant role of an HOSS effect, with Ethiopian exports still stemming from traditional and low-skill intensive manufacturing sectors.

Table 3.8: Regression results using OLS, FE and SYS-GMM for employment equations of unskilled and skilled workers

Dependent variable	Unskilled workers			Skilled workers		
	OLS	FE	SYS-GMM	OLS	FE	SYS-GMM
Lagged production worker employment	0.606***	0.117***	0.295***			
	(0.0130)	(0.0203)	-0.0452			
Production worker wages	-0.232***	-0.334***	-0.448***			
	(0.0198)	(0.0252)	(0.0508)			
Lagged admin worker employment				0.696***	0.0790***	0.280***
				(0.0125)	(0.0209)	(0.0547)
Admin worker wages				-0.0996***	-0.253***	-0.311***
				(0.0180)	(0.0233)	-0.0486
Real output	0.232***	0.202***	0.406***	0.183***	0.151***	0.462***
	(0.0092)	(0.0158)	(0.0586)	(0.0099)	(0.0164)	(0.0505)
investment / output ratio	0.00652	-0.0143	0.0256***	0.0228**	-0.0117	0.0300***
	(0.0095)	(0.0106)	(0.0088)	(0.0103)	(0.0110)	(0.0065)
Location dummy	0.0469**	-0.0855	0.161***	0.116***	0.337***	0.312***
	(0.0227)	(0.1110)	(0.0438)	(0.0250)	(0.1160)	(0.0548)
Foreign ownership share	0.0913*	-0.0365	0.168	0.111*	-0.062	0.243**
	(0.0540)	(0.0753)	(0.1160)	(0.0585)	(0.0782)	(0.1230)
Export / output ratio	-0.0027	-0.07	1.144*	0.0509	-0.166	1.136
	(0.0823)	(0.2380)	(0.6570)	(0.0891)	(0.2470)	(0.7540)
Constant	-0.467***	2.413***	-0.369	-1.070***	1.724***	-2.473***
	(0.1460)	(0.2840)	(0.7590)	(0.1400)	(0.2830)	(0.5850)
time dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*Yes*
sector dummies	*yes*	*no*	*yes*	*yes*	*no*	*Yes*
Observations	2,816	2,816	2,816	2,816		2,816
R-squared	0.768	0.572		0.789	0.443	
AR(1)			-8.227***			-9.661***
AR(2)			-1.411			1.466
Wald test chi2			1384***			1266***
Hansen			122.8			129.1

Notes: 1. Robust standard errors in brackets. / 2. ***, **, and * indicate the statistical significance at the 1%, 5%, and 10%, respectively

Looking at the results of table 2.8 from another perspective, we can analyze the results of each type of labor separately. For unskilled labor, the variable that appears to have the highest employment enhancing effect is the export variable. As the export to output ratio of a firm increases, it tends to increase its demand for unskilled labor by 114.4 percentage points. This indicates that the manufactured goods being exported follow production techniques that have not (yet) adopted more advanced laborsaving technologies.

The most prominent contributor to increasing demand for skilled labor appears to be real output. Therefore, firms that expand their entire production capacity to reach higher levels of output increase their demand for skilled labor by 46.2 percentage points. This however does not necessarily allow us to make conclusions regarding the technology levels of these expanding firms.

The various diagnostic tests showed evidence supporting the robustness of the results. The Wald test rejected the null of insignificant estimator coefficients for both unskilled and skilled labor demand equations. The Hansen test never rejected the null for either of the two equations, asserting the suitability of the instruments used. The AR tests also supported the overall validity of the model by providing evidence for a significant negative AR(1) and a non-significant AR(2).

Table 3.9: t-statistic for comparing coefficients of the two equations

Variable	t -statistic	ρ value
Real output	0.72391	0.25
investment / output ratio	0.40057	0.5
Location dummy	2.15243**	0.025
Foreign ownership share	0.4436	0.5
Export / output ratio	0.008	0.5

These mixed conclusions from the two-equation model further assert the need for further investigation. Table 3.10 presents the results from the second regression that uses one equation, estimating the impact of our variables on the ratio of skilled to unskilled workers. The dependent variable can be interpreted as a measure for skill intensity. Looking at column 3 of the table, the SYS-GMM results show that output, location, and foreign ownership, have a positive and significant effect on the skill intensity of manufacturing firms. More specifically, an expansion of output leads to an increase in skill ratio by 17 percentage points; however this variable is significant only at the 10% level. The most significant (at 1%) variable is the location dummy. It shows that there is a 20 percentage point difference between the skill ratio of firms located in and around the capital, compared to those away from it. Foreign ownership also shows a highly significant positive relationship with the skill intensity. In fact, this variable has the highest coefficient value, where an increase in the share of foreign owners within a firm leads to an increase of 203 percentage points in the skill ratio.

The investment ratio and export ratio variables were not significant. Regarding the investment ratio, it was significant in all earlier regressions, which could indicate that investment is positively related to overall employment, but not sensitive to the skill distribution within employment. This leads us to conclude the investment in Ethiopia might not be related to technological enhancement, and thus does not embody technological and innovative elements that would require higher levels of skill to operate or manage them. The exports ratio carried a negative sign, but was also not statistically significant, further asserting the earlier observation that the mechanism of learning by exporting is still not active within the Ethiopia manufacturing sector.

Table 3.10: Regression results using OLS, FE and SYS-GMM for the ratio of skilled /unskilled workers

Dependent variable: Skilled/Unskilled	OLS	FE	SYS- GMM
Lagged employment ratio	0.510***	0.0833***	0.293***
	(0.0759)	(0.02390	(0.0674)
total wage ratio	-0.0784***	-0.0609***	-0.103*
	(0.0140)	(0.016)	(0.0601)
Real output	0.00337	0.0107	0.170*
	(0.0180)	(0.0354)	(0.0926)
investment / output ratio	0.0203***	0.00494	0.000454
	(0.0056)	(0.0228)	(0.0686)
Location dummy	0.163***	0.252	0.200***
	(0.0472)	(0.250)	(0.0663)
Foreign ownership share	0.148	0.163	2.039**
	(0.0979)	(0.172)	(0.937)
Export / output ratio	0.111	-0.077	-0.497
	(0.1060)	(0.544)	(0.624)
Constant	0.578**	0.572	-1.424
	(0.2360)	(0.521)	(1.278)
time dummies	*Yes*	*yes*	*yes*
sector dummies	*Yes*	*no*	*yes*
Observations	2,863	2,863	2,863
Number of firms			881
R-squared	0.295	0.019	
AR(1)			-2.846***
AR(2)			0.944
Wald test			190.9***
Hansen			153.8
Hansen -p			0.184

Notes: 1. Robust standard errors in brackets.
2. ***, **, and * indicate the statistical significance at the 1%, 5%, and 10%, respectively

The diagnostic tests of the regression all support the robustness and reliability of the overall results. The Wald test rejected the null of insignificant coefficients. The Hansen test failed to reject the null hypothesis of unsuitable instruments with a *p-value* of 0.184. The AR tests confirmed the overall validity of the model by showing a significant negative AR(1) and a non-significant AR(2).

Concluding remarks

In this chapter, I have conducted empirical investigations to establish the role played by globalization and technology transfer in determining employment evolution in the manufacturing sector of Ethiopia. To this end, I have studied the extent to which the level of overall manufacturing employment was determined by trade, FDI and technology; and if globalization and technology transfer played a role in instigating SBTC. The empirical analysis relied on manufacturing survey data for the period 1996-2004 and deployed alternative econometric estimators.

The findings lead to two main conclusions concerning the characteristics of manufacturing sector employment in Ethiopia. The first main conclusion pertains to the quantitative effect of globalization on total manufacturing employment at the firm-level. Specifically, trade and foreign ownership are found to have a labor–augmenting effect; therefore, no negative employment effects are obvious in the Ethiopian manufacturing sector as a consequence of globalization.

The investigation to determine whether the Ethiopian manufacturing sector exhibits the presence of a skill-bias lends some evidence to this effect. In particular, foreign ownership and proximity to the capital city are found lead to a higher demand for skilled workers, as opposed to unskilled ones. The foreign ownership related finding thus suggests two things: first, the increase in total firm-level employment associated with foreign ownership stems mostly from the effect of foreign ownership on the demand for skilled labor; secondly, it lends some support to FDI-linked channels of a skill-biased technology transfer being in operation. Consistently, - while the significant effect of a location in the capital city may point out the presence of positive agglomeration effects - this outcome can also be related to a greater presence of foreign technologies in the most attractive urban area of the country.

In contrast, involvement in exporting activity is found to lead to higher demand for unskilled workers. This suggests that the effect of exporting activity on total firm-level employment is largely the result of its effect on unskilled labor. This finding is in contrast with the expectation of a possible skill bias involved by a process of "learning by exporting". However, at least for the time period considered in this study, it may well be the case that Ethiopian manufacturing was still characterized by a dominant role of an HOSS effect, with exporting still stemming from traditional and low-skill intensive manufacturing sectors.

The finding that FDI is the main channel through which skilled labor is demanded for in Ethiopian manufacturing may be of some interest from the viewpoint of policy making. In particular, the current extensive infrastructural public investment may be something commendable in this respect, since adequate infrastructures may be the missing element needed to attract FDI. On the other hand, the fact that the economy is still dominated by a State sector that is undertaking extensive direct investment activities may involve a possible risk of crowding-out of more technologically advanced FDI.

Finally, since globalization and technology transfer imply a higher demand for skilled labor, policy makers should devote a particular attention to education and training policies, addressed to avoid the occurrence of a skill-shortage that would be harmful to both technological upgrading and employment.

ANNEX II: TECHNICAL NOTE ON EMPIRICAL WORK ON THE CASE OF ETHIOPIA

Preparing the dataset

The raw dataset was initially received in SPSS format. Each year was a in a separate folder and within each folder, each variable was in a separate file, summing to a total of 108 files. Therefore, a significant amount of effort was made in order to aggregate and merge all the files properly into one panel dataset. The data also required some cleaning, as there were data entry errors, coding mistakes, and the like.

Eliminating firms from the analysis

A number of firms either had too much missing data, or did not satisfy the requirements for running the model, so they were removed so as not to compromise the robustness of the regression. Three major criteria were considered for deciding on whether to remove the firm from the dataset or keep it.

1. *No admin or production workers*: Firms that did not report having any administration workers, or production workers were removed from the analysis in order to maintain the same number of observations across the two regression equations.
2. *No consecutive years of survey*: Since the econometric model uses lagged values of the variable as instruments, firms that had observations for one year only were removed.
3. *Private vs. public*: Only the private sector firms were used for the regression analysis. This decision was made for a number of reasons. The private sector accounts for a large share of total employment, and is more affected by policy changes. More importantly, wages and employment in the public sector are not driven by market forces as much as those in the private sector, but rather are set as the result of a

different process; this makes public sector data unsuitable for the type of analysis intended for this research.

Adjusting the variables for the model

Deflators

As the dataset did not include any deflator variables, data on deflators had to be imported from an external source. The World Bank's World Development Indicators database was used to obtain two variables for deflating the nominal values of the dataset. This first is a general GDP deflator and the second is a CPI deflator. The latter was used for deflating nominal wages and the latter was used for all other monetary variables. The year 1996 was used as a base year.

Transforming variables into ratios

In order to avoid inconsistencies that might arise from using absolute values of variables such as investment, export, and foreign investment, these variables were transformed into ratios. These variables are :

1. Total net investment / total output ratio
2. Total value of exports/ total output ratio
3. Foreign paid-up capital / Total paid-up capital ratio

Variables for measuring technology transfer

Unfortunately, a measure of locally produced innovation, such as performing R&D activities or spending on R&D, does not exist in the data. Therefore, the analysis needed to be restricted to technology transfers from abroad. There were several variables that were good candidates for being proxies of technology transfer.

1. Spending on Licenses
2. Foreign ownership of the firms
3. Import of machinery
4. Total imports

Regressions with combinations of all those variables were tried out, see section below. However, only the share of foreign ownership proved to show significant results. Therefore, the rest of the variables were dropped from the final analysis.

Regression methods

Since this type of analysis is done for the first time for the case of Ethiopia, before moving on to studying the presence of SBTC, it was useful to take a step back and start from the effect of trade and globalization on overall employment. Therefore, the first regression equation was using "total employment" as the dependent variable. The equation was the final equation (10) reported in the chapter. After looking at the overall effects on total employment, the focus was then turned to studying SBTC, and hence the division into the two equations (13) and (14). (The details are discussed in the text).

The Various trials and combinations of SYS-GMM regressions

After discussing all the steps pertaining to the choice of variables, the regression techniques and the diagnostic tests, this section presents the results of the several attempts and trials made to reach the final model presented in the paper. The dependents variables are: "ltotemp", the log-transformed total number of employees, "lnprod", the log-transformed number of production workers, and "lnadmin", the log-transformed number of administrative workers.

Annex table 7: SYS-GMM regression with various combinations of variables and instrumentation, dependent variable is total employment

VARIABLES	SYS-GMM (1) ltotemp	SYS-GMM(2) ltotemp	SYS-GMM(3) ltotemp	SYS-GMM(4) ltotemp	SYS-GMM(5) ltotemp	SYS-GMM(6) ltotemp
Lagged total employment	0.162***	0.156***	0.149***	0.143***	0.145***	0.145***
	(0.054)	(0.055)	(0.054)	(0.055)	(0.055)	(0.055)
total wage	-0.321**	-0.289*	-0.331**	-0.347**	-0.361**	-0.358**
	(0.143)	(0.150)	(0.145)	(0.149)	(0.150)	(0.154)
Real output	0.510***	0.508***	0.542***	0.554***	0.564***	0.562***
	(0.085)	(0.087)	(0.078)	(0.077)	(0.076)	(0.079)
investment / output ratio	0.0298***	0.0264***	0.0302***	0.0311***	0.0322***	0.0310***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Location dummy	0.264***	0.257***	0.266***	0.270***	0.265***	0.261***
	(0.057)	(0.056)	(0.055)	(0.055)	(0.055)	(0.055)
Foregin ownership share	0.222*	0.207	0.102			
	(0.127)	(0.129)	(0.280)			
Foregin ownership dummy				0.124	0.126*	0.126*
				(0.077)	(0.076)	(0.076)
Export / output ratio	1.185*	1.260*	1.153*	1.209*	1.150*	1.122*
	(0.669)	(0.701)	(0.701)	(0.691)	(0.684)	(0.674)
imported input / output ratio	-0.0118	-0.0665	-0.156	-0.128	-0.0973	0.0716
	(0.297)	(0.300)	(0.268)	(0.279)	(0.279)	(0.092)
License dummy	0.0919	-0.0718*				
	(0.176)	(0.043)				
License fee/ output ratio			2.93	3.297	6.594	5.887***
			(3.926)	(3.978)	(5.057)	(1.855)
Constant	-2.076**	-2.140**	-2.318**	-2.364**	-2.399**	-2.402**
	(0.997)	(1.022)	(0.954)	(0.959)	(0.955)	(0.952)
Observations	3,320	3,320	3,320	3,320	3,320	3,320
Number of eid	987	987	987	987	987	987
Wald test chi2	1126***	1246***	1202***	1147***	1152***	1089***
chi2p	0	0	0	0	0	0
hansen	123.4	113.4	124.8	124	125.2	118.9
hansenp	0.448	0.627	0.725	0.583	0.529	0.563

Annex table 8: SYS-GMM regression with various combinations of variables and instrumentation, dependent variable is Admin workers

	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	lnadmin	lnadmin	lnadmin	lnadmin	lnadmin	lnadmin
Lagged admin worker employment	0.224***	0.250***	0.250***	0.245***	0.227***	0.224***
	(0.0522)	(0.0485)	(0.0485)	(0.0489)	(0.0513)	(0.0522)
Admin worker wages	-0.306***	-0.291***	-0.291***	-0.288***	-0.307***	-0.306***
	(0.0470)	(0.0468)	(0.0468)	(0.0470)	(0.0462)	(0.0470)
Real output	0.513***	0.408***	0.408***	0.408***	0.492***	0.513***
	(0.0518)	(0.0573)	(0.0573)	(0.0574)	(0.0521)	(0.0518)
investment / output ratio	0.0368***	0.0308***	0.0308***	0.0311***	0.0336***	0.0368***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)
Location dummy	0.302***	0.315***	0.315***	0.322***	0.318***	0.302***
	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)
Foregin ownership share		0.298**	0.298**	0.293**		
		(0.141)	(0.141)	(0.144)		
Foregin ownership dummy	0.117				0.118	0.117
	(0.078)				(0.081)	(0.078)
Export / output ratio	0.9	1.246*	1.246*	1.425*	1.099	0.9
	(0.727)	(0.745)	(0.745)	(0.769)	(0.741)	(0.727)
impout	-0.42	-0.42	-0.42	-0.438	-0.479*	-0.42
	(0.265)	(0.305)	(0.305)	(0.308)	(0.273)	(0.265)
License dummy		-0.0245	-0.0245	-0.0258		
		(0.155)	(0.155)	(0.046)		
License fee/ output ratio	15.67**				8.036	15.67**
	(6.666)				(5.476)	(6.666)
Constant	-3.101***	-1.755***	-1.755***	-1.775***	-2.789***	-3.101***
	(0.633)	(0.673)	(0.673)	(0.672)	(0.626)	(0.633)
Observations	2,973	2,973	2,973	2,973	2,973	2,973
Wald test chi2	1262	1202	1202	1170	1261	1262
chi2p	0	0	0	0	0	0
hansen	121.5	121.5	121.5	117.1	126.3	121.5
hansenp	0.808	0.691	0.691	0.725	0.733	0.808

Annex table 9: SYS-GMM regression with various combinations of variables and instrumentation, dependent variable is production workers

	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**lnprod**	**lnprod**	**lnprod**	**lnprod**	**lnprod**	**lnprod**
Lagged production worker employment	0.237***	0.253***	0.253***	0.254***	0.242***	0.237***
	(0.0504)	(0.0475)	(0.0475)	(0.0475)	(0.0492)	(0.0504)
Production worker wages	-0.450***	-0.476***	-0.476***	-0.475***	-0.460***	-0.450***
Real output	0.492***	0.465***	0.465***	0.465***	0.481***	0.492***
	(0.0608)	(0.0671)	(0.0671)	(0.0676)	(0.0603)	(0.0608)
investment / output ratio	0.0186	0.0159	0.0159	0.0145	0.0173	0.0186
	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.015)
Location dummy	0.166***	0.188***	0.188***	0.181***	0.175***	0.166***
	(0.044)	(0.045)	(0.045)	(0.043)	(0.043)	(0.044)
Foregin ownership share		0.145	0.145	0.144		
		(0.122)	(0.122)	(0.121)		
Foregin ownership dummy	0.0821				0.0832	0.0821
	(0.077)				(0.077)	(0.077)
Export / output ratio	1.376*	1.379*	1.379*	1.303*	1.358*	1.376*
	(0.728)	(0.728)	(0.728)	(0.712)	(0.716)	(0.728)
impout	0.0116	-0.00896	-0.00896	0.00657	-0.0194	0.0116
	(0.287)	(0.289)	(0.289)	(0.295)	(0.286)	(0.287)
License dummy			0.0345	-0.0564		
			(0.174)	(0.041)		
License fee/ output ratio	15.94**				8.593*	15.94**
	(6.317)				(4.516)	(6.317)
Constant	-1.478*	-0.908	-0.908	-0.847	-1.227	-1.478*
	(0.787)	(0.791)	(0.791)	(0.787)	(0.758)	(0.787)
Observations	3,087	3,087	3,087	3,087	3,087	3,087
Wald test chi2	1479	1020	1020	1092	1290	1479
chi2p	0	0	0	0	0	0
hansen	125.8	122	122	120.5	130.2	125.8
hansenp	0.702	0.678	0.678	0.644	0.625	0.702

Running with different dependent variables

The one-equation model solved for the possible correlation between the errors of the two equations, but this came at the cost of being able to observe relative versus absolute differences between the skilled and unskilled labor demand equations. Therefore, a final estimation was made by running the labor demand equations simultaneously using GMM. This method has been used by David Guilkey in his explanatory paper "Generalized methods of moments estimations with applications using Stata". The results are presented in the following table.

Annex table 10: GMM simultaneous equations of skilled and unskilled workers

Dependent variable	Unskilled	Skilled
Lagged production worker employment	0.632***	
	(0.0142)	
Production worker wages	-0.169***	
	(0.0204)	
Lagged admin worker employment		0.702***
		(0.0133)
Admin worker wages		-0.108***
		(0.018)
Real output	0.191***	0.181***
	(0.00925)	(0.0103)
investment / output ratio	0.209***	0.150**
	(0.0703)	(0.071)
Location dummy	0.018	0.0935***
	(0.0235)	(0.0243)
Foreign ownership share	0.169*	0.199**
	(0.0931)	(0.0943)
Export / output ratio	0.106	-0.0461
	(0.0962)	(0.0969)
Constant	-0.267*	-1.028***
	(0.153)	(0.135)
Observations	2,816	2,816

CONCLUSIONS

This work has conducted empirical investigations to establish the role played by globalization and technology transfer in determining employment evolution in the manufacturing sectors of developing and underdeveloped countries. To this end, the three chapters of the research have studied the extent to which the level of overall manufacturing employment is determined by trade, FDI and technology; and if globalization and technology transfer play a role in instigating SBTC.

The first step was to review previous theoretical and empirical literature on this topic. One main conclusion one can make from the existing literature is that there is no clear cut answer regarding the impact of technological advancement on employment in developing countries. In fact, this impact can differ between one country and the other, depending on a number of factors such as the relative skill intensity of trading partners, the degree of openness, and national absorptive capacities, among others. Therefore, I resorted to an empirical approach in this study, where I relied on firm-level data; more specifically, I used manufacturing survey data for Turkey as a case of a DC, and Ethiopia as a case of an LDC.

The use of firm-level data has the advantage of being exhaustive and permits the identification of the channels through which trade liberalization impacts labor demand. However, the disadvantage of this type of data is that it covers only workers within the manufacturing sectors, so the analysis of labor demand is restricted to its approximation with manufacturing labor. Another issue is that the surveys allow for distinguishing only between productions workers and administrative workers, which is a rather broad proxy for unskilled and skilled labor respectively. A more accurate classification could be done using the educational levels of the workers or more detailed occupational categories, which unfortunately was not available in the datasets at hand. It is something to be considered for future research within this area of study.

Moving to the main motivation for this work, it has been two-fold. One the one hand, a large number of studies have noted increasing inequality in developing countries, especially in the period following the 1980's when many DCs switched from import-substitution to trade liberalization economic strategies. This observation seems at odds with the egalitarian predictions of the HOSS theory and more in line with the SBTC notion. I wanted to look into this issue and more specifically into the nature of the SBTC in developing countries, i.e. whether it is a relative or an absolute bias. For this purpose, I took the case of the Turkish manufacturing sector for the period between 1991 and 2001. I used a dynamic frame-work to study the determinants of skill bias and its nature.

On the other hand, the discourse on skill biased technological change has not been taken beyond developing countries to the underdeveloped countries whose economies have also undergone similar trade opening structural changes. I wanted to look whether low income countries are also exhibiting SBTC or they are limited by their national capacities and abilities of the labor force that do not allow them to absorb the technology that is being directly or indirectly transferred through trade liberalization. For this purpose I took the case of Ethiopia, where I studied the Ethiopian manufacturing sector for the period 1996 - 2004. I used an econometric setting that is similar to the one I used in the Turkish case, which allows me to perform some comparative analysis between the two cases.

As for the results from the two case studies and how they can be compared to each other, I present first a summary of the results and the move to a comparative analysis between them.

The main results from the case study of Turkey show that local R&D, patents and exports are variables that contribute to the presence of SBTC within the Turkish manufacturing sector. None of the tested variables showed to have a significant negative coefficient, indicating that globalization and trade liberalization have not had permanent labor saving effects leading to lower demand for labor in general. Thanks to the dynamic two-equation setting used in the econometric specification, the variables that showed to have SBTC effects could tell an even more detailed story. In fact, local R&D and patents showed evidence for absolute skill bias, i.e. they lead to increased demand for skilled labor but not do not have a statistically significant effect on demand for unskilled labor. In contrast, exporting firms exhibit a relative skill bias effect, whereby a firm that performs export activities demands more skilled as well as unskilled labor, but its demand for skilled labor is higher. When looking at the relationship between these choice variables and skill intensity, patents showed to have the highest coefficient followed by similar effects of R&D and exports. This leads to the conclusion that direct import of foreign technology has the more evident effect on increasing demand for skilled labor.

The results of the third chapter, the case of Ethiopia, showed that trade and global integration have not had negative effects on overall employment. On the contrary, all variables that were studied showed to have a positive relationship with labor demand, thus having a labor augmenting effect. Further investigation of the coefficients of the variables through three econometric specifications allowed for analysis at the overall employment level, at the skill category level, and at the skill intensity level. The main conclusions from the empirical exercises is that output and investment have an overall expansionary effect that need not be skill biased. In addition, being located in and around the capital city of Addis Ababa and having a high share of foreign ownership are factors that lead to skill bias within manufacturing firms. However, export activities did not show to be associated with skill bias, but rather followed a logic that is more closely related to HOSS predictions. When looking at the effect of these variables at skill intensity, the share of foreign ownership appeared to play the biggest role in increasing skill intensity, so the higher the share of ownership in a firm, the higher its demand for skilled labor will be compared to unskilled labor. Investment and export did show to be sensitive to skill intensification.

One limitation in the case of Ethiopia is that at the time I conducted this study, the latest available wave of the manufacturing survey was that of 2004. Since several trade related policies were instituted during and after 2004, their effect was not yet evident in the present waves of the survey. Therefore, obtaining more recent data could provide more insight into the matter and give stronger results in support of SBTC.

Although the two case studies do not have the exact same variables, the econometric methodology is similar enough to look into the similarities and differences between the case of a developing country and the case of a least developed country. In the two cases output and investment showed to have an overall expansionary effect without exhibiting SBTC. Therefore, expanding firms' output capacities in both developing and underdeveloped countries does not seem to have a skill bias effect. In addition, the positive effect of investment for both skilled and unskilled workers appears to be in line with the predictions of compensation mechanism theory, where compensation via new investments seems to be at work. It would have been useful to have more disaggregated data on investment so one can study the effect of the different types of investment, such as investment for machinery. In fact, the Turkish survey did have some disaggregated investment data, but there were too few observations to include the variables in the econometric model.

The Turkish manufacturing survey gave importance to the R&D and know-how aspect of the industry and dedicated a number of questions to this issue. Therefore, the empirical study could rely on the two variables of local R&D and imported technology through patents, licenses and other know-how. However, the Ethiopian survey did not include any questions on R&D or similar innovation activities, which was a major limitation in the study of SBTC. Nonetheless, the absence of questions on the factor of innovation could be itself interpreted as an indicator of the lack of such activities in the Ethiopian manufacturing sector. Therefore, the effect of local innovation on demand for skilled and unskilled workers cannot be compared between Ethiopia and Turkey.

However, the effect of imported technologies through various channels can be compared between the two cases. The direct foreign effect in the case of Turkey is measured through the patents variable (a dummy that takes the value of 1 if the firm has patents, licenses or other foreign know-how), while it was measured in Ethiopia through the share of foreign ownership in the firm's paid up capital. Both proxies for direct foreign technology import showed an absolute skill bias effect. They were also the highest contributors to increases in skill intensity when compared to the other variables that also showed to cause skill bias. In Turkey, having patents increased the ratio of skilled to unskilled workers by 12.6 percentage points. The effect was much more powerful in Ethiopia, where the increase in foreign ownership was estimated to lead to a 203 percentage points increase in the skill intensity ratio.

The export variable was also present in both studies. However, it had different effects in each case. While it had a relative SBTC effect in Turkey, it did not present evidence for SBTC in Ethiopia. Therefore, the hypothesis of learning by exporting is evident only in Turkey. Several postulations can be made to explain this difference between Turkey and Ethiopia. One issue is that Ethiopia is a resource-based country that mainly exports primary commodities such as coffee, livestock, spices, seeds, fruits, vegetables, and flowers among others. Such countries face difficulties in reallocating resources towards more non-traditional to them export sectors. In the absence of strong domestic institutions, physical and human infrastructure, poor governance and other such structural problems that LDCs usually suffer from, supply rigidities could arise in the domestic markets, and hamper inter-sectoral reallocation of resources after trade is liberalized. Therefore, export within the manufacturing sector has not yet been able to attract adequate resources and skills and hence witness the process of "learning by exporting". Another related issue is the issue of national capabilities that could be hindering Ethiopian exporters from raising their demand for skilled labor. The evolutionary approach to technology suggests that firms do not operate with a neoclassical production function, but they are rather in a "fuzzy" world where they have imperfect information of a few technologies and need to make efforts to adapt to new technologies and improve them (Lall, 2004). This implies that the level of "absorptive capacity" of a labor force is an important factor that facilitates or hinders the adoption of new technologies (see Abramovitz, 1986, Lall 2004). In the case of Ethiopian exporters, it is quite possible that the manufacturing sector still does not possess the adequate level of absorptive capacity that would allow it to benefit from export as a channel for technology transfer.

Overall, looking at the results from both countries, it appears that opening up to international trade has contributed to the rise in demand for skilled workers and consequently in skill premiums, but has not had such an effect on the demand for unskilled workers. In other words, globalization and liberalization play a significant role in increasing the inequality gap between skilled and unskilled labor. This implies that policy makers in DCs and LDCs need to heed this growing phenomenon of skill biased technological change and accompany their economic policies of liberalization with policies pertaining to improvement of educational systems and provision of adequate training programs. Such policies would serve two purposes; they would help reduce skill-shortages on the one hand, and increase the potential benefit from imported embodies technologies on the other hand.

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