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Adrian Wood

This paper will argue for what is still a minority view among economists: that the main cause of the deteriorating situation of unskilled workers in developed countries has been expansion of trade with developing countries.[1] This view was advanced in Wood (1991a, b), and later developed into a book (Wood, 1994), but much the same line is taken by Batra (1993) and by Leamer (1993, 1994). It has been strongly attacked, however, by economists who think the effects of trade have been small—notably Lawrence and Slaughter (1993) and Krugman and Lawrence (1994). By way of a counterattack, this paper will outline the evidence that suggests that trade is the main cause of the problems of unskilled workers, respond to some criticisms of this evidence, and challenge the evidence for the alternative view that these problems are caused mainly by new technology. At the end, it will consider some of the implications of this debate for public policy.

Common Ground

Before entering disputed territory, it is worth listing five points of fact on which most participants in the debate agree, and which will therefore be taken for granted here.

[1]The impact of trade on labor markets in *developing* countries is just as important and controversial an issue, but lies beyond the scope of this paper. See, for example, Wood (1994, ch. 6), Robbins (1994), Feenstra and Hanson (1995) and Revenga and Montenegro (1995).

■ *Adrian Wood is a Professorial Fellow of the Institute of Development Studies at the University of Sussex, Brighton, England. His e-mail address is A.J.B.Wood@Sussex.ac.uk.*

First, the demand for unskilled labor (defined as workers with no more than a basic education) has fallen substantially over the past couple of decades, relative to the demand for skilled labor, in most developed countries. This shift in demand has increased wage inequality, or, where labor market institutions have propped up unskilled wages, as in Europe, raised unemployment among the unskilled (Freeman, 1994, this issue).

Second, over the same period in these countries, employment in manufacturing, as a share of total employment, has fallen much faster than would have been predicted from its earlier trend (Sachs and Shatz, 1994, pp. 6–7; Wood, 1994, pp. 201–3).

Third, the timing of these changes in labor markets has coincided with rapid growth of imports of low-skill-intensive manufactures from developing countries (Sachs and Shatz, 1994, p. 34; Wood, 1994, pp. 257–60).

Fourth, these changes in labor markets have also coincided with the rapid diffusion of computers in the workplace, and hence the most plausible alternative explanation of the declining demand for unskilled workers is an autonomous surge of technical progress biased against them.

Fifth, most empirical studies find that trade has made some contribution to these changes in developed-country labor markets, but only a *small* contribution, and so conclude by default that the main causal force must have been new technology. Recent examples are Borjas, Freeman and Katz (1992) and Sachs and Shatz (1994), but many earlier studies (reviewed in Wood, 1994, chs. 3 and 7) arrived at much the same conclusion.

It is this common conclusion about the *size* of the effects of trade that is the main target of this article. The methods used in most studies underestimate the impact of trade on labor markets. Modified methods that avoid their downward biases suggest a far larger impact.

Theoretical Framework

Before examining the evidence more closely, it is also worth looking at the theory, not least in order to explain what exactly might be meant by trade—an obviously endogenous variable—"causing" changes in labor markets. The main theory involved is Heckscher-Ohlin, whose central insight is that countries export goods that use intensively the factors of production with which they are relatively abundantly endowed, and import goods that use intensively factors that are relatively scarce at home. A side effect of this sort of trade, not surprisingly, is to alter the wages or earnings that different factors can command in the domestic economy.

To explain the effect on wages more precisely, consider a simple Heckscher-Ohlin model with two countries (developed and developing), two factors (skilled and unskilled labor), two traded manufactures (skill-intensive machinery and labor-intensive apparel), and an even more labor-intensive

nontraded service.[2] The developed country has a relatively large endowment of skilled labor, which gives it a comparative advantage in machinery, while the developing country has a relatively large endowment of unskilled labor and so a comparative advantage in apparel. The wage story is then a matter of one link, two forces, and three cases.

In Heckscher-Ohlin theory, trade and wages are linked solely through changes in product prices. For example, an externally induced fall in the domestic producer price of apparel, relative to the price of machinery, reduces the wages of unskilled, relative to skilled, workers. This linkage, known as the Stolper-Samuelson theorem, exists because Heckscher-Ohlin theory assumes technology (that is, the production function for each good) to be given. In other words, it assumes a fixed functional relationship between outputs of goods and inputs of factors, which (with no excess profits) implies a similarly fixed relationship between the prices of goods and the wages of factors.

What exactly are the "external" forces that might change domestic producer prices? In Heckscher-Ohlin theory, with given technology (and tastes), there are two possibilities. One is reduction of barriers to trade. Transport costs and tariffs, for example, drive wedges between the prices of goods in the two countries (and may even result in no trade—or "autarky"). In particular, they keep the price of apparel lower in the developing country than in the developed country, and vice versa for machinery. A reduction in barriers, and the resulting expansion of trade, would thus lower the relative price of apparel in the developed country.

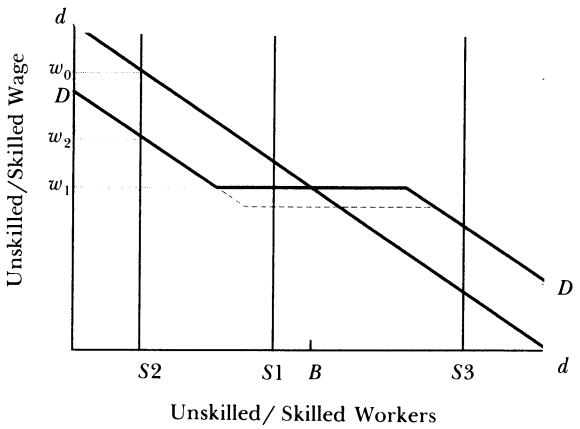
The second force is alterations in relative world supplies of skilled and unskilled labor. For instance, population growth or expansion of basic education in the developing country, by increasing its supply of unskilled manufacturing workers, would raise its output and exports of apparel. This in turn could drive down the relative price of apparel on world markets, and hence in the developed country.

The effects of externally induced price changes on wages vary, depending on the situation of the country, as can be shown by comparison of three cases, using a type of supply and demand curve diagram invented by Leamer (1995). In Figure 1, the vertical axis measures the unskilled wage, relative to the skilled wage, while the horizontal axis measures the number of unskilled workers, relative to the number of skilled workers.

Case 1: Autarky. The downward-sloping line, *dd*, is the demand curve for unskilled labor in a country where high barriers prevent trade. Wages are determined by the intersection of this demand curve with a supply curve (assumed for simplicity to be completely inelastic), whose position depends on the country's endowments of skilled and unskilled labor. For example, with

[2]The exposition can be elaborated with more goods, factors and countries, without changing its essence (Wood, 1994, chs. 2 and 9; Leamer, 1995).

Figure 1
Effects of Trade on Wages



supply $S2$, as in a country with few unskilled workers, the relative wage of unskilled labor would be at the high level, w_0.

Case 2: Diversified trade. The demand curve in a country completely open to trade is the line DD, which has two downward-sloping segments separated by a flat segment in the middle.[3] This flat (infinitely elastic) segment covers the range of factor endowments in which a trading country would be "diversified," in the sense of producing both of the two traded goods. In this range, for example in a country with labor supply $S1$, relative wages are set purely by relative world prices, at the level w_1. Thus changes in domestic labor supply, unless they are big enough to affect world prices, do not change wages—they alter only the composition of output and trade. However, if a change in world labor supplies or a fall in trade barriers abroad were to lower the import price of apparel, the flat segment of the demand curve would shift down, as shown by the dashed line in the figure, reducing the relative wage of unskilled workers.

Case 3: Specialized trade. A trading country with few unskilled workers, as at $S2$, will produce no apparel and specialize in machinery plus the nontraded service (a country with many unskilled workers, as at $S3$, would correspondingly specialize in apparel). This puts it on a downward-sloping segment of the demand curve DD, where changes in domestic labor supply do affect relative wages. For instance, an increase in the relative number of skilled workers would raise the relative wage of unskilled labor (it could do this also by moving the country from the flat to the sloping segment of the curve—from $S1$ to $S2$). By contrast, a fall in the world price of imported apparel would not affect the relative wage, w_2: it would benefit both skilled and unskilled workers in their

[3]Point B, where dd and DD cross, is the endowment ratio at which even an open country would not trade: countries to the left of B are net exporters of machinery, and those to the right are net exporters of apparel.

role as consumers, but would not affect them as producers, since apparel is not produced domestically.[4]

To summarize, in a developed country, with relatively few unskilled workers by world standards (that is, to the left of point *B* in the figure), trade with developing countries (to the right of point *B*) causes the relative wage of unskilled workers to be lower than it would be without trade, whether the outcome is diversified or specialized. In both cases, this happens because of a fall in the relative domestic price of apparel, which in both cases is reflected in a shift of the demand curve against unskilled labor. The two cases differ, though, as regards the effects on wages of subsequent changes in world prices and domestic labor supplies.

In discussing the evidence below, particular emphasis will be placed on the comparison between autarky and specialized trade, because it encapsulates most of what I believe to have happened in reality over the past couple of decades. More specifically, I argue in Wood (1994) that reduction of trade barriers has shifted developed countries from "manufacturing autarky," in which they produced all the manufactures they consumed (skill intensive and labor intensive), to specialization in the production of skill-intensive manufactures and reliance on imports from developing countries to supply their needs for labor-intensive manufactures.[5]

Barriers to developed-developing country trade in manufactures have fallen over the past couple of decades partly because international transport and telecommunications have become much cheaper, quicker and of better quality, and partly because of changes in trade policies, particularly in developing countries, more and more of which have switched to export-oriented trade regimes. These barrier reductions have done more than simply ease the flow of goods from developing to developed countries. Just as vital has been easier movement of inputs in the other direction—components, machinery, finance and information, including visits by technical and marketing experts. More generally, developed-country companies have learned how to manage globally dispersed production and procurement activities.

That these reductions in trade barriers have occurred seems beyond dispute. More open to argument is whether they were the main cause of the growth of manufactured exports from developing countries, and whether they were truly

[4] With more than two traded goods, *DD* would look rather different: instead of a single flat segment in the middle, it would have alternate flat and downward-sloping segments. On each flat, a country produces two traded goods (adjacent in skill intensity), and on each downward-sloping segment only one. All countries are specialized, since none of them produces all of the traded goods. The simple two-good story about specialization thus requires only minor modifications. It remains true (a) that labor supply changes can alter wages (by movement along a downward-sloping segment or from one segment to another), and (b) that relative wages are not affected by changes in the world prices of goods that the country does not produce. However, if a country is on a flat, and there is a change in the relative world price of the two goods it produces, then relative wages do alter.

[5] Rowthorn (1994) provides a general equilibrium simulation that neatly illustrates and extends the argument in Wood (1994).

exogenous—independent, in particular, of other demand and supply shifts in developed-country labor markets. Neither question has a simple answer, but the evidence suggests "yes, as a first approximation" to both of them (Wood, 1994, pp. 171–82). Particularly supportive is the coincidence of widening wage gaps within developed countries, implying that the imports of labor-intensive goods were not sucked in by shortages of unskilled labor, and narrowing wage gaps within the main East Asian exporters, which makes falling barriers to trade more plausible than rising internal surpluses of unskilled labor as the cause of their growing exports.

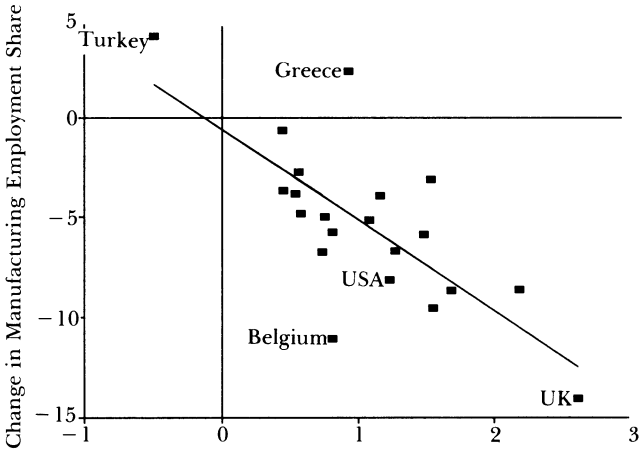
My barrier reduction story is clearly partly a story about new technology, which contributed to the improvements in transport and communications. But this is by no means the only way in which trade and technology explanations of changing relative wages might be combined. Heckscher-Ohlin theory takes technology as given, which leaves room to introduce autonomous technical change as an additional influence on wages and on trade (Leamer, 1994, 1995; Richardson, this issue). Conversely, the pace and direction of technical change may be influenced by trade, as will be argued below. So, however one looks at it, trade and new technology are intertwined: no story that excludes one or the other of them is likely to be the whole story.

Cross-Country Variation

Since most of the evidence on trade and labor markets refers to the United States, it is interesting to start in a broader perspective, by examining differences among developed countries. All these countries increased their trade in manufactures with developing countries, but the extent of the increase varied, because of differences in their own barriers to trade and in geographical proximity. Thus, if this trade were really the main cause of the problems of their unskilled workers, one would expect to find some cross-country association between these variations in the rise in trade and variations in relevant labor market indicators —and indeed one does.

Figure 2, a scatter plot from Saeger (1995), refers to all OECD countries with the necessary data. Its horizontal axis shows the 1970–1990 change in net imports of manufactures from developing countries, measured as a percentage share of GDP. In the United States, for example, these imports (minus exports) rose from −0.6 percent of GDP in 1970 to +0.6 percent in 1990, which puts the United States at 1.2 on the horizontal axis. The vertical axis shows the percentage point change in the share of manufacturing in total employment over the same period. There is a clear inverse association: countries with larger increases in import penetration experienced larger falls in manufacturing employment. Saeger finds a similar correlation with the change in the gross (rather than the net) import penetration ratio.

Figure 2
Deindustrialization and Developing-Country Import Penetration
(*OECD countries*: *percentage point changes from* 1970 *to* 1990)



Source: Saeger (1995). The regression line shown was fitted by OLS. To avoid cluttering the graph, only the U.S. and a few outliers are labelled.

In principle, the correlation in Figure 2 might not reflect causality, but rather some common influence on both import penetration and manufacturing employment. It is not easy, however, to find plausible candidates for this excluded variable (Wood, 1994, pp. 203–9). One possibility is shortages of unskilled labor, which might have forced labor-intensive manufacturing to contract and imports to be substituted. But this would imply a negative cross-country correlation between import penetration and deterioration of the relative wage and unemployment position of unskilled workers, whereas the actual correlation is strongly positive—unskilled workers did worst where import penetration rose most (pp. 265–9). There is also a positive cross-country correlation between changes in import penetration and in the overall unemployment rate, when allowance is made for differences in wage flexibility (pp. 309–21).

It is striking that such simple cross-country tests suggest so strongly the influence of increased trade with developing countries. Their results make it hard to believe that trade had only small effects, for if this were so, the association would surely be disguised by other influences.

It is also striking how tiny the numbers on the horizontal axis of Figure 2 are. The largest rise in developing-country net import penetration during 1970–1990 was not much over 2 percent of GDP, and the average only about 1 percent. Even taking the level of gross import penetration (rather than the

change in net import penetration), manufactured imports from developing countries were under 3 percent of U.S. GDP in 1990. Numbers such as these are emphasized by economists who dismiss the influence of trade. "How on earth," they ask, "could such a small tail wag the large dog of developed-country labor markets?"

There are three answers to this question. Two of them point to ways in which trade can hurt unskilled labor even where it does not raise import penetration: one is by depressing the prices of labor-intensive goods, the other by forcing firms to find ways of using less unskilled labor to stay competitive. The third is that these imports from developing countries are highly labor-intensive goods, and thus displace more domestic workers than might be supposed by simply comparing their dollar value to that of the U.S. GDP. But how many more? That question leads us into the next section.

Factor Content of Trade

The most commonly used method of estimating the effects of trade on labor markets is to calculate its *factor content*. This involves figuring out how much skilled and unskilled labor is used in producing a country's exports, and how much would have been used to produce its imports. The differences between exports and imports are then interpreted as the impact of trade on the demand for skilled and unskilled workers—by comparison with what it would have been in the absence of trade (or if trade had remained at some earlier lower level).

For example, Sachs and Shatz (1994) use factor content methods to estimate the impact of the 1978–1990 change in trade on the employment of skilled and unskilled (or, more precisely, nonproduction and production) workers in U.S. manufacturing. For each of 51 manufacturing sectors, they calculate the effect of the increase or decrease in net exports (exports minus imports) on the level of output. They then assume that both skilled and unskilled employment in each sector changed in the same proportion as its output. Summed across sectors, their results show that trade with developing countries reduced manufacturing employment, particularly of unskilled workers, since output declines were concentrated on sectors with relatively few skilled workers.

Noncompeting Imports

These (and most other) factor content calculations are biased downward because of the way in which they calculate the labor content of imports. The numbers of skilled and unskilled workers displaced by a dollar of imports in each sector are taken to be the same as the numbers needed to produce a dollar of exports, and both are estimated simply from the numbers used to produce a dollar of domestic output. The implicit assumption is that the imports in each statistical category, say "electrical machinery," are goods of the same types, and

in particular of the same skill intensity, as the goods produced in the corresponding domestic sector.

This assumption is unreasonable for manufactured imports from developing countries, which consist mostly of items of low skill intensity that are no longer produced on any significant scale in developed countries. This is true both of finished goods—especially when finely distinguished by type and quality—and of intermediate goods and stages of production, of which the most labor intensive (like assembly of electrical consumer goods) have been delegated to low-wage countries. In theoretical terms, as explained earlier, developed countries have become specialized producers of skill-intensive manufactures, and imports of labor-intensive manufactures are now "noncompeting" with domestic production.

In this situation, by using domestic labor coefficients that refer to the production of different and more skill-intensive goods, the usual method of calculation for imports inevitably underestimates their unskilled labor content. To put it another way, conventional factor content calculations understate the number of workers, particularly unskilled workers, who would be needed, in the absence of trade, to meet the demand for the goods that are now imported. Conventional factor content results thus understate the extent to which trade shifts relative demand against unskilled workers.

To obtain more accurate results, one must start by measuring the amount of labor used to produce these imports in developing-country trading partners (since goods of this sort are not produced at home). These actual inputs of labor must then be adjusted to allow for the much higher level of wages in developed countries, which would cause more skill- and capital-intensive techniques to be used if these goods were produced domestically rather than imported. It is also vital to adjust for the fact that these goods would cost more if they were produced domestically and hence that people would buy fewer of them. After these two adjustments, the estimated displacement of unskilled labor by the imports is much smaller than the actual amount of labor embodied in them—but much larger than suggested by conventional factor content calculations.[6]

Table 1 compares the conventional factor content results of Sachs and Shatz with results obtained by this alternative method (Wood, 1994, ch. 4). Part of the difference between them arises from the coverage and definitions of the data, but most is due to the methods used. Each number in the table is an estimated percentage change in demand for labor in manufacturing caused by trade. In the first row, both numbers are negative, implying agreement that trade with developing countries reduced the demand for manufacturing workers in general.

[6]A possible third adjustment, further reducing the estimated displacement of labor, would be for lower efficiency in developing countries (due to inferior technology or poor infrastructure). However, despite inefficiency in much of developing-country manufacturing, the particular countries and firms that manufacture for export to developed countries do not in general have either backward technology or low labor productivity (for references to case study evidence on this point, see Wood, 1994, p. 134).

Table 1
Factor Content Estimates of Impact of Trade with Developing Countries on Demand for Labor in Manufacturing in 1990
(*percentage difference from counterfactual situation without trade*)

	Sachs and Shatz (United States only)	*Wood (All developed countries)*
All workers	−5.7	−10.8
Skilled workers	−4.3	0.3
Unskilled workers	−6.2	−21.5
Unskilled minus skilled	−1.9	−21.8

Note: As well as the differences in method of calculation and geographical coverage of the estimates, there are differences in (1) the definition of skilled workers (Sachs and Shatz = nonproduction workers, Wood = workers with postbasic education or training); (2) the definition of manufactured exports (Sachs and Shatz include, Wood excludes, goods with a high natural resource content); and (3) the counterfactual (Sachs and Shatz assume no change from the 1978 net export/output ratio in each sector, Wood assumes no manufactured imports from developing countries and a corresponding reduction in exports).
Sources: Sachs and Shatz (1994, Table 13), Wood (1994, Table 4.9 and p. 151, note 45, but recalculated as a percentage of without-trade, rather than actual, employment).

The fundamental reason for this outcome is that the goods imported by developed countries are more labor intensive than those they export: it would occur even if trade were balanced and thus does not depend on the existence of a trade deficit, which is often portrayed as the culprit in the United States (for example, Borjas and Ramey, 1994). However, the estimated reduction in demand is about twice as large in the alternative calculations as in the conventional ones.

The second and third rows show the effects on skilled and unskilled workers separately. Again, there is agreement between the two sets of calculations that the unskilled are hit harder than the skilled, but a big difference in the estimated magnitudes. Sachs and Shatz conclude that trade reduced the demand for skilled workers nearly as much as for unskilled workers: thus, as shown in the last row, the *relative* demand for unskilled labor declined by only 1.9 percent, similar to the results of earlier studies using the same method (Wood, 1994, Table 3.10). By contrast, the alternative calculation suggests that trade slightly increased the demand for skilled labor (due to greater production of skill-intensive exports), and that the entire net reduction in demand was concentrated on the unskilled. The relative demand for unskilled labor is thus estimated to have been reduced by 22 percent—roughly 10 times more than in the conventional calculation.

Two Further Sources of Understatement

Even the modified calculations, though, underestimate the effects of trade on labor demand, for two reasons (Wood, 1994, pp. 158–65). The first is that they, like other factor content estimates, ignore the contribution of trade to technical progress. This is misleading, because a common reaction of developed-country firms to low-wage competition has been to look for new methods of production that economize on unskilled labor. (Their incentive to do so is being reduced somewhat by falling unskilled wages in developed countries, but the *level* of unskilled wages remains far higher than in most developing countries.) In some cases, this innovative effort has failed, and domestic production has been extinguished by imports. In other cases, however, "defensive innovation" has enabled firms to fight off the imports—but has still reduced their demand for unskilled labor.

At first sight, the idea of defensive innovation may seem inconsistent with economic theory: if labor-saving, cost-reducing technologies existed, why weren't profit-maximizing firms already using them? But in practice, firms do not have complete knowledge of all technical possibilities, and to learn about new possibilities they must incur search costs—R&D expenditure, for example, and managerial time and effort. Their decisions about where and how to search depend on the likely benefits, which in turn depend on market conditions. For many firms, the emergence of low-wage competitors was a drastic change in market conditions—a matter not of marginal shifts in profits, but of survival—which radically altered their search priorities.

Whatever may be the most appealing theoretical rationalization of defensive innovation, its empirical existence is apparent in case study and anecdotal evidence. It gets some statistical support from Sachs and Shatz (1994, p. 33), who find acceleration of total factor productivity growth during the 1980s in low-skill-intensive manufacturing sectors, relative to high-skill sectors. Faster productivity growth in low-skill than in high-skill sectors is also documented by Lawrence and Slaughter (1993, Figure 10) and Leamer (1994, Tables 3–4).

There is no acceptably accurate way, as yet, of quantifying the impact of defensive innovation on labor demand. However, the case study evidence suggests that its effects have been at least as large as the relocation and reallocation effects measured by factor content estimates (Wood, 1994, p. 161). This assessment receives some support from calculations of the recent rise in the proportion of skilled workers in developed-country manufacturing, relative to nontraded sectors (Wood, 1994, app. A2). The tentative conclusion is thus that allowance for defensive innovation would require something like a doubling of the modified factor content estimates.

The second source of understatement is that the factor content estimates are confined to manufacturing. Expansion of trade in services has added to the labor market impact, with developing countries emerging as substantial exporters in low-skill-intensive sectors such as shipping, tourism and

keypunching, and as purchasers of more skill-intensive services from developed countries. In addition, there is an impact on the demand for skilled and unskilled labor in the nontraded sectors that sell intermediate inputs to producers of manufactures and traded services.

Although these effects in the service sectors seem too big to ignore, there is, again, no accurate way to measure them at present (Wood, 1994, pp. 162–5). However, we know that the service exports of developing countries are about 50 percent as large as their exports of manufactures. We also know that the value added to manufactured exports in the nontraded sectors that supply intermediate inputs is about 40 percent as large as the value added within manufacturing. So, as a first approximation, the estimated impact of trade on labor demand in manufacturing might be raised first by 50 percent, and then by another 40 percent, which would roughly double it.

To summarize, what does all this suggest about the general magnitude of the labor market effects of trade with developing countries? As of 1990, in round numbers, the modified factor content estimates in Table 1 imply a 10 percent cut in the overall demand for labor in developed-country manufacturing. Double this figure to 20 percent to allow for defensive innovation. Manufacturing is now about one-fifth of total employment: without the 20 percent cut, it would have been one-quarter, so that trade has reduced the share of manufacturing by about 5 percentage points. Virtually all the reduction in demand, Table 1 also implies, was concentrated on unskilled workers. Taking such workers to be half of the labor force, the five point cut in manufacturing employment reduced the economy-wide demand for their labor by about 10 percent—relative to skilled workers, for whom demand hardly altered. Doubling this last figure to allow for the impact on services leads to the conclusion that trade lowered the economy-wide relative demand for unskilled labor by about 20 percent.

Criticism of the Estimate

This number, obviously, is a rough estimate. Also, it is for developed countries as a group, not for any particular country. Many specific doubts about the data and assumptions used in the modified factor content calculations, and some sensitivity analysis of the results in Table 1, are discussed in Wood (1994, pp. 152–8). But there is no point in debating here whether the estimate should be a bit bigger or a bit smaller: the real issue is whether it is an order of magnitude too large, or deeply flawed in its method, or misleading in some other way. Four criticisms merit special attention.

Sectoral Skill Intensities Moved the Wrong Way

The modified factor content calculations assume that imports from developing countries are concentrated on goods that are much less skill intensive than the average in each sector. Sachs and Shatz (1994, p. 32) test this claim by

comparing, across different manufacturing sectors, the rise in skill intensity during the 1980s with the initial level of skill intensity. They expected to find a negative correlation: sectors that were of low skill intensity to begin with, because they contained a high proportion of labor-intensive activities, should have experienced a bigger rise in skill intensity when competition from developing countries forced labor-intensive activities to contract (or to become more skill intensive by defensive innovation). In fact, the correlation is slightly positive: sectors that were initially less skill intensive experienced, if anything, a *smaller* rise in skill intensity.

This is a surprising result. One can construct examples where the relative sizes and growth of non-labor-intensive activities within sectors are such that trade causes skill intensity to increase more in an initially more skill intensive sector than in an initially less skill intensive one, but it takes some ingenuity. It is possible that the results are distorted by the coarseness of the measure of skill intensity used by Sachs and Shatz. They use the relative numbers of nonproduction and production workers, but much of the change in the skill mix of employment has occurred *within* these categories—expansion of professional relative to clerical nonproduction jobs, and of skilled relative to semiskilled production jobs (Berman, Bound and Griliches, 1994, Table 1; Machin, 1994, p. 8). However, this and other possible reconciliations are as yet unexplored.

Further investigation of this cross-sectoral relationship would thus be of considerable interest. It should be recognized, though, that it is at best an indirect test of the argument that imports from developing countries are much less skill intensive than developed-country production in the "same" sectors. The case study and anecdotal evidence in support of this argument seems so strong that only a direct negative test should overturn it.

The Assumed Elasticities are Too Low

Calculating the labor content of noncompeting imports, as outlined above, involves two downward adjustments—to allow for higher wages in developed countries, and for lower demand if the goods were produced domestically at a higher price. In making these adjustments, assumptions are needed about elasticities of substitution in production and consumption. The larger are these elasticities, the smaller are the labor market effects of trade. For example, if the higher price of domestically produced substitutes would deter most buyers, then the absence of imports would not much increase the demand for unskilled labor.

The results in Table 1 are based on elasticities of 0.5 both in production (between unskilled labor and a combined input of capital and skill) and in consumption (the price elasticity of demand for labor-intensive goods). Values of up to 0.9 were tried in the sensitivity analysis without greatly altering the results. However, further increases in the assumed values of these elasticities cause the labor market effects of trade to melt away quite rapidly. This may arouse concern, since econometrically estimated elasticities are often well above the range used in these calculations.

The values used are defended, and related to the empirical literature in Wood (1994, pp. 131–3, 143–4), but it is worth mentioning two general reasons why the elasticities used in the factor content calculations should be on the low side. One is that most econometric estimates of substitution in production are based on quite coarsely aggregated sectoral data, and so pick up factor price-induced differences in product mix and quality, as well as in the choice of technique for producing specific goods. They thus overstate the scope for substitution of techniques, which is what matters here. A second reason is that much of the trade in manufactures between developed and developing countries involves intermediate goods or stages of production, between which there is probably little substitutability.

The Magnitudes are Still Not Big Enough

Although my estimate of the impact of trade is much larger than those of other economists, it is arguably not large enough to explain the observed changes in labor markets. There is no difficulty with the falling share of employment in manufacturing: its recent acceleration is fully accounted for by the estimated trade-induced reduction of 5 percentage points (Wood, 1994, pp. 201–3). The issue, rather, is whether a 20 percent fall in the relative demand for unskilled labor is sufficient to explain the marked widening of skill differentials in wages and unemployment rates, since there have also been shifts in relative supply. In particular, taking the 1970s and 1980s together, the relative supply of skilled labor may well have risen by more than 20 percent, suggesting that the net effect should have been to narrow, rather than widen, skill differentials.[7]

One possible response would be to argue that trade has made the demand for labor so elastic that shifts in supply have little effect on wages—that, in terms of Figure 1, supply in developed countries is in the region of *S*1, putting them on the flat segment of the demand curve *DD*. This, however, is not a good defense of my particular position, since I maintain that supply in developed countries is actually in the region of *S*2, putting them on a downward-sloping segment of the demand curve, where supply shifts do affect wages. It is clear from Figure 1 that the coincidence of a demand shift from *dd* to *DD* and a leftward shift of *S*2 (a rise in the relative supply of skilled labor) could increase the relative wage of unskilled workers.

A better defense of my view is to argue that trade accelerated a preexisting downward trend in the relative demand for unskilled labor (which had been shifting *dd* and *DD* to the left). Large increases in the relative supply of skilled labor over the past century have been absorbed with little narrowing of skill differentials in wages, except when supply shifts have been unusually fast,

[7]This specific point was put to me by Kevin Murphy in a seminar, but much the same concern has been expressed by other labor economists (Bound and Johnson, 1992). It would be hard to find data on relative supply and wages that were strictly comparable with my estimate of the trade-induced demand shift, which refers to two coarse skill categories in all developed countries (for a partial attempt, see Wood, 1994, pp. 260–65, 443–4, 447–53). However, a rough indication of the size of the supply shift can be obtained from education statistics for the United States and other countries.

which suggests that the relative demand for skilled labor has also risen, and to much the same extent as supply (for recent evidence, see Katz and Murphy, 1992, pp. 37, 54).

This secular demand shift might be attributed to exogenous technological progress, but its similarity to the supply shift suggests a more specific hypothesis, namely that it is a lagged function of the supply shift. The causal mechanism could be that employment of skilled workers creates needs and opportunities to employ other skilled workers (through externalities of some sort). But whatever the cause of the secular demand shift, it has been amplified by recent changes in trade: thus an *additional* 20 percent shift in relative demand could have markedly widened skill differentials, despite opposing shifts in supply.

Factor Content Calculations are Misguided

The most fundamental criticism of my estimates of the impact of trade has been made, ironically, by another proponent of the view that this impact is large. Leamer (1994) rejects factor content calculations—my basic method—as "measurement without theory." His criticism is aimed at people who have used such calculations to argue that the effects of trade are small, but sauce for the goose is sauce for the gander! Let me lay out his three specific charges and to each of them offer a response.

First, Leamer argues that factor content calculations are unnecessary. In Heckscher-Ohlin theory, trade changes wages only if it changes product prices, so why do more than look at prices? My response: suitable price data may not be available (as will be explained in the next section).

Second, he argues that factor content calculations are insufficient. Externally induced changes in prices cause changes in trade flows (for example, if a country's terms of trade improve, it usually trades more), so in principle one can work out from changes in the factor content of trade what happened to wages. But this requires data on domestic labor demand and supply elasticities (in order to move from trade-induced shifts in numbers of workers demanded to changes in their wages), if not proper general equilibrium calculations, way beyond standard factor content estimates. My response: at least it can be done, as an extension of factor content calculations. There are data on elasticities (which I use), and the error caused by neglect of second-round general equilibrium effects is likely to be small.

Third, Leamer argues that factor content calculations are inaccurate, for two reasons. One is that the factor content of a country's trade is altered over time not only by external forces, such as changes in world prices, but also by internal forces, such as shifts in tastes, technology and factor supplies. Factor content calculations usually fail to control for shifts in internal forces and hence mismeasure the effects of external forces. My response: I argue, with some evidence, that the whole of the rise of manufactured imports from developing countries was due to forces external to developed countries, and in particular to reduction of barriers to trade.

The second reason for inaccuracy arises where a country is specialized and does not produce some types of goods that it imports. If it never produced these goods, then the imports cannot have affected the domestic demand for labor. Even if it did formerly produce them, the impact on the domestic demand for labor cannot be accurately measured by standard factor content calculations. My response: because I assume that developed countries are specialized, I do my factor content calculations in a nonstandard way (as explained earlier).

Evidence on Prices

Although factor content calculations can be defended, it remains important to look at product price movements. For if it is true that Heckscher-Ohlin forces have reduced the relative wages of unskilled workers, then there must have been accompanying reductions in the relative prices of labor-intensive goods. Have such price movements been observed?

Lawrence and Slaughter (1993) and Lawrence (1994) conclude that the answer is "no." They calculate two averages of price movements during the 1980s across manufacturing sectors, one weighted by each sector's share of all skilled (nonproduction) employment, the other by its share of unskilled (production) employment. If relative prices were falling in less skill-intensive sectors, the production-weighted average should rise less rapidly than the nonproduction-weighted average. But this was not the case for import prices in the United States, Japan or Germany.

Sachs and Shatz (1994, pp. 34–40) reanalyze the U.S. price data and arrive at different conclusions. After eliminating series that do not cover the whole period, and excluding computers, whose massive fall in price distorts the overall pattern, they find that import prices have in fact risen less rapidly for low-skill-intensive goods. They also examine movements in *domestic* producer prices for a much larger sample of sectors and find a similar but statistically more significant trend: during 1978–1989, prices in the least skill-intensive decile of sectors fell by about 9 percent relative to the most skill intensive.

Sachs and Shatz suggest that this change in relative prices, though in the right direction, is too small to explain the observed change in relative wages. This assessment appears to be incorrect. Logically, proportional changes in relative prices must be smaller than the associated changes in relative wages, since all goods are produced by mixtures of skilled and unskilled workers, as well as other factors.[8] But over this period, their measure of the skill differential

[8]This is known as a magnification effect. As a simple numerical example, consider two goods, the total cost of each of which consists half of wages (skilled and unskilled) and half of payments to capital and other inputs. The ratio of skilled to unskilled workers is 70/30 for one good and 30/70 for the other, and the skilled wage is initially twice the unskilled wage (so that skilled wages are 41 percent of total costs for one good and 23 percent for the other). To cause a 1 percent rise in the relative price of the skill-intensive good requires more than a 5 percent rise in the relative wage of skilled workers.

in wages—the gap between nonproduction and production workers—widened by only 8 percent (Sachs and Shatz, 1994, Table 2), which is far *less*, rather than more, than one would expect from a 9 percent change in relative prices.

In Japan and Germany, prices (of both imports and domestic output) rose slower during the 1980s in more skill-intensive sectors, even when computers are excluded (Lawrence, 1994). However, this is much less of a paradox, since the changes in relative wages in these two countries have been far smaller than in the United States. In Germany, wage rigidity has caused much of the shift in relative demand to emerge as changes in relative unemployment and vacancy rates (Wood, 1994, pp. 431–47), and in Japan there has been little widening of skill differentials in either wages or unemployment.

Feenstra and Hanson (1995) point out another feature of the Lawrence and Slaughter results for the United States, Japan and Germany, namely the consistent difference between domestic and import price changes. In all three countries, and for both the weighted sectoral averages, import prices rise more slowly —or, in Japan, fall faster—than domestic prices. Sarkar and Singer (1989) likewise find a trend deterioration in developing countries' terms of trade in manufactures with developed countries. Feenstra and Hanson interpret this as evidence that, within each sector, imports consist of a less skill-intensive mix of goods than domestic output—which is what I assume in my factor content calculations.

This heterogeneity of goods within statistically defined sectors is a major limitation of all the price data and one which has become worse over time. Manufactured imports from developing countries used to be concentrated on a few sectors, such as apparel and footwear, but are now spread across many sectors, partly because, for a wide range of goods, the production process has been split up, with the labor-intensive stages performed in developing countries, the skill-intensive ones at home.[9] This is probably why Leamer (1993, 1995) finds a large fall in the relative prices of labor-intensive two-digit sectors during the 1970s, but no clear pattern during the 1980s, even in more disaggregated sectoral data—which is in line with the mixed 1980s results of Lawrence and Slaughter, Sachs and Shatz, and Richardson (this issue).

So the price evidence turns out to be rather disappointing. In theory, it ought to settle the dispute over whether or not trade is the main cause of the widening wage gap between skilled and unskilled workers. In practice, however, it fails to deliver a clear verdict, one way or the other.

[9]There is disagreement about this. Berman, Bound and Griliches (1994) and Lawrence (1994) present evidence that "outsourcing" by U.S. firms is small, but Feenstra and Hanson (1995) criticize them for using too narrow a definition of outsourcing (namely, importing intermediate inputs). There is no reason why the splitting up of production should leave the final stage in the United States: if anything, it seems more likely that final assembly, usually a labor-intensive operation, would be undertaken abroad, and that the United States would supply skill-intensive intermediate components and services.

Rising Intrasectoral Skill Intensity

A different sort of evidence, which Lawrence and Slaughter (1993), Berman, Bound and Griliches (1994) and Machin (1994) argue decisively favors the technology explanation over the trade explanation, is the rising proportion of skilled workers *within* most sectors—despite the rise in their relative wage, which should tend to cause fewer of them to be employed.

The critics emphasize that the Heckscher-Ohlin story is about intersectoral shifts in the structure of employment: for example, lower trade barriers cause skill-intensive sectors to expand and labor-intensive sectors to contract. The associated decline in the relative wage of unskilled workers, by contrast, should give firms in all sectors an incentive to adopt less skill-intensive techniques. The fact that the ratio of skilled to unskilled workers has risen within most sectors thus suggests (a) that technical progress must be biased against unskilled workers; and hence (b) that this bias in new technology, rather than trade, is widening wage differentials.

One possible response, made by Leamer (1994, 1995), is to accept conclusion (a), but to stress that conclusion (b) does not necessarily follow from it. In a country whose trade was diversified, where domestic prices and wages were set by world prices, unskilled labor saving technical progress in all sectors could have no effect on relative wages. In terms of Figure 1, such a country would be on the flat segment of the demand curve *DD*, and thus the relative wage would not be affected by a leftward shift of the curve. All that would change is the composition of output and trade: excess supply of unskilled workers would increase the output of labor-intensive sectors and reduce net imports of labor-intensive goods.

Sectoral versus Factoral Biases

What would alter relative wages in such a country, other than changes in world prices, as Leamer explains, is different rates of technical progress in different sectors. In other words, what matters is the sectoral, not the factoral, bias of technical progress. In particular, if product prices were fixed, the gap between skilled and unskilled wages would be widened by technical progress that was slower in labor-intensive than in skill-intensive sectors (essentially because labor-intensive sectors would need to offset their growing technical disadvantage by restraining the wages of the majority of their workers). However, as mentioned earlier, the recent pattern of sectoral bias seems to have been in the other direction—with technical progress faster in labor-intensive than in skill-intensive sectors—and thus cannot help to explain why the relative wages of unskilled workers have been falling.[10]

[10] Note, though, that insofar as the faster technical progress in labor-intensive sectors is a defensive response to low-wage competition, it must be associated with falling prices in these sectors, which makes its effects on wages less straightforward than when prices are assumed to be fixed.

The response to the critics is less simple if trade is specialized. For in this case (which I believe is more relevant to developed countries today), wages could be affected also by factorally biased technical progress. In Figure 1, a specialized country would be on a downward-sloping segment of the demand curve *DD*, so that a leftward shift of the curve would lower its intersection with *S*2. Excess supply of unskilled workers, caused by their displacement from both the machinery sector and nontraded services, has to be absorbed by a rise in consumption and output of the labor-intensive nontraded service, which requires a fall in its relative price, and hence in the relative wage of unskilled workers (which also induces firms in both sectors to switch to more labor-intensive techniques, though not by enough to offset the technological trend toward greater skill intensity).

I also believe, as discussed earlier, that there has been a secular decline in the relative demand for unskilled labor, possibly as a lagged response to a rising skill supply, which long predates the recent changes in trade. This trend is likely to have been spread widely across sectors and thus to have emerged in the form suggested by the critics: technological progress that is neutral across sectors but biased against unskilled workers. But precisely because this is a trend of long standing, the critics must argue, to explain the sudden widening of skill differentials, that it has recently accelerated—and for reasons unconnected with trade. This is not implausible, in light of the rapid diffusion of computers over the past two decades, but at present the supporting evidence is distinctly thin.

Intrasectoral Effects of Trade

The critics assume that rising intrasectoral skill intensity is due to new technology and thus independent of trade. This assumption is unreasonable, especially in manufacturing, to which most of their studies refer. Even at the 4-digit level of the Standard Industrial Classification, each sector contains hundreds of goods and processes, of varying skill intensity. Moreover, the cross-sectoral effects of trade with developing countries are replicated within each sector: exports expand the more skill-intensive activities, while imports shrink the less skill-intensive ones. This would cause the ratio of skilled to unskilled workers to rise in every traded sector, even if there were no technical progress.

This intrasectoral effect of trade is clear from case study and anecdotal evidence. It also emerges from an econometric attempt to explain changes in the skill intensity of some 400 U.S. manufacturing sectors by Feenstra and Hanson (1995). They follow Berman, Bound and Griliches (1994) in most respects, but introduce, as an additional independent variable, the rise in import penetration in each sector. Its coefficient is highly significant and large enough to account for up to one-third of the increase in the average skill intensity of manufacturing during 1979–1987.

Similarly, Bernard and Jensen (1994) find that exporting explains a lot of the rise in the skill intensity of U.S. manufacturing. Using a panel data set of

more than 50,000 plants, they show that one-third of the increase in the average employment share of nonproduction workers during 1980–87 was due to more rapid growth of exporting plants than of nonexporting plants (since exporting plants employ more nonproduction workers), and that this occurred mainly within, rather than between, industries. Another third of the increase was due to rising skill intensity of employment *within* exporting plants. Bernard and Jensen also find that almost all the widening of the average difference in wages between nonproduction and production workers was due to faster growth of exporting plants, which not only employ more nonproduction workers, but also pay them relatively more.

Correlation with Technology Indicators

Trade pressures surely do not explain all the rise in skill intensity even in traded sectors, let alone in those service sectors that are not exposed to trade, either directly or as suppliers of intermediate inputs to traded sectors. Moreover, various studies have found rises in the skill intensity of employment in particular industries or firms to be correlated with rises in "technology indicators," meaning measures of capital stock, computer use, R&D expenditure, and so on. Mishel and Bernstein (1994) survey many of these studies, but see also Berman, Bound and Griliches (1994), Bernard and Jensen (1994), Feenstra and Hanson (1995), and Machin (1994). Some of their authors have taken this association to be strong evidence against the trade explanation of the recent widening of skill differentials in wages.

Like other correlations, however, this one is neutral on causation. There is a lot of econometric evidence that skill and capital are complementary, and it is no surprise to find that many skilled workers now use computers. Thus, for example, in a sector where trade was pushing up the proportion of skilled workers, either through changes in activity mix or through defensive innovation, one would also expect to see a rise in the amount of capital and the number of computers per worker. (If you hire more skilled workers, you'd better buy them something to work with!) But it would be the trade-induced rise in the skill intensity of employment that was causing the rise in technology indicators, not the other way round. The autonomous effects of new technology are hard to isolate, especially when innovation is partly induced by trade.

More plausible as evidence for the new technology explanation of widening wage differentials are studies that find an association between wages and use of computers, while controlling for education and other skill-related worker characteristics (Krueger, 1993; van Reenen, 1994). One can then argue, as Krueger does, that the increased use of computers during the 1980s, being concentrated on more skilled workers, must have contributed to the rise in wage inequality. Mishel and Bernstein (1994), too, find that changes in technology affect the wage structure, but not much difference in this regard between the 1970s and the 1980s. So they reject the hypothesis that new technology caused the rise in wage

inequality in the latter decade (and attach more importance to the erosion of unions and of minimum wages).

Where does all this leave the "trade versus technology" debate? It seems certain that new technology contributed to the recent deterioration in the relative economic position of unskilled workers—as a background trend, as a cause of lower trade barriers, and as a response to foreign competition. The key question, though, is whether spontaneous diffusion of computers and new management methods would have reduced unskilled workers to anything like their current plight if developed countries had remained industrially self-sufficient, and developing countries simply suppliers of a few primary products. The answer to this question, on the basis of the evidence now available, appears to me to be "probably not."

Prospects and Policies

The debate concerns the causes of past events, but what about the future? It is striking that even some of the people who argue that trade has so far had only minor effects go on to predict that it will have major effects in the future (for example, Sachs and Shatz, 1994, pp. 51–7; Slaughter, 1994). They argue that the emergence as exporters of labor-intensive manufactures of such vast countries as China and India will greatly expand the effective world supply of unskilled labor, to the serious detriment of the unskilled in developed countries. The dispute is thus sometimes portrayed as being over whether the effects of trade that I describe have already occurred, or are just about to occur (Woodall, 1994, p. 22).

Actually, there is disagreement about the future, too! In particular, I do not expect unskilled workers in developed countries to be much hurt by even major new entry into the world market for low-skill-intensive manufactures, simply because these goods are no longer produced in developed countries. The entry of China and India, pushing down the world prices of these goods, will benefit developed-country workers, skilled and unskilled alike.

Relatively unskilled workers in developed countries do, however, have two other things to fear from trade in the future.[11] One is stiffer competition in the world market for middling-skill-intensive manufactures, partly through developing nations such as Korea accumulating skills and partly from the countries of eastern Europe and the former Soviet Union, whose labor forces are already

[11] By focusing on the *relative* position of skilled and unskilled workers, this article avoids a second debate about trade with developing countries, namely whether it has reduced (or will reduce) the *average real* wage of all workers in developed countries. On the past, Lawrence and Slaughter (1993, pp. 166–79) show that it has not. On the future, there must be more doubt: the main risk is probably not a massive outflow of capital (which has been mobile for decades), but that the high earnings of skilled workers in rich countries are a scarcity rent that wider diffusion of knowledge will erode, rather than an enduring return to investment in human capital.

well educated. The second worry is increased tradeability of services, due to changes in technology and trade rules, which will expose the unskilled to foreign competition in previously sheltered sectors. And it is clearly just a small step from discussing trade in services to the even more thorny issue of unskilled immigration.

What should be the policy response? Even economists who argue that trade has a large impact on labor markets usually also argue that raising trade barriers is the wrong solution. Batra (1993) is an exception. But is our work, as some suggest, unwittingly giving ammunition to protectionists? That is certainly a risk, but one to which those who argue against us are just as exposed, since a guaranteed way to lose a public debate with a protectionist is to assert that imports are a minor influence on the labor market—something that few audiences of noneconomists are likely to believe. It is much more persuasive to emphasize that economic analysis confirms that there are losers as well as gainers from trade, but shows that protection is inferior to other ways of helping the losers.

What are these other, better ways? A familiar one is to try to offset the reduction in demand for unskilled workers by a parallel reduction in their supply. To some extent, this will happen automatically, since the widening economic gap between the skilled and the unskilled sharpens the incentive to acquire skills. But this supply response can probably be amplified and accelerated by government action to improve education and training. Even at best, though, this strategy will yield results only slowly: it may be a couple of decades before the relative supply of unskilled workers is cut by enough to raise their relative wage substantially.

In the meantime, we need other measures, and in particular subsidies to the unskilled. In America, where wages are flexible, the need is for subsidies to boost the living standards of workers who take low-paying jobs, in the form of tax cuts, cash supplements to wages, and better public services. In Europe, where an institutionally determined floor to the unskilled wage has to be accepted as a political constraint, the need is for subsidies to employers, to encourage them to hire more unskilled workers, especially in nontraded services. A more thorough discussion of these policy options is offered in Wood (1994, ch. 10).

Since (once protection is ruled out) the appropriate policy responses to a falling demand for unskilled labor are the same, whether it is caused by trade or new technology, the opponents in the debate over causation often agree on solutions. But economists can always find something to disagree about: in this case, some argue that subsidies, by easing the plight of the unskilled, will slow the supply response, and thus protract the problem. However, low wages and unemployment are an obstacle as well as an incentive to skill acquisition: the net effect of the subsidies, particularly on the education of the children of the unskilled, is quite likely to be positive. A more serious risk is political: it is the

reluctance among the skilled to pay the taxes needed to finance the subsidies to the unskilled.

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