THE DECLINE IN DEMAND FOR UNSKILLED LABOR: AN EMPIRICAL
ANALYSIS METHOD AND ITS APPLICATION TO FRANCE

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Abstract—The decline in the unskilled share of French employment is chiefly due to the slackness of domestic demand for those industries with the highest proportion of unskilled workers. The spread of computers has not been particularly conducive to substitution between skilled and unskilled labor. We test and accept the hypothesis of technical-progress neutrality within French industries. The mechanisms that generate inequality do not appear to be the same in France and in the United States. The source of inequality isn't so much technical progress per se as its interaction with the institutions that regulate the labor market.

I. Introduction

Perhaps one of the most worrying trends in the most-advanced western economies is the ever-deeper inequality created by the labor market. In countries that do not apply automatic official increases in their minimum wages, like the United States or Britain, the gap widened during the 1980s between wages of the highest-skilled workers and those of unskilled workers. (See, for example, Murphy and Welch (1991) or Bound and Johnson (1992).) By contrast, in continental European countries such as France, the minimum wage has been regularly increased, and wage differentials were barely greater in the early 1990s than they were 25 years ago. This has not prevented the rise of mass unemployment, primarily among the least-skilled categories of employees. In sum, the United States and Britain are characterized by wage inequality, whereas continental European countries such as France are marked by unequal employment opportunities. Either way, we are left with two basic questions. What is the origin of this rising inequality? Why has the demand for unskilled workers in the developed countries fallen so dramatically?

In the United States, a consensus explanation has gradually emerged: the main cause of widening wage differentials is technological change that has reduced demand for production labor (Berman, Bound, & Griliches, 1994) and for less-skilled workers (Katz & Murphy, 1992). The spread of computers, it is argued, is responsible among other things for creating a substantial inequality between workers who are capable of using them and those who are not (See, for example, Krueger (1993) or Mincer (1991)). Borjas, Freeman, and Katz (1991) also stress the role played in the United States by the influx of unskilled immigrant workers, as well as by the growth of imports from low-wage countries. By increasing the supply of unskilled labor directly and indirectly, these trends also help to reduce the unskilled wage rate.

We now know much more about the mechanisms affecting the wage distribution in the United States—and, more generally, in Anglo-Saxon economies—than we know about continental European economies. Our paper seeks to fill a small part of this gap by analyzing in as detailed a manner as possible the causes of the rise in employment inequality in France.

Among the industrialized nations, France is distinguished not only by the high level and steady growth of its minimum wage, but by a post-school training system, instituted in 1971, that requires firms to allocate a significant share of their payroll (currently 1.5%) for such training. Each year, nearly one-third of France's private-sector employees receive training paid for by their employers, which is twice the proportion recorded in the United States or Britain (Lynch, 1994; Goux & Maurin, 1999a). France also enforces fairly strict regulations to layoffs: any company that dismisses more than ten workers within one month must not only compensate the persons fired, but must also submit for approval by unions and the authorities a comprehensive plan for the reemployment of dismissed workers.

French institutions generally tend to protect existing workers in firms and encourage employers to find in-house solutions when adjusting to technological shocks and demand fluctuations. The downside to this system is, obviously, that it does not make it easier for the jobless to find new work.

In a way, France offers an illustration of what the U.S. and British economies might look like if they adopted reforms giving better protection to employed workers from the negative shocks in the labor market. This is one of the reasons why we would argue that France is a particularly rewarding country to study in detail. One of our working assumptions is that, because of the different institutional context, technological change does not induce the same job shifts in a French-type economy as in a U.S.-type economy.

Another interesting feature of the more-centralized French economy is that it has given birth to a very comprehensive public statistical system. Indeed, we will be able to test the impact of technical progress on labor demand by using direct measures of the spread of computers as well as of new production technologies. To our knowledge, this type of assessment of technical progress has not yet been attempted in as detailed a fashion.

Our study is organized as follows. We begin by describing the theoretical framework in which we will present our estimations (section II). Our aim, though, is not to offer a new theory of labor demand or a bolder labor market model than those that have proliferated in recent years. On the contrary, we have opted for a deliberately simple and conventional framework that enables us to make the least
ambiguous possible use of the abundant data now available for analyzing France’s labor market. We set out to identify the role of three factors: technological change, shifts in the industry composition of demand for goods and services, and the movement in relative labor costs. The method we propose may be viewed as a synthesis and extension of the approach advocated by Katz and Murphy (1992) and the techniques used by Berman, Bound, and Griliches (1994). In our view, this type of model is sufficient to identify the main mechanisms presiding over the decrease in unskilled jobs in France. It also offers the advantage of yielding some results that are directly comparable with findings on U.S. data.

Our basic model assumes within-industry neutral technical change. In section III, we develop a strategy to test this hypothesis explicitly on standard wage and employment data. We also construct an instrument for directly measuring the impact of the spread of new technologies (such as computers and automation) on the labor-demand composition by industry.

In section IV, we apply the theoretical interpretative frameworks detailed in the first two sections to industry-level data on employment, wages, and technologies compiled from surveys conducted by the French National Institute for Statistics and Economic Surveys (INSEE) between 1970 and 1993, as well as from the French national accounts. Whenever possible, we compare our evaluations with those previously obtained on U.S. data.

If we had to give a preview of the main findings of our study, we would emphasize that approximately two-thirds of the decline in the unskilled share of French employment is due to the change in the industry composition of domestic demand for goods and services. This factor has fostered job growth in industries and occupations that use the highest-educated workers. As regards the transformations that cannot be explained by changes in domestic demand, we interpret them as a response of French employers to the movements in relative labor costs. Accordingly, more than one-third of the fall in the share of jobs held by the least-educated workers reflects the substitutions generated by the fall in the relative cost of higher-educated workers within each industry and occupational category in France.

By contrast, international trade and the technological changes inherently beneficial to higher-educated workers seem to have played only a minor role in the shift in labor-demand composition by sex and education observed in France. Technical progress has been somewhat swifter in industries and occupations in which the spread of computers and new production technologies has been the most effective, but this explains only a very modest part of the decline in the demand for unskilled workers.

In sum, the mechanisms that generate inequality do not appear to be quite the same in France and the United States. In our view, these results suggest that the source of inequality is not so much technical progress per se as its interaction with the institutions that regulate the labor market. Which institutions are most likely to promote a balanced growth that is beneficial to society as a whole? The question is still open to debate.

II. A Method for Analyzing Shifts in Labor Demand

We examine an economy with $S$ sectors and $N$ labor inputs. In each sector, the production is assumed to take place under constant return to scale and technical change is assumed to be factor-neutral. Under these two assumptions, cost functions have some basic properties that follow from the structure of the cost-minimization problem and that can be very useful for analyzing shifts in the demand for inputs. Katz and Murphy (1992) have already used this framework in order to test whether the data from the Current Population Surveys (CPS) were consistent with stable labor demand within sector in the United States. In this section, we begin with the same two standard assumptions as Katz and Murphy and develop a similar theoretical framework.

To be more specific, when technical change is factor-neutral and when returns to scale are constant, the total cost function in sector $s$ at date $t$ can be written as

$$C_s(w_t, p_s y_{st}) = \min_L \left[ w_t^t L \right] \text{ subject to } p_s y_{st} \leq F_s(L),$$  \hspace{1cm} (1)

where $F_s$ is a first-degree homogeneous production function, $y_{st}$ is the demand for good $s$ at date $t$, and $w_t$ is the $(N, 1)$ vector of input costs at date $t$. The $p_s$ parameter represents the technological factors that shift employment in $s$ at date $t$. The $C_s(w_t, p_s y_{st})$ function can be rewritten as

$$C_s(w_t, p_s y_{st}) = p_s y_{st} c_s(w_t),$$  \hspace{1cm} (2)

where $c_s(w_t)$ is the unit cost function. If $L_s$ represents the $(N, 1)$ vector of labor demand in $s$ at $t$, the Sheppard lemma implies that

$$L_s(w_t, p_s y_{st}) = \frac{\partial C_s(w_t, p_s y_{st})}{\partial w} = p_s y_{st} \frac{\partial c_s(w_t)}{\partial w},$$  \hspace{1cm} (3)

where $\partial c_s(w_t)/\partial w$ represents the $(N, 1)$ vector of the partial derivatives of the unit-cost function in sector $s$ with respect to each labor input.

By aggregating on all industries and differentiating, we can write

$$dL_t = \sum_s dL_{st} = \sum_s \left[ L_{st} \frac{d(p_s y_{st})}{p_s y_{st}} \right]$$
$$+ \sum_s \left[ p_s y_{st} \frac{\partial^2 c_s(w_t)}{\partial w^2} dw_t \right],$$  \hspace{1cm} (4)

where $\partial^2 c_s(w_t)/\partial w^2$ represents the $(N, N)$ matrix of the second partial derivatives of the unit cost function in $s$.

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In other words, the aggregated variations of labor demand \((dL_i^P)\) can be written as the sum of a \((N, 1)\) vector capturing the impact of changes in technology and output, that is,

\[
dL_i^P = \sum_s \left[ L_{st} \frac{d(p_s y_{st})}{p_{st} \delta y_{st}} \right]
\]

and a \((N, 1)\) vector capturing the effect of shifts in relative costs, that is,

\[
dL_i^W = \sum_s \left[ p_{st} \frac{\delta^2 c_s(w_i)}{\delta w^2} dw_i \right].
\]

The first effect \((dL_i^P)\) consists of between-industry job reallocations. The second effect \((dL_i^W)\), on the other hand, acts on the internal structure of each industry and consists of within-industry job reallocations. The issue is now to identify these two components.

Under the constant-return hypothesis, the unit-cost function \(c_s(w_i)\) is homogeneous of degree zero and one verifies,

\[
\frac{d(p_s y_{st})}{p_{st} \delta y_{st}} = \frac{w_i' dL_{st}}{w_i' L_{st}},
\]

where the notation \(x'y\) stands for the vector multiplication in \(R^N\) (that is, \(x'y = \sum_{i=1}^N x_i y_i\)).

In our analytical framework, the impact \(dL_i^P\) can therefore be identified directly from the labor-cost structure and the employment structure.

\[
dL_i^P = \sum_s \left[ L_{st} \frac{w_i' dL_{st}}{w_i' L_{st}} \right].
\]

Because the \(dL_i^P\) component is identifiable, the \(dL_i^W\) component can also be identified by subtraction:

\[
dL_i^W = dL_i - dL_i^P = \sum_s \left[ dL_{st} - L_{st} \frac{w_i' dL_{st}}{w_i' L_{st}} \right].
\]

The identification of \(dL_i^W\) is useful as a means to test the relevance of the hypotheses on which our proposed method rests. Indeed, if the hypotheses on which we base our calculations are correct (notably the assumption of the neutrality of technical change), the \((N, N)\) matrices \(\frac{\delta^2 c_s(w_i)}{\delta w^2}\) are symmetric semidefinite negative, as is their aggregation. Hence, necessarily,

\[
dw_i' dL_i^W = \sum_s \left[ p_{st} \frac{\delta^2 c_s(w_i)}{\delta w^2} dw_i \right] \leq 0.
\]

The meaning of this condition is very simple: assuming technical-progress neutrality, job substitutions within each industry directly reflect changes in relative costs, to which they are thus necessarily and negatively correlated. Indeed, the vector product \(dw_i' dL_i^W\) can be interpreted as the excess wage cost that employers avoid by adjusting to changes in relative costs. It is important to stress that condition (8) is necessary but not sufficient; it may be fulfilled even if technical progress is biased. The search for more-powerful tests of technical-progress neutrality informs the extensions described in section III.

The \(dL_i^P\) and \(dL_i^W\) vectors allow us to measure the relative importance of supply-and-demand factors when technological change is factor-neutral and returns to scale are constant. In the following two subsections, we remain in the same basic theoretical framework and propose a decomposition of these two elementary vectors in order to separate the role of the different demand factors on the one hand and, on the other hand, the role of the different supply factors.

A. Impact of Changes in Technologies and Products

We begin by a decomposition of \(dL_i^P\). By definition, we have,

\[
dL_i^P = \sum_s L_{st} \frac{dy_{st}}{y_{st}} + \sum_s L_{st} \frac{dp_{st}}{p_{st}}.
\]

In other words, \(dL_i^P\) can be written as the sum of a \((N, 1)\) vector capturing the impact of changes in demand for goods and services, that is,

\[
dL_i^{dy} = \sum_s L_{st} \frac{dy_{st}}{y_{st}}
\]

and a \((N, 1)\) vector capturing the effect of technical progress, that is,

\[
dL_i^{dp} = \sum_s L_{st} \frac{dp_{st}}{p_{st}}.
\]

Knowing the industry output levels \(y_{st}\), the \(dL_i^{dp}\) component can be easily identified. Because the \(dL_i^P\) and \(dL_i^{dy}\)

\[\text{5 This inequality is given in Varian (1984), section 1.15. It corresponds to the test implemented by Katz and Murphy (1992) with CPS data. (See their equation (10), p. 58.)}\]
components are identifiable, the $dL_t^{DP}$ component can also be computed by subtraction:

$$dL_t^{DP} = dL_t^D - dL_t^{DP}$$  \hspace{1cm} (10)

On this basis, we can take the analysis one step further and attempt to distinguish the direct contribution of international trade in $dL_t^{DY}$. For this, we simply have to consider the accounting equation

$$y_t = D_t + X_t - I_t,$$  \hspace{1cm} (11)

where $D_t$ is the domestic demand for the good $s$, $X_t$ is the exports of that good, and $I_t$ is the imports. Writing $D_t$ as a function $D_t(\pi, R_t)$ of prices $\pi_t$ and national income $R_t$, and differentiating, we obtain

$$dy_t = \frac{\partial D_t(\pi_t, R_t)}{\partial R_t} dR_t + \frac{\partial D_t(\pi_t, R_t)}{\partial \pi_t} d\pi_t + dX_t - dI_t.$$  \hspace{1cm} (12)

If we assume that changes in national income have no significant effect on the demand structure (that is, $\partial D_t(\pi_t, R_t)/\partial R_t = D_t(\pi_t, R_t)/D_t(\pi_t, R_t)$), we can ultimately divide $dL_t^{DY}$ into four elementary contributions:

$$dL_t^{DY} = \sum_s \frac{dx_t}{y_t} L_{st} - \sum_s \frac{dx_t}{y_t} L_{st} - \sum_s D_t(\pi_t, R_t) d(\pi_t - R_t)$$
$$+ dL_t^{DC} = dL_t^{DX} + dL_t^{DI} + dL_t^{DR} + dL_t^{DC}.$$  \hspace{1cm} (13)

The first two terms express the direct impact of the change in exports ($dL_t^{DX}$) and the change in imports ($dL_t^{DI}$), respectively. The third term stands for the income effect ($d(\pi_t - R_t)$) of the changes in the trade surplus, and the balance ($dL_t^{DC}$) measures the overall impact of the change in domestic demand (net of the increase or decrease in wealth due to international trade).

**B. Impact of Changes in Relative Costs**

The impact of changes in relative costs on the labor-demand structure is all the stronger as the country specializes in productions in which labor categories can be easily substituted. In other words, the change in the composition of labor demand depends not only on shifts in trade but also on the industry structure of imports and exports. In our analytical framework, this structural effect is incorporated in the component of labor-demand change. We can assess its contribution simply by writing

$$dL_t^{w} = \sum_s \left[ \frac{dL_{st}}{y_t} w_s^t dL_{st} L_{st} \right] \left( X_t - I_t + D_t \right)$$
$$= dL_t^{wx} + dL_t^{wI} + dL_t^{wd}.$$  \hspace{1cm} (14)

For a given change in relative costs, the impact on the demand for labor ($dL_t^{wx}$) is all the stronger as the country exports products from industries whose technologies allow substitutions between skilled and unskilled labor; conversely, the $dL_t^{wI}$ impact is all the stronger as the country imports products from those same industries. Berman, Bound, and Griliches (1994) use indicators closely resembling those of equation (14).

**III. Extensions: The Role of New Technologies**

The relevance of the decompositions proposed in section II rests on the assumption of technological-change neutrality. It is important to test this hypothesis as thoroughly as possible. A first test, of course, is provided by the inequality (8). If it is not verified, we would be wrong to overlook the existence of a technical progress that fostered between-industry job substitutions. However, inequality (8) is not a sufficient condition, and it can be verified even if technical progress is biased (inherently favorable to some skills and unfavorable to others within each industry). By extending our basic theoretical framework, however, we can construct a more direct test of the absence of technical-progress bias. Let $a_{ks}$ be the technical progress affecting $k$-type labor in industry $s$. With this notation, and keeping the constant-returns hypothesis, the total cost function in sector $s$ at date $t$ can now be written as

$$C_s(w_t, p_t y_t)$$
$$= \min_L \left\{ w_t L_t \right\} \text{ subject to } p_t y_t$$
$$= F_s \left[ L_{1s}, \ldots, L_{Ns} \right] / a_{Ns}.$$  \hspace{1cm} (15)

In this framework, equation (5) becomes

$$w_t dL_{st} = \frac{dy_t}{y_t} = p_t \frac{dp_t}{y_t} + \sum_{k=1}^{N-1} \frac{da_{kt} - da_{kt}}{a_{kt}} \frac{w_s L_{st}}{w_t L_{st}}.$$  \hspace{1cm} (16)

7 According to equation (7), we have $dL_t^{w} = \sum_s [dL_{st} - L_{st} w_s^t dL_{st} w_t^t L_{st}]$. Using equation (11), it can be rewritten as $dL_t^{w} = \sum_s [dL_{st} - L_{st} w_s^t dL_{st} w_t^t L_{st}] (X_t - I_t + D_t) / y_t$, which is equivalent to equation (14).

8 Notice that the cost-minimization problem is the same as in section II when the inputs are defined by $(L_{kt} a_{kt} \ldots, L_{Nk} a_{Nk})$ and the wages by $(a_{kt} w_{kt} \ldots, a_{Nk} w_{Nk})$. The total cost is $w_t^t L_{st} = p_t y_t a_{st} (a_{kt} w_{kt} \ldots, a_{Nk} w_{Nk})$, and the Shephard lemma becomes $L_{st} a_{st} = p_t y_t a_{st} \partial c / \partial w$. The differentiation of the total cost gives $w_t^t dL_{st} + L_{st} dw_t = d(p_t y_t) a_{st} + p_t y_t \sum_s \partial c / \partial w (a_{kt} w_{kt} a_{kt} w_{kt} + w_t^t dL_{st})$. Using the Shephard lemma, one obtains equation (16).

9 If we considered the possibility of biased technical progress in each industry, we could defend the same line of argument: the impact of this type of technical change on the labor-demand structure would be all the stronger if it took place in a country that specialized in fast-changing industries.
Let us now assume that the technical progress $dp_{st}/p_{st}$ affecting all jobs in industry $s$ is randomly distributed around a mean $\tau_s$ that remains constant over time. Let us further assume that the potential biases of this technical progress are also constant over time (that is, $da_{kst}/a_{kst} - da_{kst}/a_{Nst} = \gamma_k$, $\forall k, s, t$). Under these assumptions, we can rewrite (16) as follows:

$$w'_s dL_{st} - dy_{st} = \tau_s + \sum_{k=1}^{N-1} \gamma_k m_{kst} + u_{st}$$

(17)

where $m_{kst} = w_{kst} L_{kst}/w'_s L_{st}$ is the share of industry $s$ payroll allocated to type $k$ labor and where the $u_{st}$ values are independent, identically distributed, random disturbances.

To test the absence of within-industry bias, we therefore simply regress the industry impacts of technical progress ($dL_{i}^{k}$) on the payroll share allocated to each type of labor, then we verify that the elasticities $\gamma_k$ are zero.

Now, if inequality (8) holds and if the test of zero elasticities in equation (17) is accepted, this method still provides only an indirect measure of the impact of technical change. The unexplained component of the change in labor demand is given by

$$\frac{dp_{st}}{p_{st}} = \frac{w'_s dL_{st} - dy_{st}}{w'_s L_{st} - y_{st}}$$

(18)

If, as is the case in France, information is available on the dissemination of new technologies (such as computers and production automation) by industry, we can make a more direct estimate of the impact of these forms of technical progress. Let us assume, for example, that the differential in marginal productivity between a worker using technology $q$ and a worker not using it is identical in all industries and written $\alpha_q$. Let $q_{st}$ be the rate of dissemination of technology $q$ in industry $s$. We can consequently write the impact of technical progress as the aggregated effect of the dissemination of new technologies:

$$p_{st} = \prod_q (1 + \alpha_q q_{st})^{-1} \exp(u_{st})$$

or, after differentiation and first-order expansion:

$$\frac{dp_{st}}{p_{st}} = - \sum_q \alpha_q dq_{st} + u_{st}$$

(19)

By regressing our measure of the net impact of technical progress ($dp_{st}/p_{st}$) on the changes in the rate of dissemination of new technologies ($dq_{st}$), we can estimate the $\alpha_q$ parameters. Then, we can assess the possible effect ($dL_{i}^{k}$) at the aggregated level of each technology in the shift in labor demand by education level, or

$$dL_{i}^{k} = -\alpha_q \sum_s L_{s} dq_{st}.$$  

(20)

**IV. Empirical Application**

Our empirical analysis is mainly based on the wage and employment data by skill level compiled from the 1970, 1977, 1985, and 1993 INSEE surveys on training and occupational skills. (See appendix A.) Each sample corresponds to a specific cross section of the French labor force, and workers are not followed from one survey to the other. We converted reported net salaries to employer labor costs by applying the formulas for the employer’s contribution to mandatory social benefits at each of the four dates. To our knowledge, this is the first French study that examines the change in total payroll costs rather than wages alone. This distinction is of some importance: in 1991, the government introduced specific relief from employer contributions for low-wage jobs, and such measures should clearly be taken into account.

Output and trade data are derived from the national accounts. The information on the spread of new technologies comes from surveys on workplace organization and working conditions (TOTTO), which are conducted as a complement to the Labor-Force Surveys of 1987 and 1993. These statistical sources are described in fuller detail in appendix A. (See also the presentation in Entorf and Kramarz (1997).)

From each of these surveys, one can estimate the number of workers (by occupation and industry) who, in the course of their work, have occasion to

1. use a personal computer or a terminal linked to a host computer,
2. operate or supervise a robot or any other device that is capable of automated movement in three dimensions,
3. use a numerically controlled machine tool (or a machining station),
4. supervise (and/or operate) a fully automated facility, and
5. use video and/or remote monitoring systems.

The 1987 and 1993 TOTTO surveys thus provide a measure, for each industry and occupation, of the computer-utilization rate and the dissemination of new industrial technologies such as robots, numerically controlled machines, and remote monitoring.

In describing labor supply, we distinguish between $N = 10$ labor categories, defined by a cross-classification into five education levels $\times$ employee gender. We also use a classification of activities into $S = 204$ industry-occupation categories, obtained from a cross-classification into 34 industries (using two-digit SIC system) $\times$ six broad occupational categories (manager and professional, technician and
lower-grade professional, clerical worker, other non-manual worker, skilled manual worker, and other manual worker). We interpret occupations as producing intermediate goods and services within each main industry. Our purpose is not only to analyze the data at the most disaggregated level possible (from the available surveys) but also to use an analytical framework as similar as possible to that of Katz and Murphy (1992). This will allow a direct comparison of some of our results with those obtained in the United States.

Whenever possible, we will also report the conclusions that would have been reached by using the aggregated 34-industry classification as against the 204-heading cross-classification by industry and occupation.

### A. Is Technical Progress Biased?

Before applying the method described in sections II and III, it may be useful to recall the broad trends whose mechanisms we are seeking to understand. The first and overwhelming trend is the steady fall, from 1970 to 1993, in the percentage of dropout workers: their share fell from almost one-third of total jobs in 1970 to less than 19% in 1993 (table 1). Given the differences between the U.S. and French educational systems, there is admittedly some risk in making a detailed comparison of shifts in education levels in the United States and French labor forces. All the same, one can observe that the proportion of U.S. high-school dropouts in payroll employment fell from just over 32% in the early 1970s to under 13% in the late 1980s—a sharper decline than that of school dropouts in French payroll employment.

The main difference between the two countries, however, concerns unemployment and wages. The unemployment rate for the least-skilled members of the French labor force rose from under 3% in the early 1970s to almost 20% in 1993. Over the same period, the percentage of unemployed college graduates in the labor force never exceeded 4%, apart from a brief recessionary spell in 1993. While being gradually excluded from the workplace, unskilled French workers have not become “cheaper.” Indeed, unlike the pattern observed in the United States, the differentials in hourly wages by education narrowed practically without a break between 1970 and 1993. Since 1970, on July 1 of every year, the French minimum wage (SMIC) is increased by a percentage that cannot by law be less than one-half of the growth in the real hourly earnings of manual workers.

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### Table 1.—Changes in Labor-Demand Composition by Sex and Education

<table>
<thead>
<tr>
<th>Educational Level</th>
<th>Structure in 1970</th>
<th>Evolution by Subperiod (%)</th>
<th>Structure in 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No diploma</td>
<td>23.4</td>
<td>-25.9</td>
<td>-17.6</td>
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<td></td>
<td>(0.3)</td>
<td>(1.4)</td>
<td>(1.8)</td>
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<tr>
<td>Vocational degree</td>
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<td>-5.0</td>
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<td>(1.2)</td>
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<tr>
<td>Bac or equivalent</td>
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<td>22.4</td>
<td>-1.7</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(5.0)</td>
<td>(3.7)</td>
</tr>
<tr>
<td>Bac + 2 years</td>
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<td>43.7</td>
<td>134.2</td>
</tr>
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<td></td>
<td>(0.1)</td>
<td>(13.7)</td>
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<td>(5.6)</td>
</tr>
<tr>
<td><strong>Women</strong></td>
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<td></td>
</tr>
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<td>-10.4</td>
<td>-14.5</td>
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<tr>
<td></td>
<td>(0.2)</td>
<td>(2.8)</td>
<td>(2.8)</td>
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<tr>
<td>Vocational degree</td>
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<td>3.6</td>
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<td></td>
<td>(0.3)</td>
<td>(2.2)</td>
<td>(1.7)</td>
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<tr>
<td>Bac or equivalent</td>
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<td>51.2</td>
<td>4.4</td>
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<tr>
<td></td>
<td>(0.1)</td>
<td>(7.1)</td>
<td>(4.2)</td>
</tr>
<tr>
<td>Bac + 2 years</td>
<td>1.3</td>
<td>12.1</td>
<td>160.1</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(8.8)</td>
<td>(16.1)</td>
</tr>
<tr>
<td>&gt;Bac + 2 years</td>
<td>0.8</td>
<td>79.0</td>
<td>51.5</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(16.9)</td>
<td>(10.7)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Field: wage-earners.
Reading: between 1970 and 1993, the share of male workers with no diploma in employment fell by 48.2%. It fell from 23.4% in 1970 to 12.1% in 1993. Employment is measured in months of full-time employment. Standard errors are in parentheses.

---

Note: however, that U.S. high-school graduates do not have to complete a certification exam to receive their diplomas, while French have to complete the baccalauréat. This makes the decline in the supply of French "no diploma" perhaps more striking than the American decline in "high-school" dropout.
Table 2.—Changes in Relative Labor Costs, 1970–93

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No diploma</td>
<td>1.37(0.18)</td>
<td>1.34(0.14)</td>
<td>1.24(0.14)</td>
<td>1.26(0.20)</td>
</tr>
<tr>
<td>Vocational degree</td>
<td>1.83(0.23)</td>
<td>1.69(0.16)</td>
<td>1.54(0.15)</td>
<td>1.61(0.22)</td>
</tr>
<tr>
<td>Bac or equivalent</td>
<td>2.51(0.39)</td>
<td>2.26(0.29)</td>
<td>2.05(0.28)</td>
<td>2.03(0.39)</td>
</tr>
<tr>
<td>Bac + 2 years</td>
<td>2.71(0.74)</td>
<td>2.14(0.45)</td>
<td>2.04(0.32)</td>
<td>2.20(0.50)</td>
</tr>
<tr>
<td>&gt; Bac + 2 years</td>
<td>4.14(0.71)</td>
<td>3.50(0.49)</td>
<td>3.10(0.44)</td>
<td>3.26(0.81)</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No diploma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocational degree</td>
<td>1.29(0.17)</td>
<td>1.25(0.13)</td>
<td>1.24(0.13)</td>
<td>1.25(0.18)</td>
</tr>
<tr>
<td>Bac or equivalent</td>
<td>1.67(0.32)</td>
<td>1.65(0.22)</td>
<td>1.50(0.20)</td>
<td>1.50(0.27)</td>
</tr>
<tr>
<td>Bac + 2 years</td>
<td>1.80(0.38)</td>
<td>1.73(0.33)</td>
<td>1.64(0.23)</td>
<td>1.70(0.33)</td>
</tr>
<tr>
<td>&gt; Bac + 2 years</td>
<td>2.51(0.62)</td>
<td>2.13(0.37)</td>
<td>2.98(0.30)</td>
<td>2.18(0.50)</td>
</tr>
</tbody>
</table>

Field: wage-earners.
Reading: In 1993, the average labor cost of men whose educational level was higher than the baccaulauréat plus two years were 2.56 times that of dropout women. Labor costs are estimated in 1970 francs per month of full-time employment. Labor cost is estimated from individual net monthly wages reported in the survey. We calculated the corresponding payroll taxes for each individual according to his (or her) wage level and skill. Standard errors are in parentheses. See the note for table 1 for the definition of the educational levels.

Table 3.—Inner Product of Changes in Relative Labor Costs with Changes in Relative Quantities Linked to Intra-Industry Job Reallocations

<table>
<thead>
<tr>
<th>Period</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977–1985</td>
<td>−20.7</td>
</tr>
<tr>
<td>1985–1993</td>
<td>−22.8</td>
</tr>
<tr>
<td>1990–1993</td>
<td>−576.5</td>
</tr>
</tbody>
</table>

Field: wage-earners.
Note: The table gives an estimate of the inner product $d w_f^t d w_f^s$ as the difference between the observed vector of labor demand shifts ($d w_f^t$) and the share of these shifts explained by the industry reallocation ($d w_f^s$). Each $d w_f^s$ component is measured by $\frac{f_w^j w_f^j(\gamma_i w_{f_i})}{f_w^j w_f^j(\gamma_i w_{f_i})}$, where $w_{f_i}$ is the (1.1) vector of wages, while $\gamma_i = \gamma_i - \gamma_i - \gamma_i$.

Table 4.—The Industry Impact of Technological Change and the Structure of the Wage Bill

| Dependent Variable: The Impact of Technical Progress
<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>−0.14 (0.29)</td>
</tr>
</tbody>
</table>

$F$-test: $F = 1.71 (p = 0.083)$
Number of observations: 599
R²: 0.39

$^1$ According to equation (18), the dependent variable ($d w_f^t$) corresponds to the difference between the impact of employment shifts on wage bill ($d w_f^t w_{f_i}$) and the growth rate ($d w_f^t w_{f_i}$).
$^2$ The independent variables reported in the table correspond to the share of payroll allocated to the ten different types of labor. The other explanatory variables are 20 industry dummies obtained from the cross-classification into 34 industries (French NAP40 classification) and six categories of occupation. Standard errors are in parentheses. See table 1 for the definition of the educational levels.

(skilled and unskilled). The government can also grant a small bonus. The continuous increases in the SMIC are no doubt one of the reasons why wage differentials between high-skilled and low-skilled workers did not widen in France as they did in the United States or in Britain (Dolado et al., 1996). It should be noted, however, that the measures to ease the burden of payroll contributions on low wages have recently led to a mild reversal in the downtrend in graduates' relative costs. In fact, the average relative cost of labor of university graduates stood higher in 1993 than in 1985 (table 2).

When filtered through equation (8), the French data yield some interesting initial results (table 3). First, in each of the subperiods 1970–1977, 1977–1985, and 1985–1993, the $d w_f^s$ component is negatively correlated with relative-cost variations, and the inequality (8) is verified. In other words, the data collected in French surveys can be interpreted without having to assume a technological bias that shifts labor demand in each industry and occupational category over time. Using very similar classifications and performing the same calculations on U.S. data, Katz and Murphy (1992) reach quite different conclusions: in the 1980s, the joint movement of wages and employment in the United States is incompatible with the hypothesis of intra-industry neutrality of technical progress (that is, inequality (8) is not verified). As the percentage of college graduates among U.S. workers has risen, so have their relative wages, a process that would be incomprehensible without technological changes benefitting the best-educated workers.

It bears repeating that inequality (8) is a necessary but not sufficient condition for the absence of technological bias. In keeping with the analysis detailed in section III, however, we can perform a more direct test of the technical-progress neutrality hypothesis. We need only regress the industry values of technical progress on the labor-cost shares allocated by the industry to each category of graduates. The results of this test, as well, corroborate the technical-progress neutrality hypothesis: none of the $\gamma_i$ technological-bias coefficients differs significantly from zero, and a Fisher test fails to reject the hypothesis of the ten coefficients' simultaneous nullity (table 4). In other words, there is no significant link between the impact of technical progress and the proportion of unskilled labor in total payroll employment. Such a result would be hard to imagine if technological change, in itself, reduced demand for unskilled labor.

The analysis of equation (4) yields a second interesting result. As we measure it, the effect of changes in productive

$^1$ We repeated the analysis on manufacturing sectors only and found the same result for these specific industries.
parameters on the labor-demand composition \( (dL_P^D) \) is 1.5 times as great as the effect of shifts in relative costs \( (dL_P^W) \). In numerical terms, the main changes observed between 1970 and 1993 are a decrease of approximately 18.1% in the percentage of men without a \textit{baccaulærat}\(^{12}\) in total employment, and a decrease of 2.2% in the percentage of women dropouts in total employment. As it happens, our measure of interindustry job reallocations \( (dL_P^D) \) single-handedly explains approximately 9.8 points of the decrease in the percentage of men without a \textit{baccaulærat} and approximately 2.1 points of the decrease in the percentage of women dropouts in all 60% (11.9/20.3) of the job reallocations observed.\(^{13}\) (See table 5.) The changes in relative costs explain the remaining substitutions, namely, a fall of approximately eight points in the percentage of men without a \textit{baccaulærat} in total employment.

These results, as well, contradict the findings reported on U.S. data by Katz and Murphy (1992) and by Berman, Bound, and Griliches (1994). These two studies identify intra-industry job reallocations as the prime cause of labor-demand shifts, implying a key role for intra-industry technological biases. Both studies, however, focus exclusively on manufacturing industries and therefore do not take into account the shifts in demand \( (y_{st}) \) from goods to services, or the fact that technical progress \( (p_{st}) \) takes different forms in these two broad sectors of the economy. Independent of the institutional differences between France and the United States (or Britain), it is possible that the French results come only from our using data for all sectors and not for manufacturing sectors only.

To verify that this interpretation is correct, we repeated the analysis on French manufacturing sectors only. As it turns out, the results are very similar to those obtained on all French sectors. To be more specific, we found that

2. there is no significant link between the impact of technical progress in French manufacturing industries and the proportion of unskilled labor in total payroll employment, and
3. the measurement of interindustry job reallocations \( (dL_P^D) \) explains approximately 60% of the decline in the share of unskilled labor in French manufacturing sectors.

In other words, we have much less evidence for a significant role of skill-biased technical progress in France than in the United States, even when we focus on manufacturing sectors. These findings do not necessarily contradict those obtained by Machin and Van Reenen (1998) or Machin, Ryan, and Van Reenen (1996), who report a significant effect of technology on the skill structure of a panel of OECD countries, but find also that this effect is somewhat lower in the United States and Britain where the skill structures have yet changed the most rapidly. They argue that other factors (in addition to technology) must have contributed to the declining labor market position of unskilled workers. (See also DiNardo, Fortin, and Lemieux (1996).) One plausible interpretation for our results is indeed that these institutional and/or demand factors played a quite different role in France and in the United States. De facto, the ability of institutions to set wages and to control the power of firms to lay off has not really weakened in France, while it has dramatically weakened in the United States in the 1980s. On the contrary, the interindustry job reallocation process has been much more intense in France than in the United States during the same period. The decline in the share of traditional industries began earlier in the United States than in France.

### B. The Industry Shift in Domestic Demand for Goods and Services

Turning now to the impact \( (dL_P^D) \) of the change in technologies and goods produced, the decomposition of the impact formulated in equations (9) through (13) reveals the dominant role played by the shifts in domestic demand for goods and services \( (dL_P^{DC}) \). In each subperiod, as over the entire 1970–1993 period, this single factor explains nearly all the \( dL_P^D \) effects.

For instance, according to our figures, the industry shifts in domestic demand between 1985 and 1993 caused a fall of almost two points in the percentage of men without a \textit{baccaulærat} in total employment and a fall of 1.5 points in the percentage of women dropouts, or approximately 50% of the total shifts in labor demand by education level observed during the period.
TABLE 6.—A MEASURE OF THE IMPACT OF INDUSTRY ASYMMETRIES OF TECHNICAL PROGRESS ON LABOR-DEMAND COMPOSITION

<table>
<thead>
<tr>
<th>Estimated Impact by Subperiod (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>No diploma</td>
</tr>
<tr>
<td>Vocational degree</td>
</tr>
<tr>
<td>Bac or equivalent</td>
</tr>
<tr>
<td>Bac + 2 years</td>
</tr>
<tr>
<td>&gt;Bac + 2 years</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>No diploma</td>
</tr>
<tr>
<td>Vocational degree</td>
</tr>
<tr>
<td>Bac or equivalent</td>
</tr>
<tr>
<td>Bac + 2 years</td>
</tr>
<tr>
<td>&gt;Bac + 2 years</td>
</tr>
</tbody>
</table>

Field: wage-earners.
Reading: Between 1970 and 1977, our measure of the industry asymmetries of technical progress (\(dL^{dp}\)) explains a decline of 3.7% of the share of male dropouts in total employment. Standard errors are in parentheses.
See the note for table 1 for the definition of the educational levels.

The industry asymmetries of technical progress played a far less important role than did domestic demand (table 6). Their only significant effect is to favor the rise in the share of women in total employment. Technical progress is indeed softer in industries, such as households services, where the share of women in employment is relatively high. Between 1970 and 1993, we observed a ten-point rise in the percent-age of women in total employment, and industry asymme-tries of technical progress explained only approximately 15% of these shifts.

As regards foreign trade, the values found for \(dL^{dx}\) show that the impact of export shifts was identifiable, but weak by comparison with that of domestic demand (table 7). As we measure them, the industry shifts in imports (\(dL^{di}\)) also play a minor role in labor-demand shifts. We should also stress that export shifts and import shifts had distinct impacts that tended to offset each other in both subperiods and in the entire period. As a result, the net effect of this aspect of trade was ultimately negligible. In 1970–1993, trade growth centered on goods that, in France, incorporated roughly the same educational level on the export side and the import side.

One can draw the same conclusion from an analysis of the effects of the trade structure on the composition of labor demand (\(dL^{dd}\) and \(dL^{dw}\) effects). They are weak and also tend to compensate each other. If exports and imports were distributed randomly across industries and occupations, the impact of the relative-cost variations would be neither stronger nor weaker than it is today. Analyzing the U.S. economy with statistical indicators very similar to those used here, Berman, Bound, and Griliches (1994) reached a similar conclusion on this point.

Our results suggest that the expansion of trade has no net direct effect on the composition of labor demand, but that it

TABLE 7.—CHANGES IN RELATIVE LABOR DEMAND: SHIFTS ARISING FROM INTERINDUSTRY JOB REALLOCATIONS VERSUS SHIFTS ARISING FROM RELATIVE LABOR COSTS, 1970–1993

<table>
<thead>
<tr>
<th>Impact of . . . (in Points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Level</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>No diploma</td>
</tr>
<tr>
<td>Vocational degree</td>
</tr>
<tr>
<td>Bac or equivalent</td>
</tr>
<tr>
<td>Bac + 2 years</td>
</tr>
<tr>
<td>&gt;Bac + 2 years</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>No diploma</td>
</tr>
<tr>
<td>Vocational degree</td>
</tr>
<tr>
<td>Bac or equivalent</td>
</tr>
<tr>
<td>Bac + 2 years</td>
</tr>
<tr>
<td>&gt;Bac + 2 years</td>
</tr>
</tbody>
</table>

Source: FQP surveys 1970 and 1993, INSEE.
Field: wage-earners.
Reading: Between 1970 and 1993, the share of dropout male workers in total employment fell by 48.2% (\(dL_e\)). Industry asymmetries of technical progress (\(dL^{dp}\)) contributed −0.4%, exports −2.5% (\(dL^{dx}\)), domestic demand for goods and services +3.3% (\(dL^{dC}\)), domestic demand for goods and services −34.2% (\(dL^{dc}\)), and changes in relative labor costs −14.4% (\(dL^{dc}\)). The income effect (\(dL^{di}\)) is negligible and is not represented. Standard errors are in parentheses.
See the note for table 1 for the definition of the educational levels.
does contribute more significantly to the gross reallocation of jobs (at all levels of the educational scale) among firms. These gross job reallocations between firms that prosper on foreign markets and firms that suffer from competition are invisible at the aggregate volume and structure level. However, they are a direct determinant of labor mobility, and hence of the unemployment-risk distribution and of the income variations that are experienced in each household category. The study of this redistributive effect of international trade growth lies beyond the scope of our paper.

C. The Role of Computers and New Production Technologies

As it turns out, technical progress has only a modest impact on the labor demand composition. Is it that the dissemination of robots and computers does not shift labor demand? Or is it that it shifts labor demand in opposite directions? French data make it possible to give some answers to this question.

In 1987 and 1993, INSEE conducted two surveys on work organization to complement its standard Labor-Force Survey. Thanks to the two additional surveys, one can measure the dissemination of computers and new production technologies in each industry and occupational category. In keeping with equation (19), if we regress our industry measures of technical progress \( (dp_{it}/p_{it}) \) on the change in the share of workers using the new technologies, we can estimate the impact of the new technologies on labor productivity, and hence on labor demand.

As the information on new technologies is not available for the pre-1987 period, we estimated two different models. The first regresses the industry measures of technical progress for the period 1970–1993 on the new-technology dissemination rate observed in 1993. (In other words, we took this end-of-period rate as an estimate of the spread of new technologies from 1970 to 1993.) The second model regresses the industry measures of technical progress for the subperiod 1985–1993 on the industry shifts in the share of workers using the new technologies in 1987–1993.

The first model confirms that the industries and occupations that are the most heavily equipped with new technologies today are also those in which technical progress had the strongest impact on labor demand in 1970–1993. (See table 8, column 2.) The estimates of the \( \alpha_{it} \) parameters obtained from this model suggest that each additional point of information-technology dissemination is linked to a productivity gain of 0.26%, and that each additional point of new production-technology dissemination is linked, on average, to productivity gains of 0.46%. Supplementary estimates (not reported) also suggest that the productivity gains accruing from new technologies are not significantly greater in clerical or manual-worker categories than they are in intermediate professions or managerial categories. The spread of new technologies explains some of the job shifts between broad industry categories (the 34-heading classification) but appears to have no significant role in redistributions between broad occupational categories.

The second model, which covers the 1985–1993 subperiod, suggests that the role of new technologies as productivity factors is no doubt more modest in the early 1990s than in the 1970s. We find, for instance, no clear correlation between the pace at which industries invested in computers in 1985–1993 and the impact of technical progress in the same period. To assess the recent role of computers, it may now be necessary to distinguish the type and generation of equipment in which firms invest.

As regards the spread of new production technologies, the estimated parameters obtained for the years 1985–1993 are different from zero at the 10% level \( (t = 1.6) \) and slightly smaller than the ones obtained with the first model for the entire 1970–1993 period. (See table 8, column 4.) During the 1985–1993 period, one additional point of dissemination seems to have boosted productivity by approximately 0.37%. Restricted to the years 1985–1993, our estimates also confirm that the spread of new technologies had about the same impact on each of the broad occupational categories.

On balance, if we set aside computers in the subperiod 1985–1993, our econometric analysis confirms the role of new technologies as a vector of technical progress. As they have been unevenly disseminated across industries and

<table>
<thead>
<tr>
<th>Table 8.—The Dissemination of New Technologies and Technical Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variables</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td>Dissemination of computers</td>
</tr>
<tr>
<td>Dissemination of new production technologies</td>
</tr>
<tr>
<td>Type of Occupations</td>
</tr>
<tr>
<td>Managers, professionals</td>
</tr>
<tr>
<td>Technicians, supervisors</td>
</tr>
<tr>
<td>Clerical (and related) workers</td>
</tr>
<tr>
<td>Other nonmanual workers (sales, services)</td>
</tr>
<tr>
<td>Skilled manual workers</td>
</tr>
<tr>
<td>Other manual workers</td>
</tr>
<tr>
<td>Number of observations</td>
</tr>
<tr>
<td>( R^2 )</td>
</tr>
</tbody>
</table>

¹ The dependent variable \( (dp_{it}/p_{it}) \) corresponds to the difference between the impact of employment shifts on wage bill \( (w_{it}/w_{it}) \) and the growth rate \( (dp_{it}/p_{it}) \). We distinguish between S = 204 industries obtained from the cross-classification into 34 industries (French NAP40 classification) and six categories of occupation. Standard errors are in parentheses. The method used is the two-stage weighted least squares.

occupational categories, one might legitimately expect these innovations to have been a determinant of industry asymmetries in technical progress, hence a determinant of shifts in labor-demand composition.

Indeed, consistently with equation (19), we can demonstrate that computers were responsible for a fall of 2.1 points in the unskilled workers’ share of total employment in the years 1970–1993. During the same period, new production technologies had a smaller impact and explain a fall of only 1.0 points in the unskilled workers share. The dissemination of the two types of technology thus explains no more than 15% of the total labor demand shifts between 1970 and 1993.

In the most recent subperiod (1985–1993), the spread of new technologies explains an even smaller part of the fall in the percentage of workers without a baccalauréat in total payroll employment.

V. Conclusion

The decline in the percentage of unskilled workers in total French employment is chiefly due to the slackness of domestic demand for those industries with the highest proportion of such workers. In our opinion, this factor explains approximately two-thirds of the decline in unskilled labor observed between 1970 and 1993. The contraction in relative costs and the influx of better-educated labor in the job market have also generated important substitutions of higher-skilled workers for less-skilled workers within individual industries. By our estimate, these substitutions explain roughly the remaining third of the fall in demand for unskilled labor in France.

The spread of computers and new production technologies is found to be only a modest vector of technical progress. The new technologies do not seem to have been particularly conductive to substitutions of skilled labor for unskilled labor in individual industries and occupations. More generally, the speed of technical progress naturally varied from one industry to another, but it does not appear to have played a role in the shifts in labor demand by gender and education within industries and occupational categories.

What lessons can be drawn from these findings? In our opinion, the movements in the French labor market prove that the dramatic technological changes of our time can be managed without necessarily generating new inequality in industries and occupational groups. The only preventive measures needed are regular increases in the minimum wage and incentives for firms to accommodate technical change through a strong commitment to continuing education. The inevitable problem is that, in so doing, France encourages the rise of another type of inequality between people in work and the jobless.

The choice between the U.S. model and the French model may well be a choice between two inequality models, but it may also be a choice between two growth models. The crucial issue—at least for French economists—is whether, by adopting institutions to protect itself from overly rapid restructuring, the French economy is forcing itself onto a slower growth path, with the risk of inexorably falling behind the other developed nations.

REFERENCES


APPENDIX A

INSEE Surveys on Training and Vocational Skills

The French National Institute for Statistics and Economic Surveys (INSEE) conducted surveys on training and vocational skills (Enquêtes sur la Formation et la Qualification Professionnelle, hereafter FQP) in 1970, 1977, 1985, and 1993. The most recent covered a sample of 18,000 people between the ages of 20 and 65. The previous three covered a far larger sample of approximately 45,000 people.

For each member of the labor force surveyed, the FQP provides standard information on education, age, occupation, and the employer’s industry. In this study, we use a 34-heading aggregation of the standard 38-industry classification used in the official Nomenclature des Activités et des Produits (NAP40, two-digit SIC). We have been obliged to do so because of the FQP 1970, which groups together three sets of NAP40 headings: the food wholesale trade (NAP40 heading 25) and the non-food wholesale trade (26); the food retail trade (27) and the non-food retail trade (28); and real-estate rental and leasing (35), insurance (36), and financial institutions (37).

In this study, we also use a six-category occupational classification that is an aggregated version of the French classification of occupations and socio-occupational categories: managers, intermediate professions (technical and supervisory), skilled manual workers, unskilled manual workers, clerical workers and government employees, and sales and service workers.

Our educational classification comprises five headings: graduates of “long” higher-education programs, graduates of “short” higher-education programs, holders of the baccalauréat, holders of sub-baccalauréat diplomas, and dropouts. The respective average school-leaving ages for each category in 1993 were 24.4 years, 21.8 years, 20 years, 16.7 years, and 15 years, respectively.

Survey respondents are also asked to report their exact payroll earnings in the year prior to the survey and the number of months of work corresponding to those earnings, with a breakdown into months of full-time work and months of part-time work.14

Individual wages are then converted into labor costs by applying the social-contribution assessment formulas specific to each occupational category (managerial/nonmanagerial) and to each of the four survey dates.

The 1970, 1977, and 1985 surveys do not specify the exact number of hours worked per month by part-time employees. We have regarded them as half-time workers.

By aggregating the panel data, we can use the FQP surveys to construct series for employment, labor volume, compensation of employees, and hourly labor costs by industry, occupation, age, and education for the period 1970–1993.

By comparison with the sources typically used to analyze labor demand (administrative sources or employer surveys), the FQP survey offers the advantage of covering the entire labor force in employment with no limitations in respect of industry or firm size. The survey also makes it possible to characterize the education level of working individuals not only in each industry, but also in each occupational category.

To complete these industry-by-industry panel data on jobs, labor costs, and education, we have used the industry data from the French national accounts. The series consist of annual estimates of the levels of imports, exports, and domestic consumption of each good and service in the economy.

Complementary Surveys Linked to the Labor-Force Survey

To supplement its Labor-Force Survey, INSEE conducts an annual survey on a representative subsample of the French labor force. The subsample consists of approximately 20,000 people, which represents a sampling fraction of about 1/1,000. In 1987 and 1993, these complementary surveys focused on “workplace technologies and work organization of persons in employment” (known in French by the acronym TOTTO). From each of these surveys, one can estimate the number of people (by occupation and industry) who report using a personal computer (or a word processor), as well as the number of people who report using a terminal linked to a host computer.

Both surveys also make it possible to measure the number of people who, in the course of their work, have occasion to

1. operate or supervise a robot, or any other device capable of automated movement in three dimensions,
2. use a numerically controlled machine tool (or a machining station),
3. supervise (and/or operate) a fully automated facility, and
4. use video and/or remote monitoring systems.

The 1987 and 1993 TOTTO surveys thus provide a measure, for each industry and occupation, of the computer-utilization rate and the dissemination of new industrial technologies such as robots, numerically controlled machines, and remote monitoring.