US Within- and Between-Industry Changes of Skill Intensity: Shedding light on worker's inequality

T. Lynn Riggs*, Grigoris Zarotiadis**

Very Preliminary Version

Note: This paper reflects the viewpoints of the authors and not of the US Census Bureau. It has gone through a less rigorous review than other Census publications.

* U.S. Census Bureau, Centre of Economic Studies, Chicago, tlriggs@frbchi.org

** Department of Economics, University of Ioannina, TK 45110, Ioannina, GREECE, gzarotia@cc.uoi.gr

1. Introduction

Fatefully, the driving force for the discussion in the following pages has rather an apologetic, than a visioning nature. Instead of searching for the path towards a better future, we are still busy in revealing the sources of our present privation: The worsening of inequality between workers of different skill levels for the past 30 years is an unquestionable fact[1]. In the frame of a standard argumentation, this occurrence could be seen as the price that has to be paid for the convergence of factor returns all around the world. Disappointingly, UNCTAD (1997) demonstrates a generalized increase of income inequality in several countries, both developed and developing[2]. On the other hand, these sharply widening gaps would be less noteworthy if a sustained overall rising real wage accompanied them. Theoretically, efficient reallocation of production activities across the regions increases the real output of all countries that participate in a liberalized international economic environment, regardless their initial position. Effectively designed and applied redistribution mechanisms could then take everybody to a better position. Yet, does really worsening inequality occur in a growing economic environment? Real wages have fallen for instance in the U.S. with a yearly average of about 0,4% since 1973 (Slaughter, 1998) and although Krueger (1997) is pretty much convinced of the improvement in living standards in developing countries, perhaps the most important economic success (fairy tale) story since the Second World War, the picture that we get from several empirical contributions is not necessarily the same[3].

Contributions from the early 1990s regarding the deterioration of the less skilled and/or the production workers paid mainly attention on the supply side of the labor market: Murphy and Welch (1992) highlighted the significance of the ageing of the baby boom, while others focused on the weakening of the unions and the relaxing of minimum wage regulations (Blackburn, Bloom and Freeman 1990). Afterwards, acknowledging the simultaneous worsening of relative wages and relative employment drove the theoretical interests towards demand side explanations[4], with international trade and the technology's evolution being the two main competitive arguments. Leamer (2000), Deardorff (2000) and Panagariya (2000), give a useful overview over the specific debate,

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[1] Slaughter (1998) reports that the premium for male college-educated workers in the U.S. rose from 30% in 1979 to about 70% in 1995. Analogously, the employment of production workers in the British manufacturing sector fell between 1979 and 1992 by 41%, while the decrease for the non-production workers was only 26% (Hine and Wright, 1998).

[2] Meckl and Weigert (2003), present a theoretical scenario, based on plausible assumptions, that links the final effect on relative wages also to individual decision for acquiring human capital. Thereby, they show how the standard Stolper-Samuelson effect can be reversed, in case of developing countries.

[3] According to data presented by Streeten (1998) there was a steady decline in growth rates in several countries in the three decades after 1960, particularly for the OECD. As Rodriguez and Rodrik (1999) brought up, econometric studies focusing on the same period also show no robust relationship between growth and openness. But, with respect to absolute standards of living, Kaplinsky (2001) reports that between 1987 and 1998, a period of growing global integration, the number of people living below the poverty line remained almost unchanged. Moreover, it increased significantly in some regions, notably South Asia, sub-Saharan Africa, Europe and Central Asia (Poverty Reduction and the World Bank, 1996; Global Economic Prospects and the Developing Countries 2000.)

[4] Leuven, Oosterbeek and van Ophem (2004) support this diagnosis as they test for the consistency of wage differentials between skill groups across countries with the demand and supply conditions. The specific framework does an even better job at explaining relative wages of low skilled workers. Similar are the conclusions of Hansson (2000), regarding the change in the share of skilled labor that increased steadily over the past 35 years in Swedish manufacturing. Especially for the period during the late 1980s and at the beginning of the 1990s, acceleration in the relative demand for skills appears to have propelled higher skill shares.

as they carry on with the considerable question about the value and the meaning of the factor-content-of-trade analysis and the subsequent discussion about the importance of trade and technology.

There are however a range of questions arising, when we use the standard analytical tools. **First**, the Heckscher-Ohlin model, although useful for defining the gains from trade and the international specialization tendencies, has significant difficulties in explaining the simultaneous appearance of the **three key observances** in the western economies, provided by the original paper of Berman, Bound and Griliches (1994), which uses the decomposition methodology[5], and the contribution of Francois and Nelson (1998), among others: **a rising skill-premium**, along with **specialization tendencies toward the skill intensive productions** and a simultaneous generalized tendency of **increasing skill intensity in all branches**. Restricted by the full-employment assumption, the standard approach denies the possibility of parallel within- and between-industry adjustments, regardless of which is the underlying reason, international trade or factor biased technical changes (Zarotiadis, 2004b).

Bernard and Jensen (1995) principally shed light on the specific characteristics of exporters: they are typically larger, systematically differed in their input characteristics with higher capital intensity and investment per employee and paying higher wages and benefits. At the same time they exhibit both, significantly higher ratios of non-production to production workers and higher skill premium. Following, the same authors (1997) use the mentioned decomposition methodology in order to give more attention to the relative employment and the skill premium of non-production, high-skilled employees. Yet different to the Berman Bound and Griliches approach, they examine **plant level data** for the U.S. manufacturing sector and they conclude that increases in the skill intensity and the associated increases in the wage gap can be attributed substantially to international trade, or to be more precise, to changes of exporting establishments[6].

Second, the validity of the axiomatic technology-skill complementarity is debatable. In fact, the character of technological development was not always a skill biased one. The evolution through the eighteenth century, from «artisanal shops» to the earliest factories, was characterized by a substitution of highly skilled individuals with physical capital and less skilled labor (Goldin and Katz, 1998). Even current innovations, like simplifying complex tasks with the use of computers, can cause the demand for skilled labor to fall. Acemoglu (1998) shares the same belief by saying «…new technologies are not complementary to skills by nature, but by design». In the same paper, as well as in Kiley (1999), technology's factor-bias is being endogenized, as the response to the evolution of the region's relative factor abundance. Crifo-Tillet and Lehmann (2004) relax also the technology's single factor-biased assumption, but they take account of the factor intensity of the goods where technical change occurs. Wood (1994) goes even further by regarding defensive factor-biased innovation, as well as technical progress in general, partially as the response of domestic producers to the increasing foreign competition[7].

Motivated by the mentioned questions, latest theoretical contributions concentrated on various arguments, categorized as follow: the dominating presence of intra-industry trade

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[5] Lemieux T. (2002) proposes a simple generalized procedure of decomposing changes in the whole distribution of wages, also for other distributions suitable, into three factors: changes in regressions coefficients, distribution of covariates, and residuals.

[6] More recent papers of Bernard and Jensen (2004a, b) appear to give updates of the previously mentioned work.

[7] A more detailed scenario about the "urge to survive argument" can be found in Zarotiadis (2004b).

and the boosted innovative activity of exporters[8], along with the effect of international competition on the strategic investment decisions of incumbent firms in an oligopolistic environment (Neary, 2002) convince us of the importance of intra-OECD trade too. Tybout (2001) assesses critically the plant- and firm-level evidence on linkages that derive from relaxing the perfect competition assumption within the "new" trade theory.

Very importantly, trade in intermediate inputs and producers services, along with their counterpart, namely outsourcing-motivated FDI in regions with different relative factor abundances, induce, directly or not, a relocation of segments of production processes abroad[9]. Relevant to this approach are also models based on the product cycle hypothesis, which bring forth extra arguments for the effects of international trade on domestic distribution of income (Chun Zhu, 2004). Feenstra and Hanson (2001) recognize that outsourcing has been an overlooked but important component of trade in many of the empirical studies to date. They proceed with an analysis of the nonproduction wage share (SIC4) derived from changes in outsourcing and computer use and they find that both are important components.

Our empirical analysis in the following pages aims at motivating further the theoretical discussion. We will be using the decomposition methodology too, but different to the existing procedures, we focus on the interaction of within- and between-industry changes (WIC and BIC) of the relative skill intensity in the U.S. manufacturing. Following a similar approach has been introduced in Zarotiadis (2004a), we create a time series of annually defined WIC and BIC changes, yet with data at a more detailed level of industries classification. Further we will use modern empirical techniques in order to check for the significance, the sign and the reasoning of a supposed relationship among within and between industry changes. Then, our empirical conclusions will be discussed in relation to the inspired theoretical inference, as they enrich the debate concerning the sources of the inequality by justifying the skill-biased character of the technical change.

2. Data and Methodology

This paper merges the U.S. Census Bureau's Longitudinal Research Database (LRD) with the Bureau's new Longitudinal Business Database (LBD). The LRD contains all the data collected for the Annual Survey of Manufactures (ASM, 1973-2001) and the Economic Census of Manufactures (CM, 1963, 1967-1997 collected quinquennally). Plants in the LRD have unique identifiers that allow them to be linked longitudinally. The LBD is derived from the Bureau's Business Register and contains basic information on an annual basis about the entire universe of legally operating establishments (i.e., a plant or a store) in the United States with at least one employee, for all industries.[10] The LBD also provides unique identifiers that link establishments over time and allows us to study, if not the entire life history of an establishment, at least a significant portion (from 1976-1999).

For the analyses in this paper, we use the LRD to obtain data about total employment, non-production workers, and production workers for each establishment and to classify each establishment using 5-digit SIC product codes rather than the typical 4-digit SIC code used for most publications. Each establishment is classified as follows: in both the ASM and the CM, establishments report revenues by product class code. For this paper,

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[8] Manasse and Turini, 2001 and Sener 2001

[9] Hummels, Ishii and Kei-Mu Yi, 2001; Peeters and de Vaal, 2003; Head and Ries , 2002

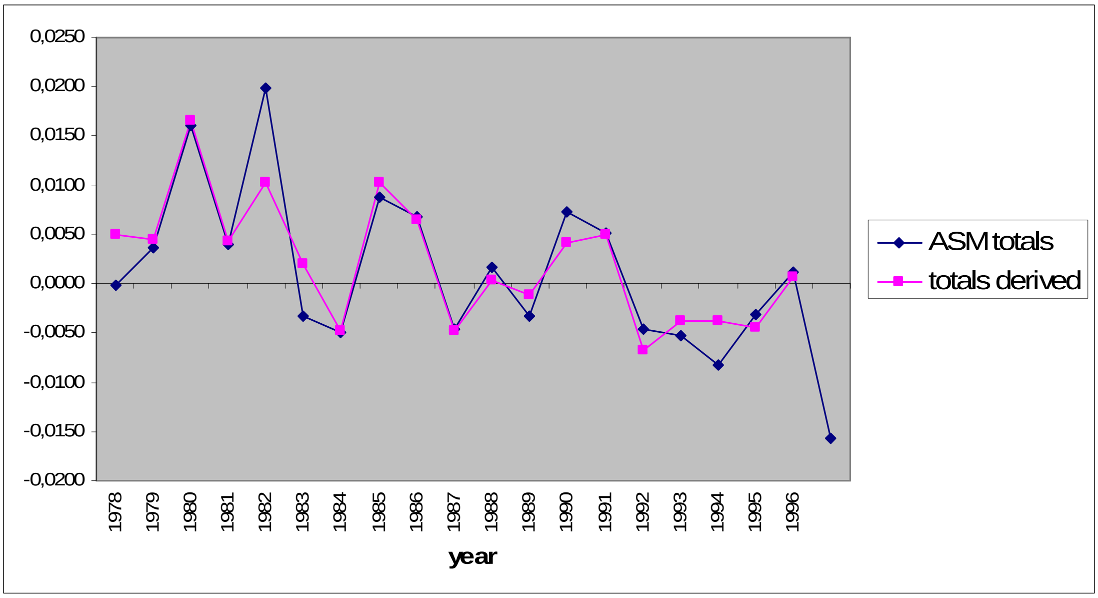
[10] For further information, see Jarmin and Miranda, 2000, *The Longitudinal Business Database*, U.S. Census Bureau, Center for Economic Studies Working Paper Series. www.ces.census.gov.

5-digit codes were assigned annually to the establishment based on the product for which the establishment had the most revenues in that year. Codes were assigned annually rather than for the entire life of the establishment since we wanted to allow for industry switching. For 1973-1996, these are 1987 SIC product class codes, typically 5- or 7-digit.[11] In 1997, the Census Bureau converted to NAICS; therefore, for 1997 and thereafter, the LRD industry product codes use the NAICS system. It is beyond the scope of this project to convert the data to one standard. Further, given the nature of these analyses of within and between industry changes, it is important to have a degree of accuracy and standardization in the system being used. Hence, these analyses use data only for the years 1976-1996[12].

The Annual Survey of Manufactures is not designed as a continuous panel, and the sample of establishments is re-selected every 5 years. There are some establishments that are retained in the sample; however, these are typically only larger establishments (employment greater than 250). While these larger firms are responsible for a vast majority of total output, examining only these firms prevents us from examining changes where change is most likely to occur, in smaller establishments. Further, using only these larger establishments is likely to not provide an accurate picture of births and deaths of establishments. For these reasons, we matched establishment data in the LRD to the LBD data using unique identifiers in order to obtain birth and death information for the establishments in our sample. The establishment-level data were then aggregated to the 5-digit industry level (weighted to account for sampling in the ASM).

Summing up the figures for production and non production employees over the whole manufacturing, after we applied the above procedure, provides us with an estimated change in relative employment of non-production workers that lies very much close to the aggregate data published by ASM (see the following diagram).

Diagram 1: Change in Relative Non-Production Employment (S/E) using published ASM totals vs. totals derived from our methodology



[11] As part of the LRD management, the Census Bureau standardized industry codes to the 1987 classifications.
[12] In "non-operating plants", all employment is non-production employment (e.g., central offices and auxiliary establishments). Non-operating plants are not included in the ASM or in CM, but their employment is tracked through other sources. Hence, these analyses focus only on operating manufacturing establishments.

This convinces us that we do not bias in any way the underlying phenomenon, even after applying the presented methodology, which offers two basic advantages over previous work done in this area:

1) using more detailed industry codes allows us to more closely examine "hidden" specialization tendencies without losing the value of aggregating above the plant level, and
2) we are able to examine the impact of births and deaths on within and between industry changes.

Specifically, we sum total employment (TE), number of production workers (PW), and other employees (OE) for each 5-digit industry over time. This gives us an industry panel from which we can assess annual changes in skill intensity at the 5-digit industry level using the traditional decomposition methodology:

1. $\Delta_t(S/E) = \Sigma[(E_i)_t/E_t - (E_i)_{t-1}/E_{t-1}](S_i)_t/(E_i)_t + \Sigma[(S_i)_t/(E_i)_t - (S_i)_{t-1}/(E_i)_{t-1}](E_i)_{t-1}/E_{t-1}$,

which is the known decomposition equation (1st term is the between industry change BIC and the 2nd term the within industry change WIC), derived for annual changes (Zarotiadis 2004).

Further, these numbers are calculated for new plants, continuing plants, and plants shutting down in each industry in each year, enabling us to assess the impact of births and deaths on the relative share of skilled employment through the following decomposition equation[13]:

2. $\Delta_t(S/E)=\Sigma[(E_i)_t/E_t - (E_i)_{t-1}/E_{t-1}]\,(S_{i,t})^r/(E_i)_t$ *"soft" BIC*

$+\ \Sigma[(S_{i,t})^r/(E_i)_t - (S_{i,t-1})^r/(E_i)_{t-1}](E_i)_{t-1}/E_{t-1}$ *"soft" WIC*

$+\ \Sigma[(E_i)_t/E_t - (E_i)_{t-1}/E_{t-1}]\,(S_{i,t})^b/(E_i)_t$ *"hard" BIC*

$+\ \Sigma[(S_{i,t})^b/(E_i)_t - (S_{i,t-1})^d/(E_i)_{t-1}](E_i)_{t-1}/E_{t-1}$ *"hard" WIC*

After calculating the four different parts of overall annual change in manufacturing's skill intensity, we proceed with a discussion of the partial correlations searching for the direction and the causality among them.

3. Industry Aggregation Does Matter

Being about to make use of the first advantage given by the aforementioned methodology, we first want to take a look on the relative significance of WIC and BIC when we move from a less to a more detailed classification level. Bernard Bound and Griliches (1994) as well as Zarotiadis (2004a) found that within industry changes of skill intensity accounted for the vast majority of overall change, at least during the 70's and the 80's.

We also provide an analogous picture when we apply the decomposition according to equation **1** for industries being classified at the 4-digit level. Although the period we are focusing in is more recent (1976-1996), we see also that WIC is similarly more important, accounting for more than 74% of overall change in relative non-production employment. Yet, the picture gets reversed as soon as we move to a more detailed classification: for

[13] In general, we do not have any data for a plant in the year in which it is considered a death. However, that fits exactly into the previous decomposition equation. For example, for firms that "die" in 1990, we calculate the number of skilled workers in 1989 that will lose their jobs in 1990 as a result of the death of the plant. See in appendix for a more detailed derivation of the 2nd equation.

industries defined at the 5-digit level WIC accounts only for 0,0159 of 0,0401, which is the total absolute change of the ratio non-production workers over total employment for the whole period. In other words, significance of WIC falls down to 40%, removing any argument for justifying that skill biased technical change, rather than international specialization adjustments, is the main cause for the observed worsening in inequality.

4. Decomposing Changes in Skill Intensity

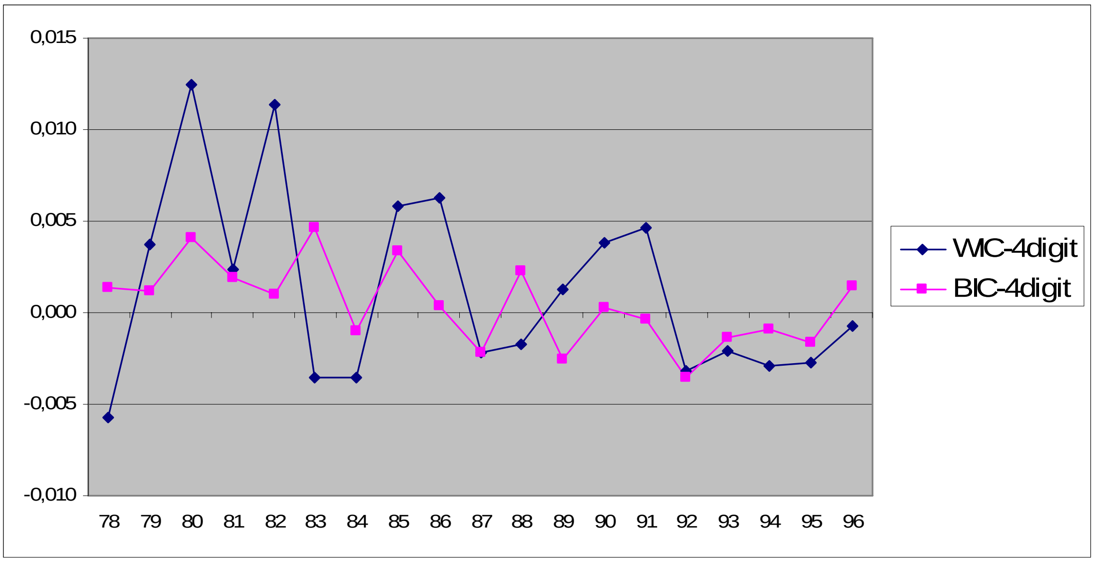
4.a Using the simple within- and between industry decomposition

Beside restating the significance of WIC, Zarotiadis (2004a) refers to the remarkable positive correlation among the annually estimated within- and between-industry changes. After denying alternative explanation scenarios, like the importance of Business Cycles and the hypothesis that BIC would result out of WIC, he concludes that either there is a defensive, by design skill biased technical change, or simply there is substantial hidden BIC into the estimated WIC, again for different reasons. Whatever the real cause is, the international competition regains in importance as to whether it causes worsening of inequality or not.

Alone the fact that moving to the 5-digit industry classification changes the decomposition dramatically, as shown in the previous section, speaks for the validity of the simplest versions of the hidden-BIC argument: In less detailed classification levels movements of firms to similar sub-industries of different skill intensity account as within-industry-changes, although they are clear specialization tendencies, or in other words direct responses to the relative intensity of international competition.

The following results of the correlations among annual WIC and BIC for 4- and 5-digit classification respectively confirm this hypothesis. Using the annually decomposed changes for the less detailed industries we calculated a significantly positive correlation of 0,38. Oppositely, when we did the same with the 5-digit industries correlation of annual WIC and BIC became almost zero (0,05). The pictures in the following diagrams provide a visual presentation of it.

Diagram 2: WIC and BIC at the 4-digit industry classification



So is the answer to an initially very "promising" paradoxical question so unexciting and boring? Is it only that, simple data limitations led us to an overestimation of WIC? Is hidden BIC due to roughly aggregated industries the only reason that lies behind the significant positive correlation of within- and between industry changes of relative employment in our times? The discussion in the following last section of the paper goes toward these queries.

Diagram 3: WIC and BIC at the 5-digit industry classification