Does technical progress create unemployment?

Gilles Saint-Paul

Universitat Pompeu Fabra, Barcelona, and CEPR, London

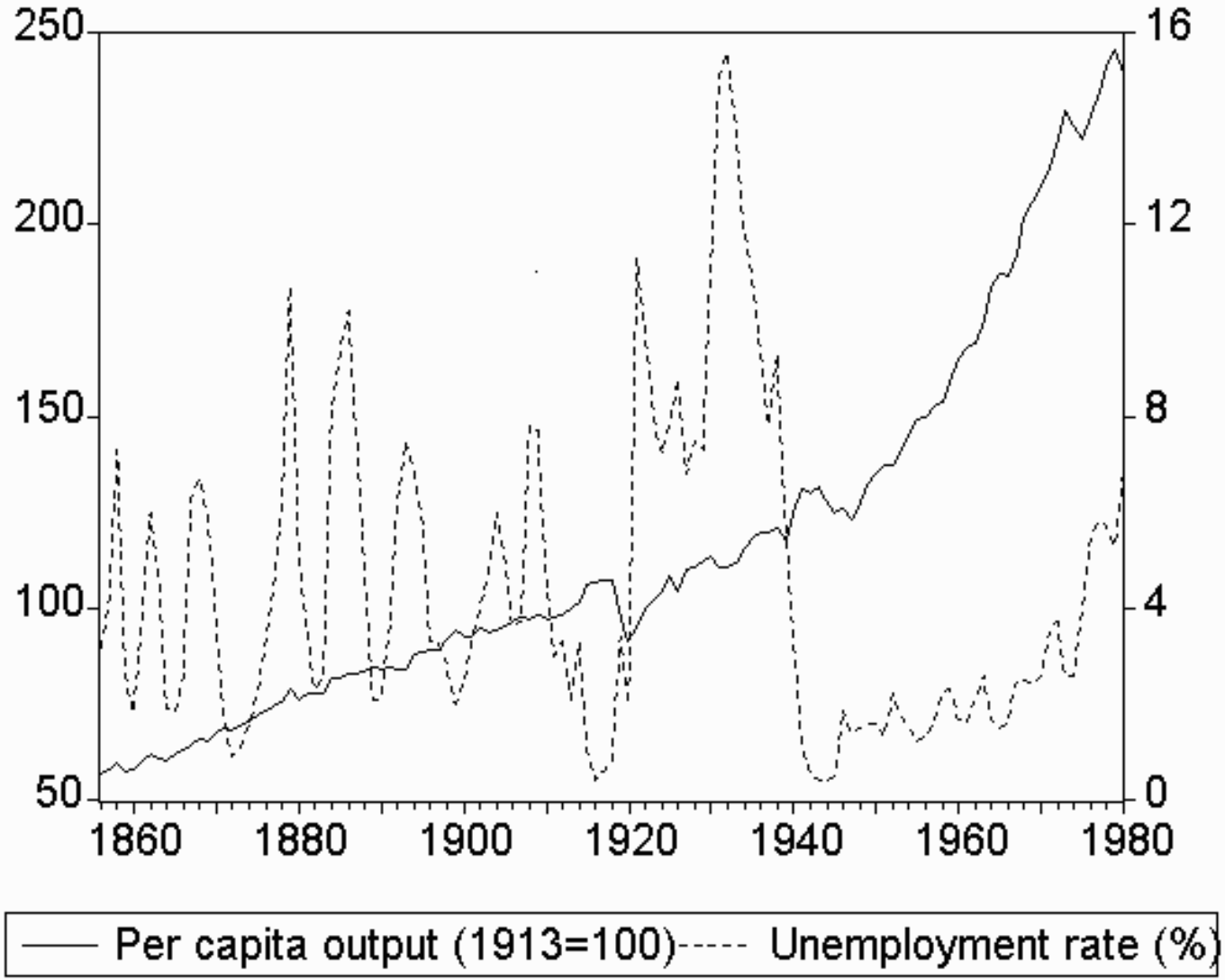
I. Introduction

Political opposition to technical change is not a new phenomenon; at the plant level, organized labour has often resisted implementation of new technologies, as is exemplified by the Luddites in the nineteenth century, the dockers strikes against the use of containers in Britain in the early 1970s, or the pervasiveness of various union workrules that impose minimum unit labour requirements on production. At the national level, it is customary to hear complaints that new technologies increase unemployment as growth fails to absorb the larger output potential they generate. This feeling that technical progress destroys jobs because output cannot follow is closely connected, in its logic, with popular recipes against unemployment such as working time reduction or pre-retirement schemes. For example, French minister of employment Martine Aubry recently declared to the press that working time reduction should be large and quick enough in order to prevent productivity growth from offsetting its supposed positive effects on employment. On the other side of the debate, economists have always had a hard time to find rigorous foundations for these views, and tend to consider that technical progress is neutral, as far as unemployment is concerned, or that, if anything, it is favourable for employment. This paper reviews some theoretical arguments and empirical evidence about the effect of technical change on unemployment. The broad conclusion is that overall, there is no reason to believe that technical progress is bad for employment, even though it is likely to destroy some jobs at the microeconomic level. But the gains in terms of welfare and the lack of a negative effect on overall employment should outweigh the costs of job loss in specific industries. Such job loss may be problematic in situations where the labor market does not function well, but then there would be resistance to any change that requires reallocation of labor, and the fundamental cause of unemployment is then a rigid labor market, not reallocative shocks. The paper is organized as follows: the first three sections discuss the macroeconomic effect of technical change on employment. The last two consider the role of asymmetric technical progress, both across sectors and skill levels.

II. The long-run

One of the most striking stylized facts of the last two centuries is the ten-fold increase in living standards that was made possible by continuing improvements in technology. If those who hold the view that technical progress increase unemployment were right, as an outcome of this process we would virtually all be unemployed by now. However, over the last two hundred years, unemployment exhibits large fluctuations, but no upward trend. This pattern is illustrated by figure 1 in the case of the United Kingdom.

Between 1856 and 1980, unemployment exhibits fluctuations around a level roughly equal to 4 %, while per-capita output grows steadily. Over that period this corresponds to a five-fold increase in productivity. This evidence is consistent with the standard way macroeconomists think of technical progress. They treat it, in the long-run, as a multiplicative factor that allows to produce and to consume more output with the same employment level. In general it is assumed that market forces restore full employment in the long run and that technical progress does not interact with them. It is possible to add equilibrium unemployment to growth models; equilibrium unemployment then results from frictions in the labour market that slow the reallocation of labour and prevent wages to adjust downwards in the presence of excess supply of labour. In the most standard treatment of equilibrium

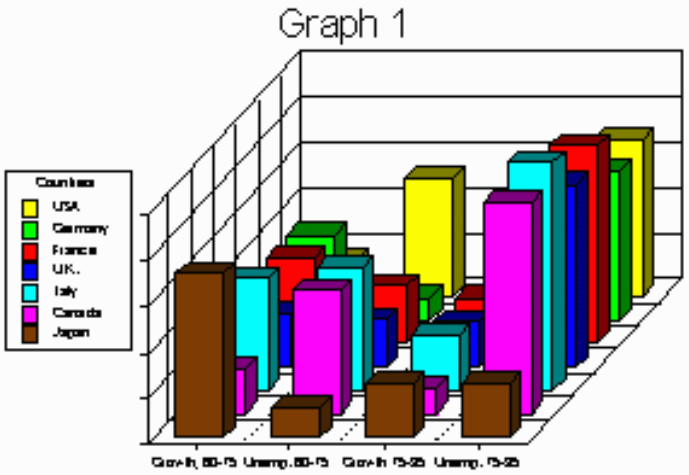

250
200
150
100
50
16
12
8
4
0
1860
1880
1900
1920
1940
1960
1980
Per capita output (1913=100)
Unemployment rate (%)

unemployment the natural rate of unemployment is unaffected by technical change, because it symmetrically affects wage aspirations and productivity. Non neutrality may be added but if anything they would lead to employment- enhancing effects of technical progress, as it would increase the value of working relative to not working. It is true that the rise in living standards has been accompanied by a secular decline in hours worked per employed. But this is simply the result that part of the increase in living standards is consumed in the form of additional leisure time. It has nothing to do with unemployment rising or jobs being destroyed because there is "no demand". More generally, the issue of whether one should work less or more when there is technical change is distinct from the issue of unemployment. Unemployment (at least at the levels and duration that we experience in Europe), is a symptom that the labor market does not function well. Reducing the amount of work is the optimal response of an economy that values leisure to the increased potential output brought about by technical progress (such increased potential output is signalled to private agents via an increase in wages, to which they react by reducing their labor supply). Thus, there is no presumption, either theoretical or empirical, that the level of technical progress negatively affects employment.

III. The medium run

While it is clear that in the long run unemployment does not rise when there is technical progress, it is also true that even in relatively well functioning labor markets, it may take a decade or more for an imbalances to be eliminated. As an example, the drastic reforms that took place in the United Kingdom at the beginning of the eighties only showed up as a persistent reduction in unemployment ten years later. Thus it is legitimate to consider whether technical change can lead to a transitory, but long, increase in unemployment. This brings up the question of whether there is an association between the pace of technical progress and the level of unemployment. According to this view, unemployment would rise when technical progress accelerates, but would be restored to its previous level once the level of technology has stabilized at a permanently higher level. This brings up the question of whether there is an association between the pace of technical progress and the level of unemployment. According to this view, unemployment would rise when technical progress accelerates, but would be restored to its previous level once the level of technology has stabilized at a permanently higher level. A possible mechanism is the need to retrain workers to get them acquainted with new technologies. A popular version of this view is that in recent years, major innovations, say in information technologies, have destroyed jobs. Computers do the jobs that humans used to do, and those who cannot use computers find their skills obsolete and end up on the dole.

Again, the recent experience does not support this view. As we can see in graph 1, the increase in unemployment has coincided with a fall in the rate of productivity growth (the so- called productivity slowdown). Productivity slowdown is one of the puzzles that has kept many economists busy for a long time. While oil shocks could in principle explain it, their reversal in the eighties has not brought productivity growth back to its pre-1975 level. Part of the productivity slowdown is also explained by the catch-up of Europe and Japan with the U.S.. But that does not explain why productivity growth has fallen in the U.S. itself. In any case, this slowdown has coincided in timing with an increase in unemployment almost everywhere. This negative association between growth and unemployment is a robust empirical regularity, and it is consistent with the so-called "capitalization effect". This effect comes from the fact that to the extent that hiring somebody is costly, it is similar to an investment decision. An expectation of faster growth reduces the time needed to recover the hiring costs. That is, even if the hiring cost rises at the same rate as productivity, at any point in the future the revenues generated by a worker hired today are higher, relative to the hiring costs incurred. Consequently the incentives to post vacancies are greater, which lead to a reduction in equilibrium unemployment. That growth is not associated with job destruction is also confirmed by statistical analysis; for example, in the French case, Cohen et al. (1997) find that an acceleration in growth is accompanied by an increase in hirings and a fall in job separations. However, one could argue that what matters is that the nature

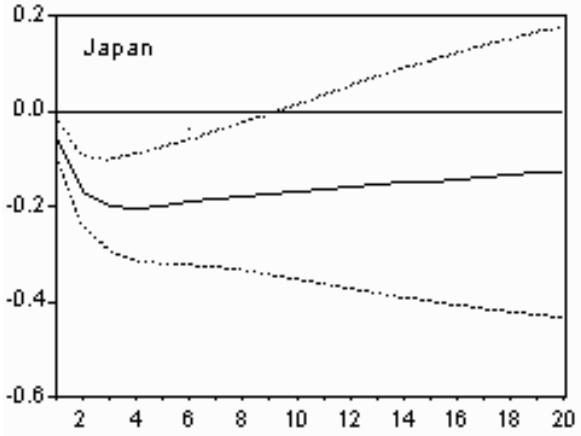

Graph 1
Countries
USA
Germany
France
UK.
Italy
Canada
Japan
Growth 60-73
Unemp. 60-73
Growth 73-85
Unemp. 73-85

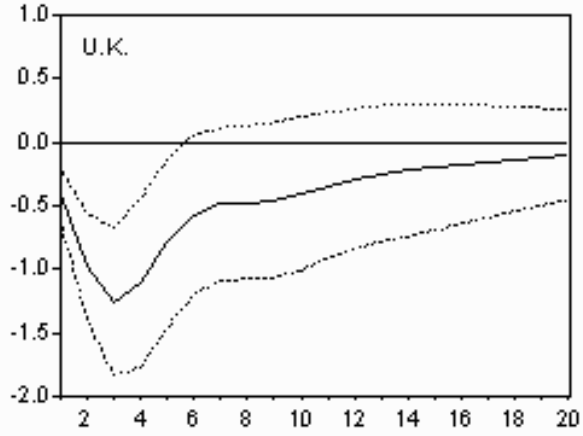
of growth has changed. According to that view, growth would be more "turbulent", more destructive of jobs than it used to be. Again, this view is inconsistent with the empirical evidence. Surprising as it may seem, the economic environment faced by individual firms is less volatile now than in the sixties. Measures of turnover, as well as measures of intersectorial labour reallocation, have fallen during the seventies and eighties. For example, in the United States, in 1971, 50 % of workers lost their jobs, and 47 % were hired; these figures were down to 41 % and 39 % in 1980. (See OECD, Jobs Study, 1994, part II, tables 6.1 and 6.2, pp. 64-65). The same picture is true for Europe. In France, the hiring rate dropped from 22 to 13 percent between 1971 and 1984, while the separation rate dropped from 19 % to 14 %. Looking at movements of labor between unemployment and employment confirms this view. Similarly, for the French economy, the pace of intersectorial reallocation of labor has fallen between 1965 and 1990.

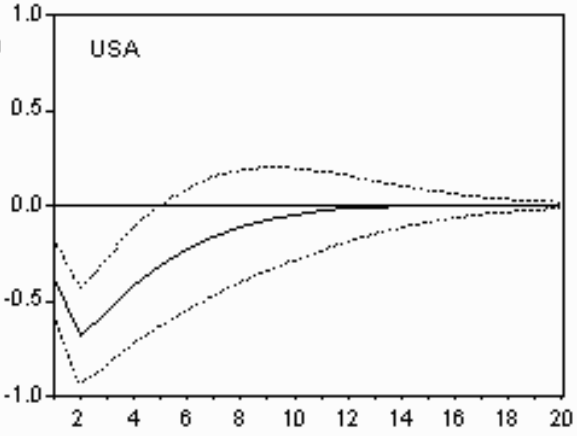
IV. Business cycle frequencies

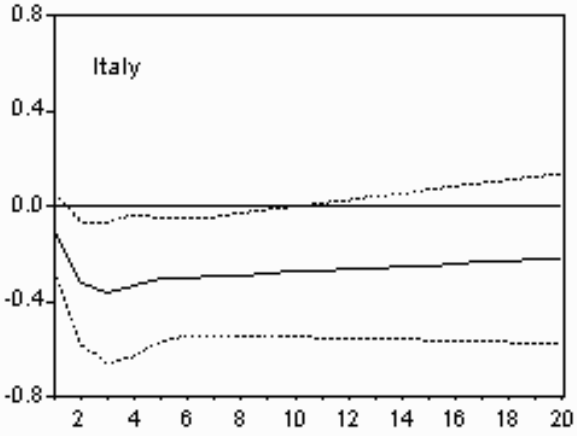
What happens, next, when we look at the very short run? That is, what is the impact effect of a productivity shock on output? In principle, an increase in productivity should lead to the inverse of what is usually called "stagflation". Inflation should fall as more productive firms can grant their workers the same increase in nominal wages while increasing their prices by less. Lower inflation in turn boosts aggregate demand by increasing the real value of nominal assets and of monetary holdings. However, a positive impact effect might require an accomodative monetary policy if rigidities in nominal price setting lead to a fall in inflation that is lower than the increase in output. Therefore, an increase in technical progress can in principle lead to a recession if the two following ingredients are present: (i) inflation fails to fall because of nominal price rigidity, and (ii) the central bank fails to accomodate the increase in the demand for nominal money balances associated with the rise in output and the insufficient falls in prices. We argue that it is unlikely that either condition is satisfied. Concerning the first condition, recent evidence on the behaviour of individual price setters suggests that as much as 70 % of prices are changed every week, suggesting that there is very little nominal price rigidity (which is perfectly consistent with having a considerable degree of nominal wage rigidity; but waht is needed for technical change to generate a recession is nominal price rigidity. Nominal wage rigidity is not enough). Concerning the second condition, given that the impact effect is a downward pressure on inflation, there is no reason why a central bank that has inflation as its target should not provide the market with the extra cash balances it requires. Even a central bank that targets the nominal exchange rate should do that, as if anything the pressure would be for an appreciation of the nominal exchange rate. Thus, only a central bank with a very sub-optimal target, namely the growth in the total nominal money stock, not adjusted for real output, would potentially fail to accomodate.

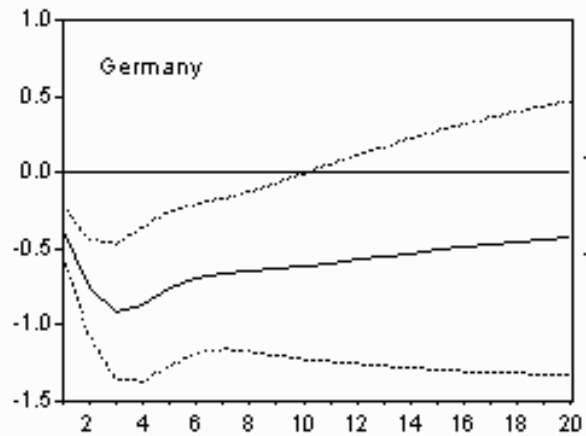
Figure 2 shows the estimated dynamic response of employment to a technological shock for the G7 economies; as is clear the response is positive. An increase in productivity leads to a reduction in unemployment followed by a gradual return to its initial level. This return can be quite slow as in France or Germany where unemployment is still substantially lower than its equilibrium level after 20 years, or more rapid as in the US where the employment effect of the shock has vanished after 10 years. There are other ways of estimating that response, and they sometime lead to a negative impact effect; however, in those cases, the initial reduction in employment is ususally quite short-lived and often statistically insignificant. Thus even if such an effect exists, which remains very doubtful, we should not worry about it and it has certainly not contributed at all to the increase in unemployment. Another interesting aspect of figure 2 is that unemployment jumps to a lower level, but reverts to its mean following a productivity shock much more rapidly, in the USA and the UK than in other countries. While this is subject to various interpretations, we interpret it as unemployment being less persistent in Anglo-Saxon countries. Such lower persistence comes from differences in labour market institutions. The cost of adjusting the labour force is lower in the US (and to a milder extent in the

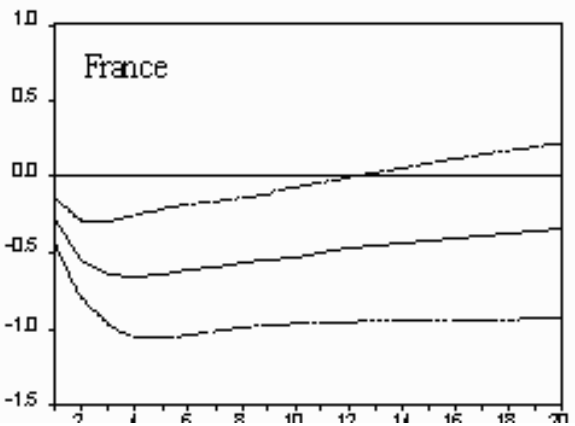

Japan
0.2
0.0
-0.2
-0.4
-0.6
2 4 6 8 10 12 14 16 18 20

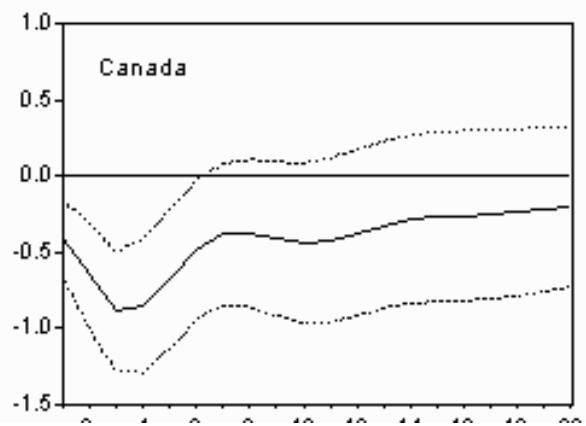

U.K.
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
2 4 6 8 10 12 14 16 18 20


USA
1.0
0.5
0.0
-0.5
-1.0
2 4 6 8 10 12 14 16 18 20


Italy
0.8
0.4
0.0
-0.4
-0.8
2 4 6 8 10 12 14 16 18 20


Germany
1.0
0.5
0.0
-0.5
-1.0
-1.5
2 4 6 8 10 12 14 16 18 20


France
1.0
0.5
0.0
-0.5
-1.0
-1.5


Canada
1.0
0.5
0.0
-0.5
-1.0
-1.5

U.K.) because of less stringent job protection regulation. This makes employers less cautious when hiring and more drastic when firing, which explains both the larger size of the intial response and the more rapid decay thereafter. Lower long-term unemployment (associated with less generous unemployment benefits), and lower bargaining power of unions (which reduces the weight of the currently employed insiders in wage formation) also account for a less persistent behaviour of unemployment. Another argument that makes a negative impact effect of increased productivity on employment highly implausible is the "sign-reversion test". If such an effect existed, then by the same token a reduction in productivity would increase employment. But the response to the oil shocks of the seventies, that were very similar to a reduction in productivity, was a clear jump in unemployment.

V. Intersectorial reallocation

We hope that the reader is now convinced that as far as the macroeconomic performance of an economy is concerned, there is no reason whatsoever to fear that technical progress may increase unemployment. However, this does not imply that everybody will keep one's job when an innovation is made. A firm in a given sector may discover that in order to absorb the extra output allowed by an increase in its productivity, it may have to lower its price to such an extent that its profit actually falls. In that case it will rather not increase its output by so much and shed labor instead. This will occur if the demand for its good is "inelastic", that is, it reacts very little to its price. This low elasticity in turn comes from the fact that when faced with a decline in the price of the good, consumers prefer to reduce their spending on that good, which allows them to increase their consumption of other goods. In other words, it is because a good is complementary to other goods in consumption that an increased productivity in that good reduces employment. This phenomenon may only prevail if technical progress is asymmetric, that is if it hits some sectors more than others. If productivity were to increase by the same percentage in all sectors, the relative price of a good vis-à-vis any other good would remain unaffected, so that consumers would uniformly increase their consumption of all goods. But, when goods are complements in consumption and technical progress is larger in one sector than in others, the relative price of the good that is experiencing technological change falls to such an extent that labor is reallocated from that sector to other sectors. Thus, technical progress destroys jobs in the sector where it occurs and create jobs elsewhere. On net, employment need not fall, but at the microeconomic level displaced workers will feel that they are indeed the victims of technical progress, since employment reallocation is needed away from the sector where productivity has increased. In principle, it is difficult for these displaced workers to end up actually worse-off than if technical progress had not taken place. Once reallocation has taken place wages have increased economywide, so that these workers end up with a better pay than they previously had. This phenomenon captures part of what has been going on. In the sixties and early seventies, massive movements toward the service sector were driven by large productivity gains in manufacturing, and many workers who ended in clerical situations ended up earning more than they previously did in factories. However, labor market rigidities may make this reallocation process painful and lead to opposition to technical change in the sector where it takes place. Regulation may make mobility more costly, increase the duration of unemployment before one finds a new job, etc. Another market imperfection that may generate losers from technical change is the well documented existence of industry rents. Some sectors pay above market clearing wages because they share monopoly power with their workers or because it is more important for them to generate appropriate incentives and good worker morale. If these sectors experience technical progress their workers may experience wage losses as they lose their rents when moving to other sectors. That is, technical progress may in principle relocate labor from "good jobs at good wages" to low-pay jobs. While this seems to capture part of the recent experience, as high paying manufacturing jobs seem to have disappear at the benefit of low pay jobs in sectors such as retail trade (the so-called "McDonald" jobs), this popular view is not supported by the statistical evidence. It has been shown that changes in relative demand over the last three decades have tended to favour high paying jobs at the expense of low paying jobs. The asymetry of the impact of technical progress on employment is documented in table 2. The second and third columns report the estimated response of employment , both in the short-run and in the long-run,

to an increase in productivity specific to a sector. The fourth and fifth columns consider a shockr specific to the rest of the economy, but that does not affect the sector. The last column reports the impact of a shock that increases productivity in all sectors by the same percentage. The response is in accordance with the arguments presented above, with the notable exception of the United Kingdom. A productivity shock in a given sector will in most countries reduce employment in that sector, both at the date it occurs and in the long-run. By contrast, a productivity shock that affects all sectors simultaneously has, if anything, a positive impact on employment.

Country	Sector-specific productivity shock, Short-run effect	Sector-specific productivity shock, Long-run effect	Productivity shock in the rest of the economy , Short-run effect	Productivity shock in the rest of the economy , Long-run effect	Productivity shock in all sectors, Long-run effect
USA	-0.23	-0.34	0.73	0.19	0.00
Canada	-0.51	-0.44	0.45	0.25	0.12
Germany	-0.19	-0.26	0.35	0.52	0.32
France	-0.08	-0.09	0.51	0.8	0.73
U.K.	0.08	0.32	-0.12	-0.26	0.04
Italy	-0.17	-0.17	0.34	0.93	0.82
Japan	-0.18	-0.13	0.09	0.15	0.08

Table 2: percent effect of an innovation that increases total factor productivity by 1 % on employment, G7 countries.

VI. Skill-biased technical progress

There is also an ongoing debate on whether technical progress is biased in the sense that it increases the demand for skills at the expense of unskilled workers. This debate is based on the observation that in the United States inequality has increased since the seventies. While average wages are stagnating, the wages of the poorest have fell by almost 30 %, while the top decile has gained around 20 %. Economists who have studied this phenomenon have eliminated explanations based on changes in the structure of labor supply, as well as those based on foreign competition from low- wage countries. They have concluded that such developments are due to technical change that increase the demand for skilled workers while reducing the demand for unskilled workers, such as new information technologies that are complements for skilled workers but substitute for unskilled workers. Such an increase in inequality has been observed in the United Kingdom too, but much less in other European countries. For example, in France, the relative wage of university graduates over other workers fell by 10 % over the eighties, while it rose by 20 % in the United States over the same period. One may however speculate that wage rigidity has prevented wage dispersion from rising, and that the same trend in the demand for skills has generated higher unemployment at the bottom of the income distribution in Europe, rather than lower wages. This very plausible hypothesis does not fare too well with the data. While it is true that the relatve unemployment rate of the least skilled has risen in France, it has also risen in the United States, by a comparable factor. Furthermore, the unemployment rate of the skilled has also risen in France, whereas it should have fallen if the hypothesis of skilled bias technical progress were correct. This hypothesis therefore remains very much a residual one, that is an explanation that has been adopted after elimination of other explanations. There is still a shortage of direct evidence in its favour.

VII. Conclusion

We have reviewed the empirical evidence on the employment effect of technical change. The broad conclusion is that if anything, technical progress reduces unemployment rather than it increases it. As far as macroeconomic policy is concerned, we have seen that its role shoud be to ensure that nominal aggregate demand rises in line with productivity growth. This should be enough to avoid any deflationary impact of technical progress. As far as sectorial policy is concerned, we have seen that technical progress is likely to destroy jobs in the sectors where its pace is most rapid. Depending on the functioning of the labor market, specific policies may be required to help displaced workers to find jobs in new industries, although a thorough reform of labor market institutions would greatly ease these problems. It is often argued, for example, that training policy is an appropriate cure for unemployment. This is based on the simple observation that unemployment is higher for unskilled workers than for skilled workers. This simple recipe too often ignores the cost of training and assumes that the government knows better than the market which training should be provided. While it is reasonable to think that more education would reduce unemployment, we believe that unemployment should be mostly considered as a symptom of an ill- functioning labour market, and that training policy will not improve the functioning of the labor market. The aim of training policy is not to cure unemployment but to increase the productivity of the workforce, and it should be evalued on the basis of its social costs and benefits. These may well be affected by the existence of unemployment, but this is not to say that training is a panacea against an ill-functioning labour market.