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Endogenous Skill Biased Technical Change: Testing for Demand Pull Effect

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GINI Discussion Paper 26
December 2011

GROWING INEQUALITIES' IMPACTS

Acknowledgement

We wish to thank our research assistant, T. van der Veen and the GINI team. A special acknowledgement to V. Maestri and B. Nolan for discussion and to all those who attended a workshop in Amsterdam.

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Bibliograhic Information

Bogliacino, F., and Lucchese, M. (2011). Endogenous skill biased technical change: testing for demand pull effect. Amsterdam, AIAS, GINI Discussion Paper 26

This paper can be downloaded from our website www.gini-research.org.

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Testing for Demand Pull Effect

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DP 26

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Abstract

In this article we use the unification of Germany in 1990 to test the hypothesis that an increase in the supply of a production factor generates skill biased technical change. We test for this mechanism in the context of the model presented by Acemoglu and Autor (2011) that allows endogenous assignment of skills to tasks in the economy. We use cohorts of workers from comparable countries as a control group. After discussing the possible confounding factors, we conclude that this effect is absent. The differential pattern among the countries seems to be determined by labor market flexibilization and tax reform.

Keywords: Skill Biased Technological Change, Polarization, Natural Experiment

JEL codes: J31, O33, O52

1. Introduction

After more than twenty years in which Skill Biased Technical Change (SBTC) has raised intense debate through a sizable strand of literature, we believe that a basic question has remained unsolved, i.e. one concerning its main determinant. Why was it that from the 1970s onwards, technical change followed a precise direction and tended to systematically favor certain production factors?

In the literature, the issue has been addressed at a theoretical level and with some indirect evidence. However, to the best of our knowledge, no empirical paper attempts to identify any of the proposed mechanisms put forward by the theory.

The aim of this paper is to address this empirical issue. At the present stage of the debate, we have now a good workhorse to account for the basic stylized facts in terms of demand and supply of skills: this model is presented in Acemoglu and Autor (2011). By addressing the allocation of skills and tasks together, it is able to fit most of the main trends in terms of change in occupational structure and wage differentials in the US labor market.

However, the picture should be completed with an account of endogenous technological change. Since the hypothesis of a steady SBTC process is not consistent with both the more recent post WWII trends because of the post 1970s breakthrough (Acemoglu, 2002) and the history of industrialization (Mokyr 1993), we need a theory of directed technical change. In our opinion, there can only be two hypotheses: *demand pull* and *technology push*. The former puts forward a causal mechanism that goes as follows: a machine is relatively more productive if associated with a certain type of worker; machines are invented by forward-looking firms; if there is an increase in the supply of skill A in the labor market, then firms will develop machines that complement skill A (Acemoglu 2007).[1] The technology push argument stresses the uneven evolution of technology and its paradigm-based nature: every cluster of new innovations shares certain properties, and the ICT revolution has an SBTC characteristic (Aghion 2002).

While there is some indirect evidence for both theories, they both lack empirical assessment. Indeed, it is very difficult to identify the causality link in both cases: apart from cross-country regressions (preliminary by definition), the only possible way is to look for some natural experiment.

Our strategy is to use a historical episode, namely the unification of Germany in 1990. Like other former planned economies, East Germany had a good education system with high enrollment rates and a focus on engineering and hard sciences (Berryman 2000). In 1990, a large inflow of highly educated workers entered the labor market and if the *demand pull* hypothesis holds, we should expect an increase in SBTC, resulting in a polarization

1 In this framework, the term "demand pull" is borrowed from Schmookler (1966). In the latter, the reference is to the role of demand in the introduction of innovation. In this case, the downstream firms who employ new skills represent the pool of consumers for the new machines; the analogy is derived from this fact.

effect in the Acemoglu and Autor (2011) framework. Since the law of unique price for skill applies, we should expect to observe the effect when we restrict the analysis to West Germany only, avoiding the inclusion of measurement error induced by the dramatic changes that were occurring in the Eastern part. As a control group, we will use the cohorts in the labor market in comparable countries.

With regard to the general trends, we show that there is some evidence of polarization in the labor market, but the process started much later than in the US. Coming to the main focus of the paper, we do not find any statistically significant demand pull SBTC effect. After considering the other forces at work, we conjecture that the reforms in labor market and tax legislation played a main role in explaining the differential behavior of earning, with an inequality enhancing effect.

This paper proceeds as follows: Section 2 introduce the issue at stake and the theoretical hypothesis, Section 3 presents the data and the methodology, Section 4 discusses at length the robustness of the results and Section 5 concludes.

2. The Framework

2.1. From the canonical model to the Ricardian Model

The SBTC hypothesis originated in the 1990s, due to mounting interest in explaining the increase in the college premium in an historical conjuncture in which the relative supply of college educated was sharply rising. The logic of the argument was quite simple: if both price and supply increase, demand should increase as well.

If the production possibility frontier can be summarized by an aggregate CES function, then in a competitive market, the marginal rate of transformation - and the skill premium in the labor market- has the following expression:

$$\log MRT = \rho \log(A_s / A_u) + (1-\rho)\log(U/S) \quad (1)$$

where *u* indicates unskilled, *s* skilled and the *A* is a technical progress term, in an augmenting form. As can be seen, there is a race between education and technology (Tinbergen 1975), which explains the observed skill premium.

The skill bias nature of technology in recent years has been addressed by multiple contributions that have tried to identify at micro, meso and cross-country level the effects of some proxies of innovation on the relative demand of skills, sometimes expressed as white collars over blue collars and sometimes as higher educated over lower educated (Acemoglu, 2002; Chennels and Van Reenen, 2002). This literature is quite heterogeneous and an evaluation is beyond the scope of this paper, but we can tentatively conclude that most of the evidence is in favor of a positive answer to this question.

A more complicate issue is the capacity of this theory to fit data. After discussing the existing literature at length, Autor et al. (2006) and Acemoglu and Autor (2011) conclude with a negative answer. In fact, this basic version raises three puzzles. Since technical change occurs in an augmenting form, it can never generate replacement of skills and decreasing wages at any percentile of distribution (a well-known stylized fact in the US). Moreover, it cannot explain the change in the occupational structure, biased against “middle class” jobs. Finally, it cannot

generate polarization in the long run: another stylized fact is indeed the increase in relative wages at both the top and the bottom of distribution together with a decrease in the middle.

Autor et al. (2003) and Autor and Dorn (2009) made the case for a theory of the labor market that could account for the replacement of middle class jobs: technical change (or trade, or offshoring) is hitting those "routine jobs" that can easily be replaced by machines (or externalized) and favoring jobs that cannot be outsourced (manual jobs) or tend to "complement" technology (abstract jobs).

Such a model is labeled Ricardian and is presented and discussed in Acemoglu and Autor (2011), building upon Acemoglu and Zilibotti (2001). In this model, there is a continuum of tasks of mass one that can be allocated to different skills (high, medium and low) and each task has a simple *perfect substitute* production function:

$$\begin{aligned} Y &= \exp\left[\int_0^1 \ln y(i)di\right] \\ y(i) &= A_L \alpha_L(i) l(i) + A_M \alpha_M(i) m(i) + A_H \alpha_H(i) h(i) \end{aligned} \tag{2}$$

where $\alpha_J(i)$ is the productivity of skill *j* in task *i,* and *A* is a standard factor-augmenting productivity term. The equilibrium of this model is determined by three simple rules: each task should be assigned to maximum one skill, all those offering the same skill should be paid the same price and there should not be arbitrage across skills.

This model has two main advantages when explaining the change in earning distribution: on the one hand, the replacement of skills across tasks can generate decreasing wages for some workers; on the other hand (and related to the previous point), it can account for polarization.

The reason why this is possible is straightforward: while technical change still occurs in an augmenting form, in this framework, it can change the pattern of competitive advantages, displacing some workers from the tasks that they were previously performing.

Using this theoretical framework as a benchmark, a third question, one that is the main focus of our contribution, should be addressed. What is the source of SBTC? The theory needs to put forward a source because, through history, we observe different "biases": in fact, as discussed by Acemoglu (2002), the hypothesis of a steady SBTC process is not consistent with data, given the acceleration of the post 1970s and the presence of historical episodes of de-skilling.

As a matter of fact, we can only provide two general hypotheses, i.e. the direction can only be exogenous or endogenous.[2] The first case - the technology push story - is a general label under which more specific mechanisms are put forward such as the technological revolution (Caselli 1999), the decline in the price of ICT capital (Autor

2 "Exogenous" and "endogenous" is meant with regard to the source of the bias, regardless of the underlying theory of technical change, which in all cases follows the baseline setup of a standard endogenous growth model.

et al., 2003; Krusell et al. 2000) and the introduction of General Purpose Technology (Aghion 2002). The second case is the one in which technological change is directed because of profit incentives. The most important version of the theory is in Acemoglu (2007) (a generalization of Acemoglu, 1998), which is based on a demand pull argument: technologies complement skills, so that where there is an increase in the relative supply of a skill, there are more incentives to "direct" the new machines towards the skill that is becoming relatively abundant.

To the best of our knowledge, any other possible argument can be reframed in either one or the other: a) besides demand and supply, there may be institutional changes, but to have an effect, they should either drive the adoption skill biased machines (exogenous) or affect the profit incentives (making one of the factor market relatively more scarce or abundant[3]); b) any behavioral impulse towards skill bias is a technology push argument as well, i.e. related to the logic of the scientific discovery along a trajectory (Dosi, 1988) or related to some cultural factor (as in the version that stresses the "ideological" shift of the 1980s, as described in Howell, 1999).

In the Acemoglu (2007) framework, a weak skill bias effect occurs when the partial effect of an increase in the skill supply on the wage is positive and a strong effect when the total effect including the adjustment in the supply is positive.

In both cases, the assumptions that should hold are the ones needed for a locally isolated equilibrium: the equilibrium technology should be in the interior of the convex technology set, and the net production function should be twice differentiable. The strong version of bias requires also non-convexity of the (properly defined) global production function (a standard assumption of Endogenous Growth Theory).

3 Technically, even a Marxian-Hicksian argument in which technical change is "Unskilled Labor" Saving because of bargaining power can be relabeled as a demand pull effect. In that framework, the introduction of machines is triggered by the induced scarcity of a factor. However, we will not state that our test of demand pull à la Acemoglu can cover these cases, because the environments (especially the assumptions on the functioning of the labor market) are very different and we opt for a conservative interpretation of our results.

2.2. An empirical framework

In their empirical framework, Acemoglu and Autor (2011) regress the rate of change of the hourly wage per cohort over a set of proxies of technological change, controlling for the initial pattern of competitive advantage:

$$\Delta w_{sejk\tau} = \sum_t \beta_t^A \gamma_{sejk}^A \cdot 1[\tau = t] + \sum_t \beta_t^M \gamma_{sejk}^M \cdot 1[\tau = t] + \Lambda + e_{sejk\tau} \quad (3)$$

where *s* stands for sex, *e* for educational level, *j* for region, *k* for age group and τ for time, the gammas are the shares of each cohort in abstract and manual jobs (the excluded category is routine jobs) and are interacted with decade dummy. Λ is a set of dummies, related to the various characteristics of the cohorts.

The logic of the argument is the following. They classify the occupations into three categories: abstract, routine and manual. The central group consists of occupations that are more prone to replacement by Information and Communication Technologies (and/or outsourced); the first group is the one that has a strong complementarity with new technologies and the last group is the one with a weak complementarity since it is not outsourceable. The implication of the model is that the decline in the market price of the routine tasks (due to technological change) will drive down the price of the skill groups that initially had a comparative advantage in this task.

If both β_t^A and β_t^M are positive, there is polarization (given the omitted category of routine jobs), if only β_t^A is positive, then complementarity only occurs for the high skilled group.

By taking the initial occupational shares, they control for the pattern of comparative advantage; interacting the shares with the decade dummies, they try to identify changes in wage structure as an effect of the raising competition of information technologies. They control for all the observable characteristics that are related to the definition of the cohorts.

It is difficult to give a causal interpretation to the coefficient in this framework because the time dummies should be interpreted as fully capturing the technical change. Even assuming a pure reduced form interpretation, endogeneity of the supply makes it impossible to interpret the effects as an endogenous bias of technology.

3. Data and methodology

3.1. Empirical Strategy

We propose using a natural experiment. We look for an exogenous source of variation in skill supply, in our case, for the high-skill group. Under the abovementioned assumptions, SBTC occurs. Since these workers had a comparative advantage in abstract tasks, we would expect the interaction between the time dummy and the initial share of abstract occupations to impact positively on the rate of growth of wage, i.e. we interact it with the treatment effect.

Our proposed formulation is a slight modification of (3):

$$\Delta w_{sejk\tau} = \sum_t \alpha_t^A \gamma_{sejk}^A \cdot 1[\tau = t] \cdot D_{it} + \sum_t \alpha_t^M \gamma_{sejk}^M \cdot 1[\tau = t] \cdot D_t + \sum_t \beta_t^A \gamma_{sejk}^A \cdot 1[\tau = t] + \sum_t \beta_t^M \gamma_{sejk}^M \cdot 1[\tau = t] + \Lambda + e_{sejk\tau} \quad (4)$$

where the only change is in the D_{it} variable, which is a standard treatment dummy: it is equal to one for the treated country after the shock and zero otherwise. Indeed, this is the only way we can try to identify the treatment effect, in the relationship between the initial pattern of comparative advantage and the wage, while any other effect would be confounded with any other country-level factor.

As a natural experiment, our source of variation is the unification of Germany in 1990. Like all the other Soviet economies, East Germany had very high enrollment rates and a high quality of education, especially in the engineering and scientific domain. We consider the effect on West Germany alone, to eliminate other sources of variability arising from adjustment and to control for composition effects (Friedberg, 2001).

As a control group, we use other countries in the same data source, following criteria of comparability, lack of treatment and availability of homogeneous data. Details are given in the next section.

By using the patterns of comparative advantage before the unification, identification occurs under the following assumptions: a) the pattern of comparative advantage of East German workers is not systematically different from their West German colleagues, for a given type of skill; b) the pattern of comparative advantage of East German workers before the unification should not be correlated with the subsequent wage dynamics in West Germany. For the latter, we could not find any possible objection (to the best of our knowledge) and this is also accepted in the literature (Friedberg 2001). The former may be questionable, but given the good level of the educational system

and the fact that these workers were certainly facing less integration problems, we do not expect a systematic post shock occupational downgrading.[4]

We should mention that if a) fails, although we cannot pretend to fully identify, we can still find indirect evidence of endogenous SBTC. Unless there is fully random assignment of Eastern workers to tasks (very unlikely), there should be some systematic allocation of the former in a way in which skill A in East Germany is considered perfect substitute for a skill B in West Germany. If this is the case, we should see a significant effect in one of the two alphas (the sign depending of course on how this East-West matching is performed). In other words, if we assume for example that high educated eastern workers substitute for medium skill western workers, who had a pre-treatment comparative advantage in routine tasks, we should see negative (and significant) alphas (the effect of a Medium Skill Biased Technical Change shock, as discussed in Acemoglu and Autor, 2011). However, the interpretation is more complicate because we cannot provide a justification for alternative assigment, that is why we prefer to be conservative and in the case in which a) does not hold, interpret the results as indirect evidence.

In the literature our approach is close in spirit at those contribution that use immigration as source of exogenous variation. It has been used in a variety of analysis on labor market issues, as documented by the review in Boustan et al. (2011). A few papers investigate wage differentials. Gandal et al. (2004) use the Russian immigration to Israel in the 1990s to discuss the change in skill mix, but without looking at causal connections. Kerr and Lincoln (2010) discuss the "supply side" of innovation, namely the innovation introduced by immigrants, controlling for crowding-out and crowding-in, while we are concerned with supply-and-demand interactions. Finally, Lewis (2011) uses the data on immigration to predict the adoption of unskilled labor saving technologies, exploting as instrument the tendency by workers to settle in "cultural enclaves". However, this study is restricted to the high

4 In this approach, we are immune to the "attenuation bias" discussed by Aydemir and Borjas (2011). First of all, as we discussed above, the endogenous reallocation of workers is immaterial for the prediction of the model. Secondly, we do not exploit cross cells variability, but rather aim at identifying the effect exploiting the law of unique price for a skill. To put it plainly, we are only trying to identify the effect at the skill level, counting on the diffusion process related with technology adoption, while the bias induced by measurement error would affect the use of cross cells variability due to inflows by immigrants.

school dropout-high school graduated differentials and limited to a subset of manufacturing, while ours includes the overall economy and controls for workers re-allocation through tasks.

To summarize, this is the set of issues that we investigate:

a the presence of polarization in Europe, as a response to the changes in the technological domain (regardless of its origin), which is reflected in positive β_t^A and β_t^M. Essentially, we expect to observe a baseline trend in Europe approximately similar to the one sketched by Acemoglu and Autor (2011) for the US, except for the possibility of different timing and magnitude, and taking into account the fact that our time span is shorter;

b since the West Germany economy witnessed a supply shock on the labor market that does not characterize our control group, we expect to have a differential effect for the former. Under the assumptions discussed above, this shock should generate SBTC and we therefore expect a positive and significant effect of the treatment, captured by positive α_t^A and α_t^M.

3.2. Data

Data for this study come from the Luxembourg Income Study, a project that collects national survey data, standardizes them (where possible) and offers researchers remote access to the anonymized data. Data are organized in waves. A household and a personal database are available for each survey (LIS, 2011).

The main object of our study is Germany. We use data from the 1989 wave of the person level survey (pre-treatment) that covers only West Germany. From the following two waves (1994 and 2000), we extract the sub-sample belonging to West Germany: we match the household and person database using the unique identification variable and extract the region of residence information.

When selecting the countries that we should use as a control sample, we used two criteria: comparability of countries and comparability of data in the LIS questionnaire. France is the best candidate: it is comparable to (West) Germany for GDP per capita, population, labor market institutions (high firing cost) and size of the welfare system (level of taxation and so on). Fortunately, the quality of the data in terms of comparability is also very high. The waves are 1989, 1994 and 2000 as for Germany.

We exclude all the former Soviet countries because they were “treated” and exclude non-European countries for (lack of) comparability. We exclude Scandinavian countries and Finland because they did not provide comparable educational classification: in the database they do not have the re-ranking of educational attainment harmonized to ISCED 1997 (UNESCO, 2006). We also exclude Austria, Belgium, Italy and the Netherlands because they do not provide the ranking of occupational classification according to the ten ISCO classes (ILO, 1987)

and, finally, we exclude Ireland because the variable wage is empty for the pre-treatment wave. We include Spain (1990, 1995, and 2000) because we have comparable variable definitions.

The variable wage refers to annual gross wage, including both taxes and contributions to the social security system. We do not have information on hours for Spain and France and will discuss the role of hours in Section 4 below. We express everything in 2000 PPP euros, using inflation rate information from IMF and exchange rates and PPP conversion rates from Eurostat.

In Germany, wages are available gross of taxes and employee contributions to the social security system. We add the employer contributions using the information provided by the OECD Tax database (OECD, 2011a). For France, data are gross of taxes and net of social security contributions, and we add them using the same OECD source. Spanish data are net of taxes and contributions: we use OECD data for both (for taxes, information on the methodology is in OECD (2011b).

The cohorts are based on sex (male or female), education (primary, secondary or tertiary according to ISCED classification), age (25-34, 35-44, 45-54, 55-64) and macro-region of residence. For the latter, we define two regions for West Germany, two for France and two for Spain. The North of Germany includes West Berlin, Schleswig-Holstein, Hamburg, Lower-Saxony, Bremen and North Rhino-Westfalia and the South, Hessen, Rheinland-Pfalz, Saarland, Baden-Wuerttemberg, and Bayern. In France, in the first region, we include the following NUTS-1[5] regions: Ile-de-France, Bassin Parisienne, Nord, Ouest and in the second one, we include Sud-ouest, Centre-est, Méditerranée. In Spain, the center-north includes the North-East, North-West, Center, and Madrid NUTS 1 regions whereas the South, includes South, East and the Canary Islands.

To determine the pattern of comparative advantage, we split occupations into three groups: the Abstract jobs category corresponds to the ISCO groups of managers, professionals, technicians and associate professionals, and skilled agricultural workers, Routine jobs include clerical support workers, crafts and related trades workers, and plant and machine operators and finally, Manual tasks are those classified as ISCO group services and sales workers, elementary occupations and armed forces occupations.

In order to weight the regressions, we build weights from the normalized sample ones provided by the original survey: the new cohort weights are the sum of the weights of all the individuals belonging to a cohort. In this way, we also assess the impact of cells in which there are few individuals.

5 Nomenclature of territorial units for statistics (NUTS). For a definition and discussion, see Eurostat [2007].

4. Results and discussion

4.1. The Treatment

If we look at the distribution of educational attainment in East and West Germany in 1994[6], we can see there is a supply shock.

In East Germany, the share of population aged 25-64 with tertiary education was 36% for males and 31% for females, against 27.8% and 27.1% respectively for the West. For the 35-44 age group, the shares are 40 and 41 for the East compared with 33 and 25 for the West; for the 44-55 age group, they are 44 and 32 compared with 30 and 19; for the 55-64 age group, they are 50 and 19 compared with 23 and 12. The only small difference is in the 25-34 age group, where the shares are 17 and 32 for the East and 24 and 21 for the West. When computing the shares, we used the sample weights.

The exogeneity of the treatment is based on the political scenario that paved the way to reunification and we are not aware of any factor behind a systematic correlation with the wage dynamics in West Germany or the pattern of comparative advantage of skills groups before the unification, as compared with other countries such as France and Spain. We test the effect on West Germany only, because including the whole of Germany would include significant noise due to adjustment to the market economy by the East and because we want to correct for composition effects.

As a statistical support for the validity of the treatment, we add two additional arguments. On the one hand, the pattern of comparative advantages in the pre-treatment period is not statistically different for the treated and control groups. The t-test for the share of abstract jobs is 1.02 and equality of the means is not rejected (p-value 0.30); for the manual share, the statistics is -0.41 (p-value 0.67). In both cases, we corrected for unequal variances.

On the other hand, there is almost perfect balancing in terms of age composition in the pre-treatment period: considering the four age cohorts (25-34; 35-44; 45-54; 55-64), the shares for Germany are 32.6, 27.8, 26.8, and 12.6 whereas for the control group they are 31.1, 32.5, 22.8, and 13.4 (the shares are weighted with sample weights). With regard to distribution by skill, the share of high skill in Germany is indeed higher in 1989 (24.3%

6 The educational attainments of population aged 25-64 in 1994 is of course determined by choices made in the pre-treatment period.

compared with 16.3%), but if we run a t-test for the high-skilled wages in the pre-treatment period, the equality of the means is not rejected (the statistic is equal to -0.67, p-value 0.50).

In terms of interpretation of the results, we should point out that since we are not able to correct for the subsequent endogenous allocation of the skill supply (although we control for part of it through educational and age dummies), we will only identify the total effect. Since this version of SBTC occurs under stronger assumptions (although non-convexity is fairly standard in this kind of literature), a rejection does not imply the absence of a weak form of the bias.

As we said above, the implication of the model holds regardless of the endogenous re-allocation of skills to tasks: an SBTC effect should translate to an increase in the relative wages of high and low skilled workers. Since these groups have comparative advantages in abstract and routine tasks, this should be seen in the interaction between pre-shock shares and the treatment. However, in the identification, we should be careful with the attribution of the effect to labor demand through technological change because of the presence of confounding factors. We will discuss them in detail in a subsection below.

4.2. The Results

We run separate regressions for male and female workers. In each case, we use Weighted Least Squares and the weights are calculated as a sum by cohort of the sample weights. We include country, region, age group, and the educational attainment fixed effect. Results are shown in Table I.

table I *WLS Stacked First-Difference Estimates of the Relationship Between Demographic Group Occupational Distributions in 1989 and Subsequent Annual Changes in Demographic Groups' Mean Log Wages by LIS wave, 1989 — 2000*

	Males	Females
	(1)	(2)
Abstract Occupation Share		
1989 Share x 1989-1994 dummy	-0.021 (0.056)	-0.084 (0.056)
1989 Share x 1994-2000 dummy	0.061 (0.040)*	0.199 (0.075)***
1989 Share x 1989-1994 dummy x West Germany	0.020 (0.044)	0.036 (0.100)
1989 Share x 1994-2000 dummy x West Germany	0.048 (0.043)	0.009 (0.097)
Manual Occupation Share		
1989 Share x 1989-1994 dummy	-0.034 (0.011)***	-0.268 (0.150)*
1989 Share x 1994-2000 dummy	0.428 (0.079)***	0.411 (0.105)***
1989 Share x 1989-1994 dummy x West Germany	0.097 (0.146)	0.047 (0.182)
1989 Share x 1994-2000 dummy x West Germany	0.061 (0.158)	-0.143 (0.185)
Lambda	Yes	Yes
Obs	142	136
R-squared	0.51	0.38
F-test (Pvalue)	7.41 (0.00)	4.01 (0.00)

Source: LIS data for West Germany 1989, West Germany 1994, West Germany 2000, France 1989, France 1994, France 2000, Spain 1990, Spain 1995, Spain 2000. Each column represents a WLS regression of average (annual) rate of change of annual wages by cohort and year, where cohorts are defined by sex, age (25-34, 35-44, 45-54, 55-64), region of residence (North and South), country of residence, and educational attainment (ISCED 1, 2 and 3). Weights are calculated as sum by cell of the sample weights.
Abstract, Routine (the omitted category) and Manual jobs are defined according to ISCO classification, homogeneous among the three countries: Abstract includes ISCO classes managers, professionals, technicians and associate professionals, and skilled agricultural workers; Manual includes services and sales workers, elementary occupations and armed forces occupations.
Lambda includes time, country, region, age groups, and educational attainment fixed effects.
Standard errors in parenthesis. One, two or three stars indicate significance at ten, five and one percent respectively.

First of all, a few comments need to be made on the general pattern of change, for comparability with Acemoglu and Autor (2011). The decade can be broken down into two sub-periods. In the first part, there is clearly a compression effect (negative coefficients for both abstract and manual jobs) and in the second period, there is a polarization effect. These effects are statistically significant. This first set of results suggests that the dynamic of

polarization in Europe started at least ten years later than in the US. Most of the change seemed to occur in the manual jobs category, which means that those affected were the low skilled workers.

In principle, the sign of the treatment effect is coherent with the demand pull SBTC theory, but it is not statistically significant. The only exception is the coefficient for the treatment interacted with the second wave dummy and the share in manual occupation for women which is negative (but not significant). According to this evidence, even if there has been an increase in the demand for skilled workers, we cannot speak of an acceleration with regard to the control group. Acemoglu and Autor (2011) consider a much larger time span; however, we think that it is difficult to assume than in ten years, technical change does not display its effects (although the literature is not unanimous on this point, e.g. David, 1990), and in any case, if we were to extend the time period further, the identification of the treatment effect would cast serious doubts because of the complex set of factors intervening.

4.3. Robustness of the Results

In Table II we report the results of the demand pull effect estimated from a series of slightly modified versions of (4). The regressions are identical to those in Table I, but in the first six columns we omit Spain from the control group, in columns 3-8 we exclude categories six and ten from the ISCO classification (skilled agricultural workers and armed forced occupations), which may be affected by some peculiar dynamics, and finally in the last six, we weight the regressions using the mean start and end-year share of employment of each demographic group for each wave (this is the same weighting procedure as Acemoglu and Autor, 2011).

The main change is that the exclusion of Spain makes some of the coefficient turning out significant: a positive effect for male high skilled workers in the second wave and a negative effect for female lower skilled workers in both periods. As we will argue below, we suggest that this can be attributed to the confounding factors.

Table II Summing up of the estimated demand pull effect

	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treatment Effect										
abstract-first wave	0.015 (0.029)	-0.050 (0.038)	0.019 (0.026)	-0.035 (0.034)	0.017 (0.028)	-0.031 (0.035)	-0.014 (0.048)	0.014 (0.113)	-0.006 (0.052)	-0.017 (0.117)
abstract-second wave	0.045 (0.028)	0.005 (0.036)	0.046 (0.025)*	0.016 (0.032)	0.044 (0.026)*	0.018 (0.033)	0.017 (0.045)	-0.025 (0.107)	0.027 (0.048)	-0.047 (0.111)
manual-first wave	0.023 (0.099)	-0.140 (0.069)**	0.057 (0.089)	-0.088 (0.060)	0.046 (0.091)	-0.080 (0.059)	0.011 (0.154)	0.004 (0.193)	0.030 (0.163)	-0.079 (0.206)
manual-second wave	0.098 (0.106)	-0.148 (0.070)**	0.140 (0.095)	-0.100 (0.060)	0.130 (0.095)	0.094 (0.060)	-0.040 (0.160)	-0.203 (0.196)	-0.016 (0.169)	-0.279 (0.209)
1989 Shares x Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lambda	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spain included	No	No	No	No	No	No	Yes	Yes	Yes	Yes
ISCO 6and 10	Yes	Yes	No	No	No	No	No	No	Yes	Yes
Weights	Sample	Sample	Sample	Sample	Cohort	Cohort	Cohort	Cohort	Cohort	Cohort

Source: LIS data for West Germany 1989, West Germany 1994, West Germany 2000, France 1989, France 1994, France 2000, Spain 1990, Spain 1995, Spain 2000. Each column represents a WLS regression of average (annual) rate of change of annual wages by cohort and year, where cohorts are defined by sex, age (25-34, 35-44, 45-54, 55-64), region of residence (North and South), country of residence, and educational attainment (ISCED 1, 2 and 3). Weights are either calculated as sum by cell of the sample weights (labeled sample in the table) or as mean start and end-year share of employment of each demographic group for each wave. (cohort in the Table). The treatment is a dummy for West Germany interacted with 1989 occupational shares and time dummies (the regressions are identical to those in Table 1).

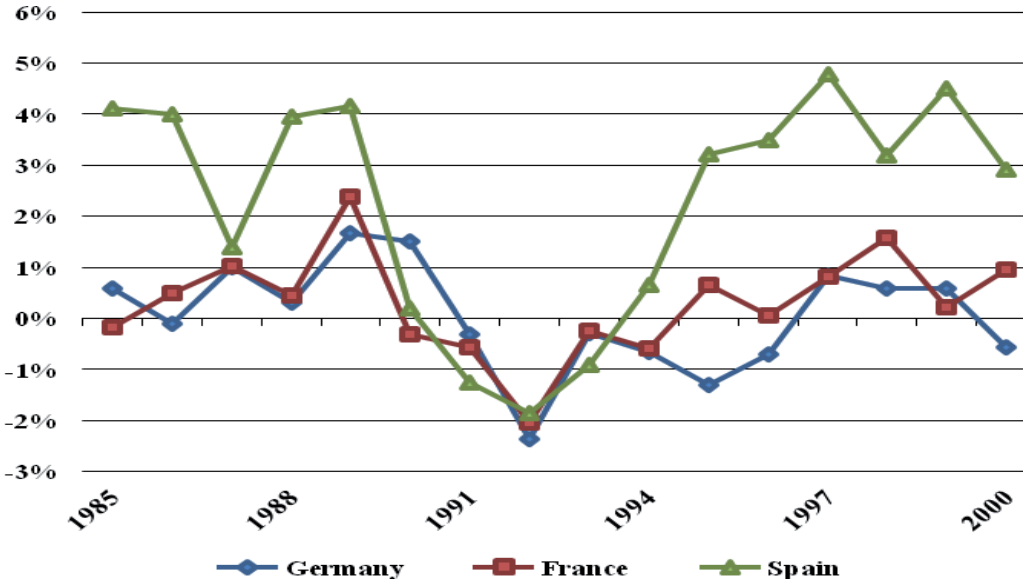
Abstract, Routine (the omitted category) and Manual jobs are defined according to ISCO classification, homogeneous among the three countries: Abstract includes ISCO classes managers, professionals, technicians and associate professionals, and skilled agricultural workers; Manual includes services and sales workers, elementary occupations and armed forces occupations. The ISCO 6-10 row indicates that "skilled agricultural" and "armed force" are included.

Lambda includes time, country, region, age groups, and educational attainment fixed effects.Standard errors in parenthesis. One, two or three stars indicate significance at ten, five and one percent respectively.

As usual, for if the identification is to be consistent, we need to discuss the confounding factors. In the previous section, we have already discussed the time length (to let technical change fully display its effects) and the use of West Germany to eliminate the distortionary effects of the economic adjustment in the East.

The first variable to take into consideration is the role of worked hours. In fact, Acemoglu and Autor (2011) consider hourly wages. In addition to the fact that hours are usually subject to measurement error in surveys, we do not expect them to play any significant role in this case. In Figure I, we plot the rate of change of working hours over the 1985-2000 period. Data are taken from the EUKLEMS database (O'Mahony and Timmer, 2009). We consider Germany as a whole because we cannot distinguish between West and East. The two series for France and Germany are almost indistinguishable. Spain has a slightly most pronounced U-shaped pattern at the beginning of the 1990s but the dynamics are the same. In addition, a change in working hours related to endogenous re-allocation of skills to tasks is not relevant for affecting the basic prediction of the model, as already discussed above.

Figure I The change in worked hours over the period 1989-2000 in the three countries



Source: EUKLEMS.

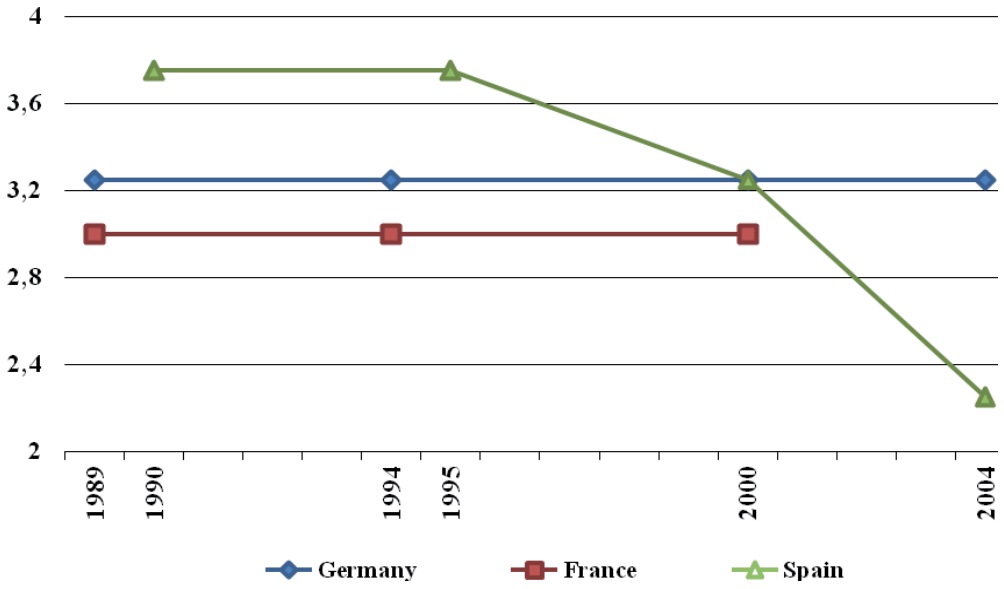
Another important confounding factor is represent by institutional changes: labor market regulations and taxes should be taken into consideration at least since they affect the incentives to supply production factors and innovate.

In Figure II and III, we show the indices for the strictness of employment protection for regular and temporary contracts. Data are taken from OECD EPL (Venn, 2009). An increase in the index means an increase in the rigidity of the labor market. Germany introduced labor market flexibilization like many other countries in Europe in the period of the treatment; Spain made pronounced liberalization in the same period, while France maintained the same legislation. As a result, the regressions in Table I control for the effect of labor market reform whereas

the exclusion of Spain sums up the two effects. A confirmation of our interpretation comes from the emerging of a negative and significant effect for female lower skilled workers: since these reforms lower the bargaining power of unskilled workers, this is acting in the sense of decreasing wages on the lower tail of distribution. We retain the

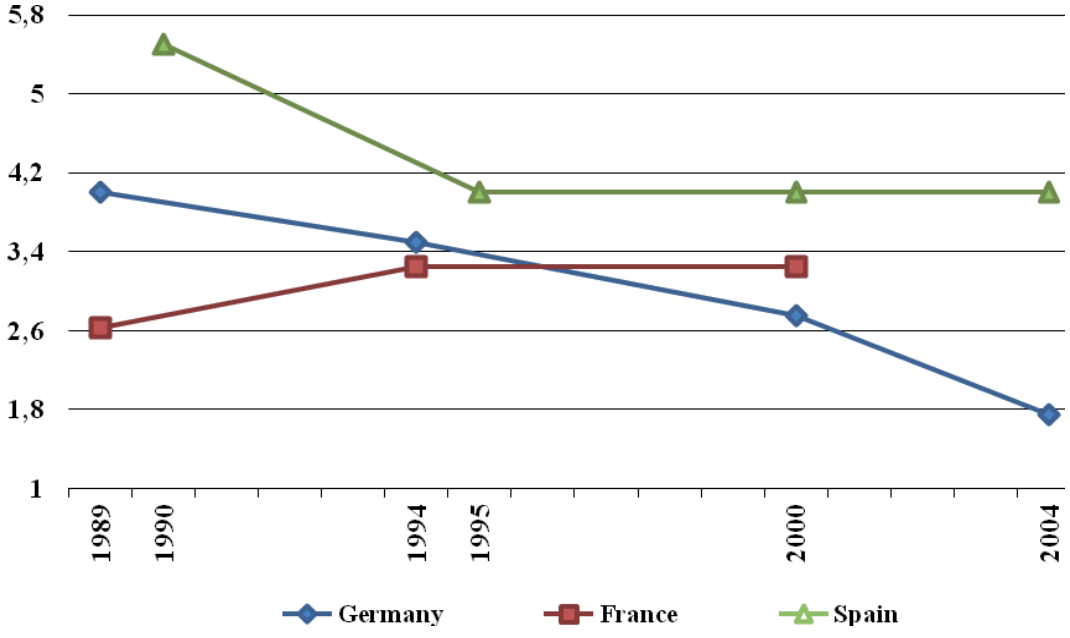
estimation in Table I as our preferred test, given that the assumptions on the labor market in Acemoglu (2007) are the standard competitive ones.

Figure II The change in Employment Protection Legislation. Regular contracts (EPR_v1 index)



Source: OECD EPL

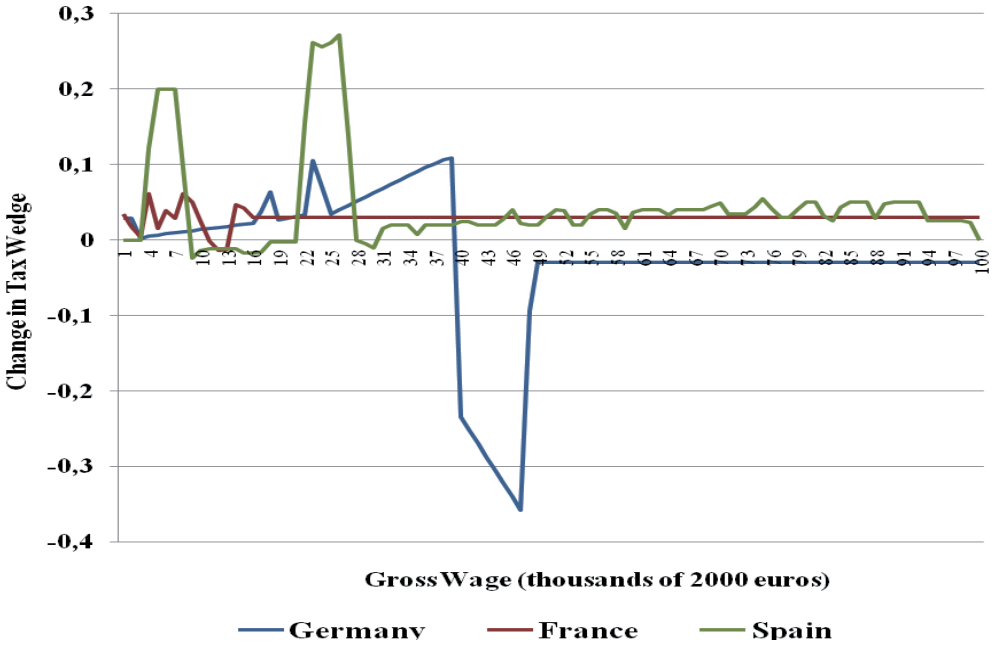
Figure III The change in Employment Protection Legislation. Temporary contracts (EPT_v1)



Source: OECD EPL

With regard to taxation, in Figure IV we consider the change in the tax wedge, including employer and employee social security contributions and taxes. We consider the situation of a single individual, but this should be interpreted with caution since in France and Germany, the family situation matters. The amounts are expressed in 2000 PPP euros. Germany has a formula based system: the marginal rate increases monotonically from a minimum to a maximum. However, we could not compute them for 1989 and 1994 because some of the necessary data was missing and we therefore used a linear approximation. The change in tax wedge is the simple difference between the tax wedge in 1994 and the tax wedge in 1989. Although preliminary, the evidence suggests that the three countries increased regressivity in the period in question. As for labor market regulation, the change is stronger for Spain and Germany and weaker for France and this effect tends to amplify the effect of the high skill supply shocks (which have systematically higher wages): as a result, we reassert that the best estimation is the one in Table I which, filters out this effect at least partially.

Figure IV The change in the marginal tax wedge between 1989 and 1994

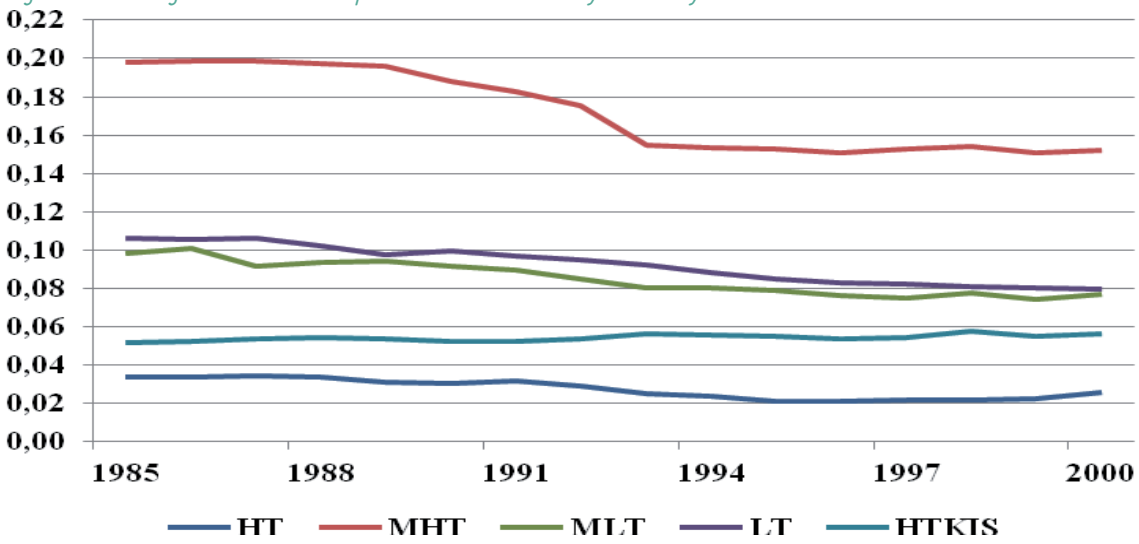


Source: OECD (2011a) and (2011b). The tax wedge includes both contributions to social security (by the employer and the employee) and taxes. The wages are in 2000 PPP euros (thresholds have been properly adjusted in order to compute the taxes). The change in tax wedge is the difference between the tax wedge in 1994 minus 1989. For Spain, the period is 1995-1990, coherently with the two data points in LIS.

Finally, a comment should be made on the role of demand. There are two possible ways in which it may affect wage dynamics. The first is in terms of effective demand, but we include both time fixed effect and country dummies separately and the second is related to changes in sectoral specialization as long as the latter is characterized by strong diversity in task composition. However, using data from OECD STAN (OECD, 2011c), we can see that the pattern of sectoral specialization changes homogeneously in the three countries. Data are plotted in Figure V,

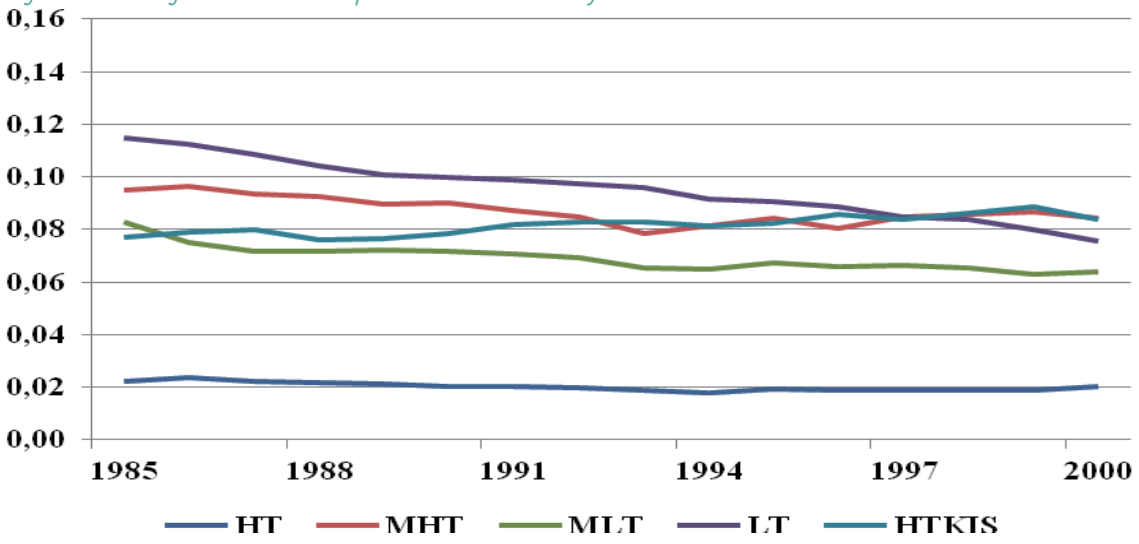
VI, VII. The decline of Medium High Tech in Germany after the reunification is more pronounced, but this is due to the decline in car manufacturing in East Germany and in the estimation, we only consider West Germany.

Figure V Change in Sectoral Composition of the economy: Germany 1985-2000



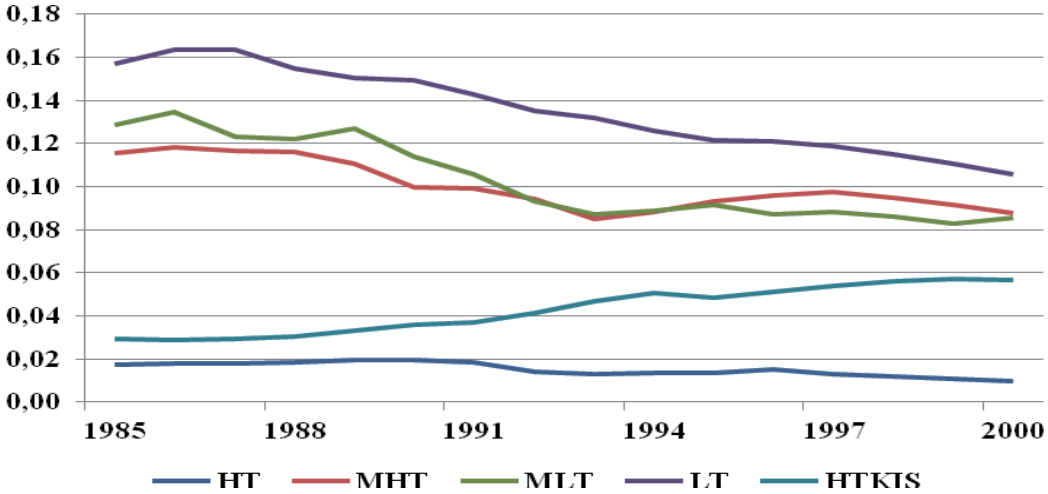
Source: OECD STAN. The reported shares are computed in terms of value added with regard to the sum of manufacturing and market services. Sectors are defined according to NACE rev.3. High Tech (HT) is the sum of 30, 32, 33; Medium High Tech (MHT) is the sum of 24, 29, 31, 34, 35; Medium Low Tech (MLT) is the sum of 23, 25-28; Low Tech (LT) is the sum of 15-22 and 36-37; High Tech Knowledge Intensive Services (HTKIS) are 64, 72, 73.

Figure VI Change in Sectoral Composition of the economy: France 1985-2000



Source: OECD STAN. The reported shares are computed in terms of value added with regard to the sum of manufacturing and market services. Sectors are defined according to NACE rev.3. High Tech (HT) is the sum of 30, 32, 33; Medium High Tech (MHT) is the sum of 24, 29, 31, 34, 35; Medium Low Tech (MLT) is the sum of 23, 25-28; Low Tech (LT) is the sum of 15-22 and 36-37; High Tech Knowledge Intensive Services (HTKIS) are 64, 72, 73.

Figure VII Change in Sectoral Composition of the economy: Spain 1985-2000



Source: OECD STAN. The reported shares are computed in terms of value added with regard to the sum of manufacturing and market services. Sectors are defined according to NACE rev.3. High Tech (HT) is the sum of 30, 32, 33; Medium High Tech (MHT) is the sum of 24, 29, 31, 34, 35; Medium Low Tech (MLT) is the sum of 23, 25-28; Low Tech (LT) is the sum of 15-22 and 36-37; High Tech Knowledge Intensive Services (HTKIS) are 64, 72, 73.

5. Concluding remarks

In this paper we use a natural experiment – the German re-unification – to assess the existence of demand pull SBTC. Under some assumptions, the enlargement of the supply of skilled workers should change the incentives of innovators, directing technical change in a way that tends to complement skills. We used French and Spanish cohorts of workers in the labor market as a control group.

The evidence suggests the presence of non-monotonic trends in the labor market in Europe, with the emergence of polarization in the 1990s. No significant presence of demand pull effect is found, which would have materialized in a further polarization shock.

The identification of the effect is based on two key assumptions: the absence of correlation between the pattern of comparative advantage of East Europe before the reunification and the subsequent change in wages in West Europe (an assumption that is difficult to reject) and the correlation between the occupational allocation of the workers sharing the same skills across the border. Although we were not able to find evidence of a systematic downgrading of East German workers, even this assumption is not very problematic. In fact, unless we assume a perfect substitutability of East German workers across the full set of skills, their entry into the labor market should have changed the supply of skill in a way that would have generated a skill biased response (for some skills). Since we cover all the occupational structures, this should affect at least one of the three categories of jobs. As discussed by Acemoglu and Autor (2011), the post shock reallocation of skills through tasks is not relevant to the implication of the model and does not prevent identification.

The existence of demand pull SBTC is very important for the design of policies. We believe that this aspect has been largely neglected by the literature. Indeed, under these assumptions, educational policies affect the direction that inequality will take in the long run. Since, as discussed in Section Two, the only potential alternative explanation for SBTC is a technology push, then policies against inequality are "paradigm-specific", i.e. they depend on the type of techno-economic paradigm that prevails in the economy. Moreover, in addition to the obvious "general equilibrium" effects, policies for innovation enablers (such as those favoring human capital accumulation) and inequality reducing ones should be coupled since they are not necessarily related.

Another implication of our work is that most of the effect of earning distribution seems to be shaped by context specific effects, related in particular to labor market institutions, as can be seen by the differential effect produced by the inclusion or exclusion of Spain in or from the control sample, which helps us filter out the effect of taxation and labor market deregulation. The latter change clearly had a negative effect on the wages of low skilled workers, enhancing inequality.

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Aims

The core objective of GINI is to deliver important new answers to questions of great interest to European societies: What are the social, cultural and political impacts that increasing inequalities in income, wealth and education may have? For the answers, GINI combines an interdisciplinary analysis that draws on economics, sociology, political science and health studies, with improved methodologies, uniform measurement, wide country coverage, a clear policy dimension and broad dissemination.

Methodologically, GINI aims to:

- exploit differences between and within 29 countries in inequality levels and trends for understanding the impacts and teasing out implications for policy and institutions,
- elaborate on the effects of both individual distributional positions and aggregate inequalities, and
- allow for feedback from impacts to inequality in a two-way causality approach.

The project operates in a framework of policy-oriented debate and international comparisons across all EU countries (except Cyprus and Malta), the USA, Japan, Canada and Australia.

Inequality Impacts and Analysis

Social impacts of inequality include educational access and achievement, individual employment opportunities and labour market behaviour, household joblessness, living standards and deprivation, family and household formation/breakdown, housing and intergenerational social mobility, individual health and life expectancy, and social cohesion versus polarisation. Underlying long-term trends, the economic cycle and the current financial and economic crisis will be incorporated. Politico-cultural impacts investigated are: Do increasing income/educational inequalities widen cultural and political 'distances', alienating people from politics, globalisation and European integration? Do they affect individuals' participation and general social trust? Is acceptance of inequality and policies of redistribution affected by inequality itself? What effects do political systems (coalitions/winner-takes-all) have? Finally, it focuses on costs and benefi ts of policies limiting income inequality and its effi ciency for mitigating other inequalities (health, housing, education and opportunity), and addresses the question what contributions policy making itself may have made to the growth of inequalities.

Support and Activities

The project receives EU research support to the amount of Euro 2.7 million. The work will result in four main reports and a final report, some 70 discussion papers and 29 country reports. The start of the project is 1 February 2010 for a three-year period. Detailed information can be found on the website.

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GINI GROWING INEQUALITIES' IMPACTS

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Project funded under the Socio-Economic sciences and Humanities theme.