Are new work practices and new technologies biased against immigrant workers?

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Abstract

Purpose – To analyse if introduction of new technologies and work practices are negatively related to the employment opportunities of immigrants.

Design/methodology/approach – A representative plant level panel survey merged with register data is used. Random effect regression Tobit models are estimated. The dependent variable is wage costs share of immigrants at the plant. The important explanatory variables are measures of new technologies and work practices.

Findings – The results show that workplaces where employees use personal computers (PCs) intensively and have broad autonomy hire fewer non-Western immigrants who have not been raised in Norway. The negative relationship is especially strong for low-skilled non-Western immigrants.

Practical implications – Future work is desired to confirm the results obtained in our study. Access to data with reliable instrument variables for technology and new work practices would be especially helpful. Our results tend to favour integration policies, which provide immigrants with language training combined with general information about the receiving country

Originality/value – The estimation framework for studying this topic is new. We also present original evidence on the relationship between characteristics of the "new" economy and demand for immigrant workers.

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1. Introduction

In this study, we investigate whether, and to what extent, the problems faced by immigrants in the labour market are aggravated by changing organisational structures in the workplace and by the use of new technology in the production process. The introduction of new technologies and work practices are two characteristics of 'the new economy' that have emerged in advanced industrialised countries during the past decades. Such changes comprise a move away from traditional assembly-line organisational structures towards multitasking, job rotation, teamwork, the use of computers, reductions in management levels and the decentralisation of responsibility (Lindbeck and Snower, 2000). One main element of technological development has been the increasingly widespread use of computers in the production process. A study by the OECD (1999) shows that these kinds of organisational changes seem to have been extensive in Sweden and Denmark (Norway was not included in this OECD study).

The main argument is that new technologies, combined with new organisational practice, require greater interpersonal communication than the traditional assembly-line type of production. In addition to handling the formal language, effective communication demands the understanding of social and cultural codes, unwritten rules, implicit communication, norms etc. These kinds of skills and abilities clearly have important country-specific elements with which persons who have migrated are naturally not well endowed. Thus, increasing the importance of communicative skills caused by the introduction of new technologies and organisational practices may have placed immigrants at a competitive disadvantage in the labour market.

Immigrants are not a homogenous group of workers, and we hypothesise that the increasing demand for communicative abilities should be particularly difficult for non-Western immigrants to honour, especially those who have not been raised in Norway, as their

knowledge of language as well as social and cultural codes is likely to be quite limited. Moreover, we would expect that communication problems would increase with the cultural and geographical distance between immigrants' country of origin and Norway. As previously mentioned, this implies that we would expect immigrants originating in non-Western countries to be more disadvantaged than those originating in Western countries. It also implies that we would expect the difference in employment propensities relative to native Norwegians to be smaller for immigrants who were raised in Norway—that is, those who arrived as children. In the empirical analyses, we will test these hypotheses by distinguishing immigrants according to their country of origin and age at arrival.

Furthermore, the research literature suggests that new technologies and work practices are biased in favour of workers in higher skill groups (for a recent overview, see Acemoglu and Autor, 2011). We approach this view by analysing whether the relationship between new technologies, new work practices and the share of immigrants in total wage costs is uniform across skill groups. We estimate demand functions for different groups of workers distinguished according to country of origin, age at arrival in Norway *and* educational level. By distinguishing between immigrants and natives in this way, we implicitly argue that both groups can be treated as different factors of production. In recent years, several studies have analysed the general elasticity of substitution between native and immigrant workers. Many of these studies report that natives and immigrant workers are far from perfect substitutes in production, even within rather narrowly specified cells defined by work experience and education (see, e.g., Manacorda et al., 2012; Ottaviano and Peri, 2012; and D'Amuri et al., 2008).

Therefore, the main merit of this paper is to test the hypothesis that new technology and new work practices are biased against immigrant workers, and to investigate the extent to which this bias is dependent on skill level and age at arrival. Our analytical approach is to

estimate factor demand equations for different skill groups. We employ a matched employer-employee data set from a (panel) survey conducted among Norwegian establishments. These data contain survey information from daily managers on the use of different forms of new work practices and indicators of new technology, linked with information from administrative registers on employees' wages, education and country of origin.

A set of translog cost share functions, modified to take into account the panel aspect of the data and the occurrence of many zeros for the dependent variable is estimated. The objective is to determine how the establishments' use of certain technologies and organisational practises affects the demand for immigrants relative to native workers. Our matched panel employer-employee data material allows us to perform a rigorous analysis of this question.

Immigration to Norway: Policy, population and labour market performance

Historically, Norway has had considerable restrictions on labour immigration, particularly from non-Western countries. One exception is a period of liberalisation between 1957 and 1975, during which there was a considerable influx of low-skilled labour immigrants from countries such as Pakistan, Turkey and Morocco, especially at the beginning of the 1970s. As of 1975, an "immigration stop" was implemented; this applied to labour immigrants from outside of the Nordic countries. Exceptions were made for workers with desirable skills that could not be provided by native-born Norwegians; these workers mainly arrived from other rich Western countries. In 1994, Norway joined the common labour market within the European Economic Area (EEA), which meant that citizens from the member countries could apply for work in Norway on very liberal terms. However, the restrictive rules applying to labour immigration from non-Western countries have been maintained since 1975.

During the last 30 years, the proportion of immigrants in the Norwegian population has increased considerably from approximately 2 per cent of the population in 1980 to approximately 13 per cent in 2012. Until 2005, this was primarily due to an inflow of people from non-Western countries who were seeking protection or family reunification in Norway. By 2004, immigrants constituted 7 per cent of the Norwegian population, of which almost 75 per cent were of non-Western origin (Statistics Norway).

While the labour market situation for Western immigrants is quite similar to that of natives, non-Western immigrants occupy a weak position in the Norwegian labour market; their labour force participation is relatively low and their unemployment high. By the third quarter of 2004, the unemployment rate among non-Western immigrants in Norway was 10 per cent (Statistics Norway 2012), more than three times higher than that of natives. Many empirical studies show that similar patterns are found in Sweden and Denmark with regard to the labour market situation for non-Western immigrants (see, for example, Pedersen and Smith, 2002).

The remainder of this paper proceeds as follows: in Section 2, we present related literature; in Section 3, we propose an econometric framework for estimating the relationship between technology, work organisation practices and the composition of the workforce; in Section 4, we describe the data and variables used in the analysis; in Section 5, we present the results; and, finally, in section 6, we summarise and conclude.

2. Related literature

Very few papers have directly studied the relationship between new technology, new work practices and the demand for immigrant workers. Peri and Sparber (2009) and Amudeo-Dorantes and De la Rica (2011) are two exceptions. Peri and Sparber (2009) show that foreign-born workers in the US specialise in occupations that require manual and physical

labour skills, while natives pursue more intensive jobs that involve communication and language tasks. Amudeo-Dorantes and De la Rica (2011) present results from a similar analysis of Spain, suggesting that immigration appears to have affected the task specialisation and occupational distribution of natives of the same gender.

Even though there are few studies that are directly relevant to this topic, our paper relates to the economic assimilation literature. Empirical studies from Scandinavia indicate that, in recent decades, the labour market problems faced by non-Western immigrants have been aggravated. Barth et al. (2004) analyse labour market assimilation for different cohorts of immigrants in Norway, comparing those arriving before the mid-sixties with those arriving in the first half of the nineties. They conclude that early cohorts have higher earnings than their more recent counterparts. This finding suggests that labour market assimilation for immigrants has become more difficult over time. Rosholm et al. (2006) analyse the male immigrant experience in Sweden and Denmark from 1985 to 1995. Their results show that immigrants in both Sweden and Denmark experienced a similar decline in employment prospects relative to natives during this period, despite diverging business cycles in the two countries. The main hypothesis that the authors propose in order to understand these results is that organisational structures, which are changing towards more flexible work organisation, have resulted in a decreasing demand for immigrant employees due to their relatively low level of (country-specific) communicative skills. However, the authors were unable to test this hypothesis using the data at hand.

Bratsberg et al. (2010) analyse the life cycle employment profiles of non-Western labour immigrants who arrived in Norway during the early 1970s. They find important differences in labour market progress between non-Western immigrants and natives. During the first years after arrival, almost all of the immigrants worked and their employment rate exceeded that of natives. However, starting about 10 years after arrival, the employment rate

of this immigrant group began a sharp and steady decline. One explanation that the authors suggest for these declining employment rates among immigrants is the changing structures of labour demand, especially in regard to organisational structures and the shift towards more flexible work organisations.

Our paper also relates to the literature that has analysed the relationship between new technologies and work organisation practices. This literature indicates that the introduction of new technological and work organisation practices is interrelated. It also indicates that such changes in the production process require increased interpersonal cooperation related to problem-solving capacities and imply more frequent contact between individual employees. Gant et al. (2002) use US data to show that the network of interactions increases and becomes denser in innovative workplaces. The network of workplace communication among workers, especially in the areas of production and maintenance, is much more extensive under the more innovative and participatory human resource management (HRM) arrangements than under more traditional HRM practices. In innovative firms, all workers communicate more extensively to solve operating problems on the line; therefore, workers have much denser communication networks. Based on a sample of French manufacturing plants, Greenan and Walkowiak (2005) analyse the relationship between the operation of computers, the intensity of communication and the use of new work practices. They find that workers who utilise a computer in the frame of their work communicate more intensively with their hierarchical superiors and their close and distant colleagues inside the workplace. Another finding is that computer use is positively correlated with participation in teamwork as well as with the degree of control that the worker has over the definition of his/her work content.

Finally, our paper relates to the general literature on the impact of new technology and work organisations on the demand for skilled workers. A key point in the literature is that technological innovation and new forms of work organisation have increased the demand for

more educated workers (see, for example, Berman et al., 1994; Katz and Autor, 1999; Caroli and Van Reenen, 2001; Caroli, 2001; and Acemoglu and Autor, 2011). Evidence of skill-biased technological changes has also been found in the Norwegian labour market (Salvanes and Førre, 2003). Røed and Nordberg (2004) suggest that workers at the same skill level have also experienced changes in relative employment opportunities. Their results show that relative employment opportunities for workers at the lower end of the wage distribution—conditional on the level of education and work experience—have worsened significantly in Norway during the 1990s. This suggests that the changes in the structure of labour demand during the last decades have not been related solely to a higher return to education. As argued above, this pattern may have arisen from the increasing importance of communicative skills for *both* low- and highly educated groups of labourers. However, we would expect the communicative deficit to be larger among the least educated.

3. Empirical specification

The cost function

We analyse the relationship between plant-level indicators of technological adaptation and the firm's workforce structure within a factor demand framework. The estimated equations are derived from a simple quasi-fixed translog cost function (see, e.g., Brown and Christensen, 1981), assuming that producers minimise the costs given an output constraint. In the production process, both variable and quasi-fixed inputs are utilised. For our purpose, a general translog cost function for the producer may be specified as follows:

$$(1)\quad \mathrm{LnC}_{it} = \beta_0 + \sum_j \alpha_j \ln \mathrm{W}_{ijt} + \sum_{j,k\, j\neq k} \sum \beta^{w}_{jk} \ln \mathrm{W}_{ijt} \ln \mathrm{W}_{ikt} + \beta_K \ln \mathrm{F}_{it} + \sum_j \beta_{jF} \ln \mathrm{W}_{ijt} \ln \mathrm{F}_{it} + \beta_Y \ln \mathrm{Y}_{ji} + \sum_j \beta_{jY} \ln \mathrm{W}_{i\,jt} \ln \mathrm{Y}_{it}$$

C_{it} signifies the variable costs of producer *i* at time *t*. Workers with different types of experience and education constitute the variable factors of production, and W_{ijt} is the wage of workers of type *j*. F_{it} signifies the quasi-fixed factors and Y_{it} the level of output. By assuming that costs are homogeneous of degree one in factor prices, we can impose the standard restrictions and, using Shepard's lemma, a series of *j* variable wage cost share equations of the familiar form are derived:[1]

$$(2) \quad S_{ijt} = \frac{W_{ijt}N_{ijt}}{C_{it}} = \frac{\partial \ln C}{\partial \ln W_j} = \alpha_j + \sum_{k \neq l} \beta_{jk}^{w} \ln\left(\frac{W_{ikt}}{W_{ilt}}\right) + \beta_{jY} \ln Y_{it} + \beta_{jF} \ln F_{it}$$

N_{ijt} is the number of workers of type *j*, employed by producer *i*, and S_{ijt}, accordingly, is the wage cost share of these workers.

In our specific context, the variable factors of production are defined by the five types of workers: (1) natives, (2) Western immigrants who arrived as children, (3) Western immigrants who arrived as adults, (4) non-Western immigrants who arrived as children and (5) non-Western immigrants who arrived as adults.[2] In the more detailed specifications, these are further defined on two levels of education (high and low).

The quasi-fixed factors of production are defined by three types of capital: i) physical capital (K), ii) the level of adaption to new communication technology (PC) measured by the share of workers on the plant who are using a personal computer and iii) organisational capital (ORG) measured by a set of binary variables indicating whether new work organisation practices are in use at the plant. The econometric specification underlying our empirical analysis is then derived from (2) as follows:

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[1] The restrictions that are imposed upon the model from the structural equations are: i) *Symmetry*, implying $\beta_{jk}^{w} = \beta_{kj}^{w}$, and ii) *homogeneity*, implying two cross-equation restrictions, $\sum_j \alpha_j = 1$ and $\sum_j \beta_{jm} = 0$, and iii) one within-equation restriction, $\sum_{m \in M} \beta_{jm} = 0$, where *m* refers to all independent variables in equation (1) and *M* is the total number of variables.

[2] The definition of Western and Non-Western immigrants and the distinction between child and adult immigrant are explained in the next section.

$$(3)\quad S_{ijt} = \alpha_j + \sum_{k\neq 1} \beta^{w}_{jk} \ln\left(\frac{W_{ikt}}{W_{i1t}}\right) + \beta_{jK} \ln K_{it} + \beta_{jY} \ln Y_{it} + \beta_{jQ} PC_{it} + \beta_{jO} ORG_{it} + \beta_{jX} X_{it} + u_{ijt}$$

W_{ikt}/W_{i1t} are average wages for group *k (k =1-5)* divided by the average wage for group *1* (natives). X signifies a vector of plant-specific control variables and u_{ijt} is the error term. If new communication technology and new forms of organisational work practices are biased against immigrant workers, we expect a negative relationship between the variables indicated by PC and ORG and the immigrant workers' share of total wage costs. We have proposed that the main mechanism underlying this bias is that the use of PC technology and new organisational practices increase the return to communicative capacity. Thus, we expect the negative relationships to be reinforced by the cultural distance between Norway and the home countries of the immigrants, and to be weakened by the length of time the immigrants have stayed in Norway. The implications of these expectations in the formal context of equation (3) are that the *PC* variable and *ORG* variables have a more negative influence on the wage cost share for non-Western compared to Western immigrants, i.e., $\beta_{2Q} > \beta_{4Q}$ and $\beta_{3Q} > \beta_{5Q}$ (and the same ranking with regard to the β_{jO}). Furthermore, the negative communication bias is stronger towards those immigrants who were not raised in Norway, i.e., $\beta_{2Q} > \beta_{3Q}$ and $\beta_{4Q} > \beta_{5Q}$ (and the same ranking with respect to the β_{jO}).

Thus far, we have presented a framework that has been used by the majority of the empirical analyses within this field (see, e.g., Berman et al., 1994 and Doms et al., 1997). In our context, there is one important problem in adapting the framework of these studies—our dependent variables are censored. A large proportion of firms have none (or only some) of the groups of immigrants in their labour force. For example, approximately 50 per cent of the firms employ no non-Western immigrants who arrived as adults. The same is true for 53 per cent of the firms with regard to non-Western immigrants who arrived as children. The corresponding percentages for Western immigrants are 47 and 25 per cent, respectively. In

such cases, standard ordinary least square (OLS) will produce inconsistent results, and estimation techniques that take account of this censoring should be applied. Thus, we estimate the factor demand equations by a simultaneous Tobit maximum likelihood procedure. Furthermore, since the data material is organised as a panel, we estimate random effect Tobit models. One advantage related to this approach is that we can take into account all restrictions implied by the structural cost equations. Another advantage is that exploitation of the panel structure improves the efficiency of the estimator and also restores consistency in a non-linear model.[3] A disadvantage of this approach, as shown below, is that the restrictions implied by the structural cost equations become quite complex in this non-linear setup; hence, recovery of the omitted parameters of the model becomes cumbersome.

We assume that the cost shares reflect an underlying tendency, H_{ijt}, to employ immigrants belonging to each of the four types of immigrant workers. The relationship between this underlying latent tendency and the cost shares is described in (4):

$$(4)\quad H_{ijt} = \alpha_j + \sum_{k \neq 1} b^{W}_{jk} \ln\left(\frac{W_{ikt}}{W_{i1t}}\right) + b_{jK} \ln K_{it} + b_{jY} Y_{it} + b_{jQ} PC_{it} + b_{jO} ORG_{it} + b_{jX} X_{it} + e_{ijt}$$

$$S_{ijt} = \begin{cases} H_{ijt} & \text{if } H_{ijt} > 0 \\ 0 & \text{otherwise} \end{cases}$$

Where the error term is specified as an error component model, i.e., we assume that: $e_{ijt} = \varepsilon_{ijt} + \eta_{ij}$, $\varepsilon_{ijt} \sim N(0, \sigma^2_{ijt})$ and that the random effect follows a discrete distribution. In each equation, we allow for up to three different support points, and the correlation of the random effect between equations is completely flexible.

We believe that (4) reflects a plausible assumption. When employing the Tobit approach, we estimate the parameters of the latent index. For these parameters, the restrictions imposed by the assumptions of *homogeneity* and symmetry are quite complicated: What we estimate are the '*b*'s, but the restrictions are in terms of the 'β's, which are also the parameters

[3] In a non-linear setup, neglect of the panel structure in the data leads to inconsistent estimates.

of interest. A more detailed presentation of the parameters, the symmetry condition and the likelihood function model is presented in Appendix B.

Relative wage measure

Another problem is that introducing the relative wage measure at the workplace level as one of the explanatory variables would considerably reduce the number of observations since a large share of the firms do not employ immigrant workers. We deal with this problem by including relative wage measures at the regional (county) level. The regional group-specific wage measures are calculated from information on individual wages, place of residence, country of birth and duration of residence in Norway. Combined with information about the same individuals' working hours, we construct individual hourly wages, which are, in turn, aggregated up to county level. Thus, it is likely that identification of the wage effect may be difficult because differences in wages not only reflect exogenous movements in the price of labour, but also unobserved differences in workers' skills and abilities.

Unobserved heterogeneity and the direction of causality

Even though we control for a series of workplace characteristics, the error term in (4) may be correlated with the right-hand side variables. Since our data set has a panel structure, one way to approach this problem could be to run a plant fixed-effect model. However, it is well established that any attenuation bias from measurement error in the explanatory variables, which will bias the estimates towards zero, will be greatly exacerbated by this procedure (Griliches and Hausman, 1986). We have self-reported binary measures of new technology and work practices. These measures will certainly contain measurement errors, which will be exacerbated in a fixed-effect setting. Therefore, we decided not to pursue this strategy.

Another fundamental problem is dealing with the issue of endogeneity. That is, even when unobserved heterogeneity is removed, plants may still change their strategies with regard to technology and organisational work practices in response to the composition of skills available in the local labour market. In recent years, quite a few scholars have examined this opposite direction of causality, i.e., to the one that we propose: These researchers include Quispe-Agnoli and Zavodny (2002), who analyse the productivity effects of immigration; Gandal et al. (2004), who analyse the effect of immigration on technology; Dustmann and Glitz (2011), who analyse how changes in the skill mix of local labour supply are absorbed by the economy; Gonzalez and Ortega (2011), who analyse the different channels by means of which regional labour markets have absorbed the large increase in the relative supply of low-educated (foreign-born) workers; and Lewis (2011), who analyses how the combination of skilled and unskilled labour in a plant's metropolitan area affects its use of technology. Many of these studies support models in which producers adapt techniques to factor mix, i.e., a direction of causation that is the reverse of our hypothesis.

The only solution to rule out the reverse causality hypothesis is to undertake an instrumental variable approach; however, no appropriate instrumental variables for *PC* and *ORG* are available in our data. However, we will claim that, in our case, this endogeneity problem is relatively minor. The main argument is that in the period under study, immigrants constitute such a small fraction of the Norwegian labour force. Since the implementation of organisational practices and new technology takes time, and in light of the increasing growth of the Norwegian immigrant population, the immigrant shares of the labour forces may have been even smaller when the relevant investment decisions were made. Thus, it is difficult to imagine that plants have, to a significant extent, designed their technology and/or organisational practices to fit the ethnic composition of the local labour supply.[4]

[4] In some of the preliminary versions of the analyses performed, the shares of immigrants in the local (county)

Still, we cannot rule out the possibility of reverse causality and we will, therefore, be somewhat careful, giving the results a strict causal interpretation. However, even if the causality interpretation is toned down, the estimated relations are still interesting as they nevertheless reflect an association between technology and organisational structures on the one hand and the wage cost share of immigrants on the other.

4. Data and variables

The data come from an employer-employee panel data set consisting of both survey and register information. The starting point is an establishment-level survey of a representative sample of Norwegian workplaces conducted by the Institute for Social Research and Statistics Norway in 1997. By establishment, we refer to the physical local workplace/plant unit. The survey respondents were the daily managers and the questions covered several topics related to the establishment's employees as well as its environment. The sample of workplaces was drawn from Statistics Norway's database of establishments and enterprises ("Bedrifts- og foretaksregisteret"). It is stratified from information on sector (public versus private) and plant size and is representative of private and public workplaces in Norway with more than 10 employees. The response rate was 76 per cent. The survey was repeated in 2003 and the response rate at that time was 77 per cent. All plants participating in 1997 were asked to participate again.

In this paper, we limit the analyses to private sector establishments that were operational in both 1997 and 2003. The net sample used in the empirical analyses consists of 1,088 observations, or 544 workplaces. By limiting the analyses to establishments that existed in both 1997 and 2003, we are analysing a group of plants that have been rather stable over time.

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labour market were included as control variables in the estimations of the cost share equations. This had no effect on the values of the estimated coefficients related to the ORG and PC variables.

It is generally difficult to identify the direction in which this could bias our results relative to the total population of Norwegian establishments.

Statistics Norway has linked information from several public administrative registers to all the establishments that participated in the surveys, including both employee- and employer-level information. With regard to the employees, we have information on country of origin, level of education and wages. Individual wage data is collected from the tax register and aggregated at the establishment level for each type of worker. All analyses are restricted to workers 20–60 years of age.

The dependent variable is the *wage costs share* for each of the five categories of workers (S_{ijt}): natives, Western immigrants who arrived as children, Western immigrants who arrived as adults, non-Western immigrants who arrived as children and non-Western immigrants who arrived as adults. Western countries include Western Europe, USA, Canada, New Zealand and Australia. Non-Western countries are those in Asia (including Turkey), Africa, Southern and Central America and Eastern Europe.

To distinguish between immigrants raised in Norway (i.e., who arrived as children) and those who were not (who arrived as adults), we exploit information on age upon arrival in Norway (Age_N) and number of years of education after mandatory education (Education). We define:

$$\begin{aligned} \text{Child immigrant if : } Age_N &\leq 16 + \text{Education} \\ \text{Adult immigrant if : } Age_N &> 16 + \text{Education} \end{aligned}$$

where the right-hand side is intended to proxy the age of entry into the labour market. This way of distinguishing between those who immigrated as children and those who immigrated as adults is similar to the definition used in Borjas (2003). Workers in the different ethnic groups are divided into two categories, according to skill level: Low skill (compulsory school and secondary school) and high skill (university or college degree).

To establish an indicator for the use of new *technology*, we apply the managers' answers to the following question: 'How large a share of the employees uses PCs or other computers in their daily work?' This is, of course, a crude measure with regard to the use of new technology in a workplace. PCs are used to accomplish a wide variety of tasks, which differ significantly with regard to their complexity. On the other hand, this measure has the advantage of being widely used in different studies across countries. This facilitates the possibility of comparing the results of different studies.

To indicate the prevalence of *new work practices* (ORG), we use four dummy variables to measure job rotation, use of teamwork, multitasking and the degree of autonomy given to the workers. Information on *job rotation* is taken from the managers' replies to the following question: 'Are any of the employees involved in job rotation?' (yes/no). Information on *teams* is taken from the following question: 'Are any of the employees organised in work teams?' (yes/no). Information on *multitasking* is taken from the following question: 'Are employees given training so that they can cover (be responsible for) several work areas?' (yes/no). Finally, the degree of *autonomy* in the workplace is taken from answers to the following question: 'What opportunities do employees have to make their own choices so as to find the best way to accomplish their assignments?' The alternatives were: full opportunities; quite good opportunities; some good opportunities; and none. Based upon this, we construct a binary indicator of autonomy in the workplace, taking the value 1 if the manager answers 'full opportunities', and 0 otherwise.

The control variables include information on relative wages (W_k/W_l), output (Y), capital (K), region, industry, recruitment problems and downsizing (X). 'Relative wages' measures the mean 'hourly wages' of the different types (ethnicities) of worker relative to native workers in the same skill group. 'Hourly wage' is constructed from individual information on total wage during the period of employment at the workplace, the length of

this period and agreed daily work hours. 'Mean hourly wages' is measured at the regional (county) level.[5] 'Output' is measured by sales, and 'capital' by the establishment's sum of equity and debt. 'Location' is indicated by 19 regional dummy variables (counties) and 'industry' by 18 dummy variables defined from two-digit NACE codes. Information on the severity of the recruitment problems is derived from a question to the managers about how difficult it is to recruit qualified personnel. If the answer is 'very difficult', a dummy is given value 1. Information on downsizing is based on the question of whether any major organisational changes have taken place during the last five years. If yes, the manager is asked whether this led to a reduction of employees. If so was the case a dummy variable taking the value 1 is constructed. Finally, we include an indicator for the year 2001 in order to account for the general increase in the number of immigrants into Norway over time.

5. Results

Descriptive statistics

Table 5.1 presents descriptive statistics for the dependent and some of the independent variables. The first row shows that, in the average workplace, approximately 90 per cent of the total wage costs go to natives. The largest immigrant group in this sample is Western immigrants who arrived as children (3.9 per cent), followed by non-Western immigrants who arrived as adults (2.9 per cent).

[Table 5.1 about here]

The next two rows show the mean share of total wage costs for low- and highly skilled workers.[6] Approximately 70 per cent of the plants' wage costs go to low-skilled natives, while approximately 20 per cent go to high-skilled natives. The immigrant groups with the largest

[5] There are 19 counties in Norway.
[6] The wage shares sum to unity for all workers and for low- and highly skilled workers together.

wage share are low-skilled non-Western immigrants who arrived as adults, and low-skilled Western immigrants who arrived as children, both with 2.6 per cent.

The average share of employees using PCs in their daily work is 46 per cent. A total of 6 of 10 workplaces make use of teams, while 4 of 10 workplaces use job rotation. One in four gives their workers a great deal of autonomy, while more than four out of five plants train their workers so that they can cover several work areas (multitasking). Table A1 in Appendix A presents correlation coefficients between the included variables for technology (PC) and the new work practices (ORG).

Analytical results

All the models (presented below) of the relationship *between the ethnic groups' wage cost shares and the plants' use of new technology and new work practices* are estimated using the simultaneous Tobit system of equations presented in section 2.[7]

As a starting point for the econometric analysis, we estimate this relationship *without* dividing the ethnic groups into skill levels. A system of four simultaneous equations is estimated; the omitted fifth equation is the one for natives. The core results are presented as elasticities in Table 5.2, while the estimated coefficients with standard errors are shown in Appendix A, Table A3.[8]

[Table 5.2 about here]

[7] The dependent variable in all the analysis presented in the article is the ethnic groups' share of wages in the plants' total wage costs. We have also run regressions using employment shares as the dependent variable instead. The qualitative results are not sensitive to the choice between these dependent variables.

[8] The formula for the elasticity is: $\varepsilon = \frac{\partial s_j}{\partial PC}\frac{PC}{s_j}$, where j is worker group. In the construction of the elasticity, we use the average effect on the observed variable, i.e., we multiply the estimated coefficient with the share of non-censored observations in the material.

The approximate interpretation of the PC elasticities in Table 5.2 is as follows: If the proportion of workers using a PC in the establishment increases by one per cent, the wage cost share of non-Western immigrants arriving in Norway as adults decreases by 0.46 per cent. For non-Western immigrants who arrived as children, the negative relationship is clearly weaker, i.e., since the estimated coefficient, which is not statistically significant, predicts a 0.12 per cent decrease. Furthermore, the results show that the proportion of workers using a PC in a workplace is positively and significantly related to the share of Western immigrants who arrived as children, while the relationship is positive, but not significant, for Western immigrants who arrived as adults. The structure of these results may lend preliminary support to the hypothesis claiming that new technologies are biased against non-Western immigrants, particularly those who arrived as adults.

Regarding the indicators of new work practices, we find no clear pattern between these organisational characteristics and the employment of ethnic groups. On the one hand, workplaces that give their employees a great deal of *autonomy* employ fewer non-Western immigrants, although this result is only statistically significant for those who arrived as children. This result is in line with the hypothesis stating that new work practices may harm the employment possibilities of immigrant workers or groups that are perceived to possess low levels of communicative skills. On the other hand, in workplaces where *multitasking* is an important feature of daily work, non-Western immigrants who arrived as children have a *higher* share of total wages and this outcome is at odds with the same hypothesis. Furthermore, there are no significant relations between the use of *teams* and the cost shares of any of the immigrant groups.

However, all of the above results may be heavily influenced by compositional effects since the ethnic cost shares are not divided according to skill level. As previously mentioned, evidence in the empirical literature suggests that new technologies, as well as new work

practices, increase return to education. Thus, we now turn to the main analysis where we estimate the model controlling for education, i.e., the wage cost shares are calculated separately for each skill level within the ethnic group. A system of nine simultaneous equations is estimated and the omitted tenth equation is the one for highly skilled natives.

As above, the core results are presented as elasticities in Table 5.3, while estimated coefficients and standard errors are elaborated in the Appendix, Table A.4. The interpretation of the PC elasticities for the non-Western immigrants in Table 5.3 is now as follows: If the proportion of workers using a PC increases by one per cent, the wage cost share of low-skilled non-Western immigrants arriving in Norway as adults and children decreases by 0.63 per cent and 0.21 per cent, respectively. For the highly skilled non-Western immigrants, the corresponding numbers are a 0.27 per cent decrease and a 0.28 per cent increase for those arriving as adults and children, respectively. These results show that the negative relationship for non-Western immigrants who arrived as adults, reported in Table 5.2, is driven, to some extent, by a strong negative relationship for low-skilled workers in this group.

[Table 5.3 about here]

For all the ethnic groups, including natives, the relationship between PC intensity in the workplace and wage cost share is more positive for highly skilled than for low-skilled workers. Furthermore, a negative relationship is statistically significant for all low-skilled groups. However, among the low skilled, the most negative relationship, in this regard, is revealed for the non-Western immigrants who arrived in Norway as adults. Overall, the results for the PC variable related to the low-skilled workers are in line with our hypothesis regarding communication-biased technological change.

Among the highly skilled workers, it is only for non-Western immigrants arriving as adults that we find a negative relationship between PC and wage cost share. For immigrants

(both non-Western and Western) arriving as children, the PC coefficient is positive and significant. Thus, the pattern of results for the highly skilled also seems to support the hypothesis of communication-biased technological change; that is, since the relationship between PC and cost share is considerably more negative for the group that is supposed to have the lower communicative capacity.

For highly skilled non-Western immigrants arriving as adults, the PC elasticity is much smaller compared to the elasticity for low-skilled non-Western immigrants arriving as adults. This suggests that education, to some extent, 'protects' against potential threats from the increasing importance of new technologies. Such a relationship may eventually be due to a range of quite different mechanisms. One possibility is that as a part of their education, people learn to communicate across cultural borders; another is that those with better communicative abilities educate themselves to a greater extent. However, the relatively weak negative relationship between the cost share and the PC variable for the highly skilled adult immigrants compared to the low-skilled is also in line with the findings of Greenan and Walkoviak (2006). This study shows that the operation of computers increased the intensity of interpersonal communication more among the employees with a low level of education than among the highly educated.

Regarding the indicators of new work practices, we still find no very clear pattern between these organisational characteristics and the employment of ethnic groups. As in the previous analysis, *multitasking*, *work teams* or *job rotation* do not appear to be strongly related to the wage cost shares across skill groups. However, after controlling for education, the results related to the autonomy variable are, to some extent, more in line with our prior hypothesis of communication-biased organisational change. The negative relationship between *autonomy* and the demand for non-Western immigrants who arrived as children, reported in Table 5.2, is no longer statistically significant. The opposite is true for non-

Western immigrants who arrived as adults. The autonomy coefficient for this group was not significant in Table 5.2. When splitting the groups according to skill level, we find a negative relationship between autonomy and demand for low-educated workers, and a non-significant relationship between autonomy and the demand for highly educated workers.

Robustness checks

One could argue that since the measures of skill level are rather approximate, it may be that within each group there are substantial differences in educational attainment. If non-Western immigrants within each group are less educated, the results will reflect the usual skill-biased technological change story. Table A2 in Appendix A sheds some light on this issue by presenting the mean values for years of education within each skill group. Among the highly skilled workers, average years of education are higher for non-Western immigrants than for natives. This adds no support to the hypothesis that the results are driven by compositional effects. Among the low-skilled workers, average years of education are somewhat lower for immigrants who arrived as adults; however, this applies for both non-Western and Western immigrants. The results in Table 5.3 suggest that it is mostly among non-Western adult immigrants that we find a negative relationship between PC and wage cost shares. If skill bias were the main issue, one would expect this to also affect Western adult immigrants.

Another potential source of bias is age differences between natives and immigrants. The introduction of new technologies and work practices may increase the productivity of young workers relative to old workers, reflecting age-biased technological change (Rosen, 1975). Some empirical evidence on this matter exists; for instance, Aubert et al. (2006) analyse the relationship between indicators of technology, new work practices and the age structure for a sample of French manufacturing plants. They find that both new technology and new work practices are biased against older workers. Thus, if natives are, on average, younger, it may be

that our results are driven by age-biased technological change. Table A2 in Appendix A presents average values for age within each skill group. Among the highly skilled workers, the average age for non-Western immigrants who arrived as adults is somewhat higher compared to that of natives; however, the difference is rather modest (42.4 versus 38.9 years). Among the low-skilled workers, the average age for non-Western immigrants who arrived as adults is somewhat lower compared to the average age for natives (39.5 versus 40.5). These small differences do not lend strong support to a hypothesis stating that age-biased technological change against older workers is driving the results in Table 5.3.

5. Conclusions

As described in the introduction, non-Western immigrants hold a weak position in the Norwegian labour market. Studies also indicate that their labour market position has weakened during the last decades. In this paper, we have analysed whether any features of the 'new economy' may help to explain these trends, which are also clearly visible in other Western economies. The introduction of new communication technologies (PCs) and novel organisational practices are two main characteristics related to the evolution of modern working life during the last decades. We have analysed whether by increasing the importance of interpersonal communication and informal human capital, such changes are negatively related to the employment opportunities of immigrants. We distinguished between five ethnic groups: natives, Western immigrants who arrived as children, Western immigrants who arrived as adults, non-Western immigrants who arrived as children and non-Western immigrants who arrived as adults.

To analyse the relationship between indicators of new technology, new work practices and the demand for immigrant workers, we used representative workplace-level panel data

containing both employer- and employee-level information. We estimated factor demand equations where the dependent variable is the ethnic groups' share of total wage costs.

The results reveal that workplaces where PCs are used intensively, and which give their employees more autonomy in their daily work generally tend to have lower wage cost shares for immigrants. These relationships are particularly strong with regard to low-skilled immigrants from non-Western countries who obtained no basic schooling in Norway—that is, who arrived as adults. Thus, the results suggest that new PC technology and some new work practices are biased against immigrant workers, particularly against the low educated within this group who arrived from culturally distant countries of origin. The strongest result appears in relation to the indicator of new technology—the PC variable—rather than the indicators of new work practices. This may seem, to some extent, to be at odds with the communication hypothesis. However, as shown in Greenan and Walkowiak (2005), workers who use a computer communicate more intensively with their hierarchical superiors, communicate more with their colleagues in general as well as with the outside world and participate more frequently in meetings. Greenan and Walkowiak (2005) also show that, to us, a computer is more strongly correlated with the intensity of communication among low-educated workers. Thus, this analysis clearly indicates that the communication requirements of the workplace are positively correlated with the PC variable, and even more so among the low-educated workers.

Our results seem to be in line with those of Rosholm et al. (2006), who report negative employment developments among immigrants in Sweden and Denmark from 1985 to 1995, and interpret this as the effect of the increased importance of interpersonal communication due to changes in technology and organisational work practices.

Future work is desired to confirm the results obtained in our study. Access to data with reliable instrument variables for technology and new work practices would be especially

helpful. Still, a preliminary discussion of the policy implications of these findings may be warranted. Our results tend to favour integration policies, which provide immigrants with language training combined with general information about the receiving country; this is done intensively and soon after arrival. Once a certain basic communicative level is achieved, we would suggest the intense use of temporary employment subsidies combined with on-the-job language training courses sponsored by the public sector in order to neutralise the negative impacts of lacking communicative abilities.

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Table 5.1. Descriptive statistics. Mean values and standard errors

	Natives		Non-Western immigrants				Western immigrants			
			Adults		Children		Adults		Children	
	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev
Wage shares										
-All workers	0.896	0.116	0.029	0.073	0.014	0.031	0.019	0.033	0.039	0.040
-Low-skilled	0.702	0.218	0.026	0.068	0.007	0.018	0.018	0.034	0.026	0.032
-Highly skilled	0.195	0.187	0.004	0.012	0.004	0.001	0.004	0.012	0.013	0.026

	All	
	Mean	Std.dev
PC	0.461	0.361
Teams	0.616	0.486
Autonomy	0.267	0.443
Multitasking	0.812	0.387
Job rotation	0.439	0.496

Note: For definitions of non-Western and Western immigrants, as well as definitions of adult and children immigrants, see section 3.

Table 5.2. Demand for immigrant workers. Dependent variable: Wage cost shares. Simultaneous panel Tobit model

	Non-Western immigrants		Western immigrants	
	Adults	Children	Adults	Children
	Elasticity	Elasticity	Elasticity	Elasticity
PC	-0.461***	-0.122	0.034	0.053***
Teams	-0.032	-0.070	-0.015	-0.008
Autonomy	-0.037	-0.121***	0.046*	-0.010*
Multitasking	-0.098	0.277**	0.100	-0.016
Job rotation	0.008	0.033	-0.043	-0.003
Censored observations	546	507	580	817
N	1088	1088	1088	1088

Note: Additional control variables include log output, log capital, a variable for downsizing, a year dummy, a regional relative wage measure, 18 industry dummies, 18 county dummies, a dummy variable measuring recruitment problems, and a variable measuring the main occupational group's share of the total number of workers. Level of significance: *** 1 per cent. ** 5 per cent. * 10 per cent. One equation (the equation for natives) has been omitted.

Table 5.3. Demand for native and immigrant workers. Low- and highly skilled workers. Dependent variable: Wage cost shares. Simultaneous panel Tobit model

	Low-skilled					**Highly skilled**			
	Natives	Non-Western immigrants		Western immigrants		Non-Western immigrants		Western immigrants	
		Adults	Children	Adults	Children	Adults	Children	Adults	Children
	Elasticity	Elasticity	Elasticity	Elasticity	Elasticity	Elasticity	Elasticity	Elasticity	Elasticity
PC	-0.105***	-0.630***	-0.207*	-0.190**	-0.109*	-0.266*	0.279*	0.169	0.488***
Teams	-0.025***	0.128	-0.062	-0.054	-0.016	0.194	0.136	0.291*	0.041
Autonomy	-0.010**	-0.069*	0.027	-0.039	-0.049*	-0.014	-0.117	0.042	-0.044
Multitasking	-0.002	-0.197	0.203	-0.120	-0.106	-0.213	0.089	0.085	-0.161
Job rotation	0.008	0.030	-0.044	0.039	-0.023	-0.092	0.048	-0.092	0.029
Censored at 0	2	594	704	507	352	857	848	859	624
Censored at 1	35	0	0	0	0	0	0	0	0
N	1088	1088	1088	1088	1088	1088	1088	1088	1088

Note: Additional control variables include log output, log capital, a variable for downsizing, a year dummy, a regional relative wage measure, 18 industry dummies, 18 county dummies, a dummy variable measuring recruitment problems, and a variable measuring the main occupational group's share of the total number of workers. Level of significance: *** 1 per cent. ** 5 per cent. * 10 per cent. One equation (the equation for natives) has been omitted.

Appendix A

Table A1. Correlation coefficients between explanatory variables. Pearson correlation coefficients

	Teams	Autonomy	Multitasking	Job rotation
PC	-0.075**	0.092***	0.008	-0.113***
Teams		-0.060**	0.097***	0.099***
Autonomy			0.022	-0.091***
Multitasking				0.263***

Note: Level of significance: *** 1 per cent, ** 5 per cent, * 10 per cent.

Table A2. Descriptive statistics for highly and low-skilled workers. Age and education. Mean values and standard deviations in parenthesis

	Highly skilled		Low-skilled	
	Age	Education	Age	Education
Natives	38.9	6.19	40,5	1,91
	(9.88)	(1.65)	(11,1)	(1.15)
Non-Western immigrants arrived as children	33.7	6.42	30.0	2.06
	(8.29)	(1.70)	(8.14)	(1.05)
Non-Western immigrants arrived as adults	42.4	7.26	39.05	1.62
	(7.65)	(1.49)	(9.02)	(0.92)
Western immigrants arrived as children	37.5	6.41	37.2	2.07
	(8.93)	(1.71)	(10.1)	(1.10)
Western immigrants arrived as adults	44.5	7.46	44.4	1.81
	(8.24)	(1.44)	(10.74)	(0.88)

Note: Education refers to number of years of education after completion of compulsory school.

Table A.3. Demand for immigrant workers. Dependent variable: Wage cost shares. Simultaneous panel Tobit model

	Non-Western immigrants				Western immigrants			
	Adults		Children		Adults		Children	
	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err
PC	-0.058***	0.008	-0.007	0.005	0.003	0.006	0.018***	0.005
Teams	-0.003	0.005	-0.003	0.003	-0.001	0.004	-0.002	0.003
Autonomy	-0.008	0.006	-0.012***	0.004	0.007*	0.004	-0.006*	0.003
Multitasking	-0.007	0.007	0.009**	0.005	0.005	0.005	-0.003	0.004
Job rotation	0.001	0.005	0.002	0.003	-0.004	0.004	-0.001	0.003
Log output	0.014***	0.003	0.002	0.002	0.012***	0.002	0.001	0.002
Log Capital	-0.001	0.002	0.004***	0.001	-0.002	0.001	0.001	0.001
Downsizing	-0.005	0.007	0.002	0.004	-0.003	0.004	-0.012***	0.004
Censored observations	546		507		580		817	
N	1088		1088		1088		1088	

Note: Additional control variables include a year dummy, a regional relative wage measure, 18 industry dummies, 18 county dummies, a dummy variable measuring recruitment problems and a variable measuring the main occupational group's share of the total number of workers. Level of significance: *** 1 per cent, ** 5 per cent, * 10 per cent. One equation (the equation for natives) has been omitted.

Table A.4. Demand for native and immigrant workers. Low- and highly skilled workers. Dependent variable: Wage cost shares. Simultaneous panel Tobit model

	Low-skilled									
	Natives		Non-Western immigrants				Western immigrants			
			Adults		Children		Adults		Children	
	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err
PC	-0.160***	0.015	-0.079***	0.012	-0.009*	0.005	-0.014**	0.007	-0.009*	0.005
Teams	-0.029***	0.012	0.012	0.008	-0.002	0.004	-0.003	0.005	-0.001	0.003
Autonomy	-0.025**	0.013	-0.015*	0.009	0.002	0.004	-0.005	0.005	-0.007*	0.004
Multi-tasking	-0.002	0.018	-0.014	0.010	0.005	0.006	-0.005	0.007	-0.005	0.005
Job rotation	0.013	0.012	0.004	0.009	-0.002	0.004	0.003	0.005	-0.002	0.004
Log output	-0.027***	0.005	0.012***	0.004	0.006***	0.002	0.008***	0.002	0.003	0.002
Log Capital	-0.001	0.003	0.001	0.003	0.001	0.001	0.001	0.001	-0.000	0.001
Down-sizing	0.010	0.015	-0.008	0.011	0.001	0.005	-0.007	0.007	-0.002	0.005
Censored at 0	2		594		704		507		352	
Censored at 1	35		0		0		0		0	
N	1088		1088		1088		1088		1088	
	Highly skilled									
	Natives		Non-Western immigrants				Western immigrants			
			Adults		Children		Adults		Children	
			Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err
PC			-0.011*	0.006	0.011**	0.005	0.007	0.006	0.032***	0.006
Teams			0.006	0.004	0.004	0.004	0.009*	0.005	0.002	0.004
Autonomy			-0.001	0.005	-0.008	0.005	0.003	0.005	-0.005	0.004
Multi-tasking			-0.005	0.006	0.002	0.005	0.002	0.007	-0.006	0.004
Job rotation			-0.004	0.005	0.002	0.004	-0.004	0.005	0.002	0.004
Log output			0.011***	0.003	0.004**	0.002	0.014***	0.003	0.009***	0.003
Log Capital			0.000	0.001	0.001	0.001	-0.003	0.002	0.001	0.002
Down-sizing			-0.004	0.005	0.006	0.005	0.002	0.005	-0.009	0.007
Censored at 0			857		848		859		624	
Censored at 1			0		0		0		0	
N			1088		1088		1088		1088	

Note: Additional control variables include a year dummy, a regional relative wage measure, a dummy variable measuring recruitment problems and a variable measuring the main occupational group's share of the total number of workers. Level of significance: *** 1 per cent, ** 5 per cent, * 10 per cent. One equation (the equation for highly skilled natives) has been omitted.

Appendix B

Econometric specification:

The parameters of the actual cost shares, the β's, can be expressed as a function of the parameters of the latent index. The relations between the two sets of parameters (illustrated for the capital variable) are the following:

(B1) $$\beta_{jK} = \frac{1}{n}\sum_i \partial S_{ijt} / \partial \ln K_{it} = b_{jK} . \frac{1}{n}\sum_i P(H_{ijt} > 0) = b_{jK}\,\overline{P(H_{ijt} > 0)}$$

or at least this is the case if we think of β as the average influence of a variable on the outcome, which is what the parameter captures in the linear case. The parameter restrictions, which in the translog cost function model were just parameter restrictions are now slightly more complex in the sense that they also depend on the fractions of uncensored observations.

However, the cross equation restriction in ii) on the α's and β's (and the singularity of the error covariance matrix) can be ignored by leaving out the first equation from the estimations, while the within equation restriction in iii) is circumvented by the division with one of the price variables (here, the wages of natives), in each equation.

The only restriction left is thus the symmetry restriction in i). It is now important to note that the symmetry restriction does not imply that $b_{jk}=b_{kj}$, but rather, that

(B2) $$b^w_{jk}\,\overline{P(H_{ijt} > 0)} = b^w_{kj}\,\overline{P(H_{ikt} > 0)}$$

such that $$b^w_{jk} = b^w_{kj}\frac{\overline{P(H_{ikt} > 0)}}{\overline{P(H_{ijt} > 0)}}$$

These restrictions are incorporated directly in the estimation process. Upon imposing these modified symmetry constraints, and defining

$$e_{ijt} = S_{ijt} - \alpha_j - \sum_{k \neq 1} b^w_{jk} \ln\left(\frac{W_{ikt}}{W_{i1t}}\right) - b_{jK}\ln K_{it} - b_{jY} Y_{it} - b_{jQ} PC_{it} - b_{jO} ORG_{it} - b_{jX} X_{it} - \eta_{ij}$$

the contribution to the likelihood function (maximized using code written in GAUSS) for workplace *i* is

$$L_i(\theta) = \int \prod_{j=2}^{N} \left[\left(\Phi(e_{ijt} / s_j)\right)^{s_{ijt}=0} \cdot \left(\frac{1}{s_j} \varphi(e_{ijt} / s_j) \right)^{0<s_{ijt}<1} \cdot \left(1 - \Phi(e_{ijt} / s_j)\right)^{s_{ijt}=1} \right] dF(\eta_{i2}, \eta_{i3}, ..., \eta_{iN}$$

In order to test the sensitivity of the estimates, we also estimate the equation specified above without these restrictions imposed.