RESEARCH SEMINAR IN INTERNATIONAL ECONOMICS

School of Public Policy
The University of Michigan
Ann Arbor, Michigan 48109-1220

Discussion Paper No. 428

Technology, Trade, and Increasing Inequality: Does the Cause Matter for the Cure?

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June 17, 1998

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ABSTRACT

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This paper addresses an issue that has received a great deal of attention in recent years, both from international trade economists and from labor economists: What has caused the relative wage of skilled labor compared to unskilled labor in the United States to increase through the 1980s and 1990s? Prime candidates for causing this change have been "trade" – the increased competition of U.S. workers with unskilled workers abroad – and "technology" – new products and processes that may have increased the productivity of skilled workers or skill-intensive industries relative to their unskilled counterparts. The paper reviews what has happened to relative wages and the explanations that have been suggested. A brief look at the empirical evidence from this literature is suggestive, but hardly conclusive. But the paper then asks whether the answer to this question really matters. It turns out that the appropriate policies for dealing with this change in relative wages do not depend on whether the cause of the change has been trade or technology. The paper concludes with an argument about the first-best policy for dealing with the increased wage differential, but also with some skepticism that any policy at all is needed.

Keywords: Trade and Wages
Inequality

JEL Subject Code: F1

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Technology, Trade, and Increasing Inequality: Does the Cause Matter for the Cure?[*]

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I. Introduction

Beginning in the late 1970s or early 1980s, a phenomenon emerged in United States labor markets that was quite different from what had come before. After rising over time more or less together since World War II, the wages of skilled and unskilled workers began to diverge. The wages of skilled workers rose relative to those of unskilled workers, and the latter actually fell in real terms. This pattern has continued ever since, with the result that the differential between the two is now higher than ever before. This in turn has contributed to an increase in inequality within the United States population, which has been a cause of concern at many levels of public policy.

Economists began to look at this phenomenon starting in the late 1980s, seeking to identify the cause or causes of what was happening. A lively debate ensued over issues of both methodology and substance. The two principal causes that have been identified for the increased skill differential have been technology and trade, although other causes have been mentioned as well. Much research has focused on measuring the relative contributions of these two causes toward the increased differential that has been observed.

[*] I have benefited greatly from conversations about the topic of this paper with John Jackson, Bob Stern, Gordon Hanson, and many others.

In this paper I will review the arguments and some of the literature, then go on to ask about the importance of the answer to this question. That is, does it really matter, from a policy perspective, whether the increased skill differential was caused by technology, by trade, or by something else? Should policies in response to this development be any different if the cause was mostly trade than if it was mostly technology? The tone of the debate over the causes has often seemed to imply that it does matter, and in particular that if trade is the cause of the increased differential, then it will follow that restricting trade should be the cure for the resulting rise in inequality.

I will argue first that one may not want to do anything about this change in the skill differential per se, but rather that policies to deal with the resulting increase in inequality should leave the differential intact. Furthermore, whether the increased skill differential should be reversed by policy does *not* depend on what has caused it. Similarly, if one believes that the increased skill differential is a problem, then the appropriate policies to deal with it, again, do not depend on whether the cause was trade, technology, or something else. Not surprisingly, since I am a trade economist, I will argue that trade restrictions are a bad policy in any case for dealing with the increased differential. But more importantly, to the extent that one can make a case for restricting trade in order to prop up the wages of unskilled workers, this case itself does not depend on whether trade depressed those wages in the first place.

In subsequent sections I first review, in section II, what has happened in labor markets over the last twenty years, primarily in the United States. Then I turn in section III to various explanations that have been advanced for these developments, including both technology and trade. In section IV I look briefly at the empirical evidence that has

been collected regarding these causes, and I try to identify a consensus in this diverse literature. Finally, in section V, I ask whether the cause should matter for policy, and I develop the arguments begun above.

II. What Happened

Real wages of both skilled and unskilled workers rose more or less together from the end of World War II until the early 1970s. At that point the first oil crisis and other changes in the U.S. and world economies stopped that growth, but again wages of all workers continued to move together, now in a downward direction. All this changed, however, in about 1980. Wages of skilled workers then began again to rise, but those of unskilled workers continued their decline. As a result, the skill differential – the ratio of skilled to unskilled wages – began a steady climb. This climb has continued more or less uninterrupted ever since.

This can be seen in the data on wages in several ways, depending on how one defines skilled and unskilled workers. Obviously a sharp distinction between the two is impossible and inappropriate, since workers possess different degrees and kinds of skill, acquired in different ways, ranging from genetic inheritance, education, and on-the-job-training to experience and perhaps even age itself in some occupations like university teaching.

One measure of the skill differential is simply to compare the average wages of workers with different levels of education. Figure 1, taken from Harrigan and Balaban (1997, Figures 1 and 2), does this for college graduates (including those with higher degrees), high school graduates (including those with some college but no degree), and

high school dropouts. The top panel shows the real wages of these three groups over the period 1963 to 1995, while the bottom panel shows the skill differential in the form of the ratios of college graduate wages to wages of the other two groups.

The trend of an increasing skill differential can be seen in both of these panels, starting in 1980, and it is most pronounced for the largest difference in education levels, the college grads versus the high school dropouts. That ratio, which hovered around two during the 60s and 70s, had risen well above 2.5 by the early 90s, and was close to three by 1995. That is, college grads have gone from earning only twice as much as high school dropouts before 1980 to earning almost three times as much today. The corresponding changes in real wages themselves are somewhat harder to see in the graphs, but they show both an overall (but not continuous) increase for the college grads and a decrease for the high school dropouts.

Another way of distinguishing skilled from unskilled workers is by the type of work that they do. Table 1 shows the increase in the relative wages of five categories of worker in the United States over the period 1980-1990, all relative to a sixth category of worker, Operators, whom I take to be the lowest skilled of those reported. It reports that the wages of what are presumably the most skilled workers, Managers, rose 24% relative to the wages of Operators, and indeed that all occupations gained at least slightly relative to Operators. Figure 2, from Lawrence and Slaughter (1993, p. 182), shows the relative wages of non-production workers versus production workers over the period 1958-1989 together, in the lower panel, with the relative employment levels of the two groups. Again, production workers may be taken to be less skilled, on average, than non-

production workers, and here again we see a substantial increase in the relative wages of the latter starting in the early 1980s.

An obvious question that arises when relative prices change is whether there have also been changes in quantities. In this case, as the bottom panel of Figure 2 shows for production and non-production workers, the relative quantity of skilled (non-production) workers has increased, but over a much longer period than just the 1980s. Indeed, it seems to have increased more rapidly before the wage differential began to rise. Figure 3 (from Harrigan and Balaban, 1997, Figure 3) gives a similar message for the different education groups of Figure 1: The share of college-educated workers rose from around 10% in the mid-1960s, to almost 20% in 1980, and then further to more than 25% in 1995. Over the same periods, the share of high-school dropouts fell, first from over 40% to about 20% in the early 80s, and then to about 12% more recently. The share of high school graduates has also increased, although it has remained fairly stable since 1980. Thus the composition of the labor force in the United States has shifted in a major way towards more skilled labor. Much of that shift occurred before the skill differential began to rise, but it has continued even since.

Most of the attention in this debate has centered on labor markets in the United States, but it is interesting to note the extent to which similar changes are occurring elsewhere. In the developed countries of Europe, there is evidence that something similar has been happening, although it tends to be an increase in the relative unemployment levels of unskilled workers rather than a fall in their relative wages. This, most observers agree, is due to the fact that European social institutions are structured to resist reductions

in wages. As a result, changes that appear in wages in the U.S. appear in employment in Europe.

III. Explanations

Wages, like any other prices if they are determined in competitive markets, result from the interaction of supply and demand. Therefore the first place to look for an explanation of a change in relative wages is on those two sides of the market. Figure 4 shows what would happen in a labor market with conventionally shaped supply and demand curves if relative wages were to increase as a result of a shift of just one of these forces: only supply, or only demand.[1] For a shift in supply to cause an increase in the relative wage of skilled labor, as shown in panel (A) on the left, the supply curve of skilled labor must shift to the left. The increase in the relative wage is then accompanied by a decrease in the relative quantity of skilled labor employed. For a shift in demand to cause the same change in relative wages, the opposite must be true of quantities, as shown on the right in panel (B). Therefore, we should be skeptical from the start that the observed increase in the skill differential of the United States was due solely to changes in supply, since as noted in Figures 2 and 3, the relative employment of skilled versus unskilled workers has increased over time, not decreased.[2]

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[1] These supplies and demands are specified in terms of relative labor quantities, skilled versus unskilled, and determine their relative wage, w_S/w_U. In this way a diagram that is usually used only for the partial equilibrium analysis of a single market can be adapted to represent a general equilibrium for the labor markets of an entire economy. Special problems can arise, however, if the labor market is that of a single country that trades actively with the rest of the world. In that case, to the extent that prices of goods are fixed by trade, the demand curve for labor becomes horizontal and it is not possible to generate a change in relative wages from just a shift in supply. I will return to this point below.

[2] Of course it is possible that there have been shifts in both supply and demand. Shifts in supply could have contributed to the increase in the skill differential while shifts in demand could have also prevented the relative employment of skilled labor from falling. It does not seem plausible, however, that changes in

Looking therefore on the demand side of the labor market, there are actually many reasons one can imagine that a shift in demand such as is pictured in Figure 4B might have occurred. However, I should first take note of an implication of international trade theory that complicates the story somewhat.

This implication is the well-known Factor Price Equalization (FPE) Theorem, first proved by Samuelson (1948) half a century ago in the context of what has become the standard economic model of international trade. This model is variously called the Factor Proportions Model or, after its originators, the Heckscher-Ohlin (H-O) Model. It explains trade in terms of the available quantities ("endowments") of primary factors of production, such as labor (or types of labor), capital, and land, whose abundance or scarcity would, in the absence of trade, determine their factor prices, including the wage of labor. But with trade, these factor endowments determine instead the comparative advantages of different countries, and thus their trade patterns. Each country is able to produce more of, and more cheaply, goods that use intensively its abundant factors.

Furthermore, the model under free trade has the surprising feature, discovered by Samuelson, that within some limits on cross-country differences in factor endowments, factor prices such as the wage in a country *do not* anymore depend directly on national factor endowments. Instead, factor prices depend on goods prices, and these are in turn determined in the world market.

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supply could tell the whole story alone. For example, it could be that demand for skilled labor has been rising all along, and that supply was also rising along with it, but only until 1980. If the trend in demand continued but the trend in supply slowed down, then we would observe much the same patterns in both wages and employment as are shown in Figure 2. The cause, in that case, could be argued to be on the supply side.

The FPE Theorem derives its name from the further implication that, if countries share the same technologies and face, under free trade, the same international prices of traded goods, then they will also have the same prices of factors. Even without identical technologies, however, the model implies that factor prices in a trading country will not change as a direct result of changes in its factor quantities. That is, in order to be consistent with equilibrium in goods markets that are facing prices of goods that are fixed internationally, factor prices within the country cannot change even as the quantities of the country's factors that are demanded do change. Leamer and Levinsohn (1995) have therefore also called this the Factor Price Insensitivity Theorem.

The importance of this for the discussion here is that it means that the demand curve for a country's labor, when we draw it as a function of wages, is not downward sloping after all, but is instead horizontal at a level that depend on prices of goods. This is shown in Figure 5.

The panel on the left shows how prices of goods and relative wages are related, the relative wage of skilled labor increasing with a rise in the relative price of skill-intensive goods. This curve, which is central to much of what will come below, is perhaps most easily thought of as illustrating how wages determine prices, rather than the other way around. That is, as the relative wage of skilled labor rises, it is no surprise that the relative costs of skill-intensive goods – goods that use a relatively high proportion of skilled labor – will rise as a result. If prices depend on costs, as they do in any country where the goods are produced, then the relative price of these goods will rise as well. This is what the curve labeled WP in the left panel shows. And it can equally well be

thought of in reverse, as the wages caused by prices, as long as both kinds of goods are being produced.

Once the relative wage is determined in this way, the panel on the right shows the demand for labor as a horizontal line, drawn at the level of the relative wage determined on the left. What it says is that given the prices of goods that they face, producers will collectively be willing to employ many different ratios of the two kinds of labor without there being any change in relative wages. The way this can happen is not by individual firms or industries changing the proportions that they employ the two factors, as they would in response to a change in relative wages in Figure 4. Rather, the various economy-wide demands for factors are accomplished by changes in the sizes of industries that employ them. What happens, for example, if the relative supply of skilled workers increases without a change in world prices, is that skill intensive industries expand and others contract so that a higher total ratio of skilled to unskilled labor becomes employed. You cannot see this in the figure, but it is going on behind the scene along the horizontal labor demand curve labeled $D(P^0)$.

The figure can then be used to illustrate two things. One, not shown here, is that changes in the supply of labor, such as would be shown by horizontal shifts of the supply curve S, will change the quantities of labor employed, but not their price. The second is that a change in relative prices of goods *will* change relative wages and will also cause the labor market to adjust along the supply curve. Thus the increase in the relative prices of skill-intensive goods that is shown by the arrow in the left-hand panel of Figure 5 causes the relative wage of skilled labor to rise in both panels, and induces an increase in the relative quantity of skilled labor supplied.

This view of wage determination leads one to focus on prices of goods, rather than on quantities of factors, to find explanations for the rising skill differential. Changes in quantities can still matter, but only to the extent that they also cause changes in prices. A fall in the relative supply of skilled labor, as in Figure 4A, for example still raises the relative skilled wage in a closed economy, but it can do so there because it also causes relative prices of skill-intensive goods to rise. If the country were open to trade, however, and if it were very small, then the drop in skilled labor would be accommodated by a shift of the country's industry to produce fewer skill-intensive goods and more unskill-intensive goods, and neither prices nor wages would have to change. World wide, then changes in factor quantities, either supplied or demanded, will matter for factor prices within the trading countries only to the extent that they also cause changes in goods prices. A fall in the relative supply of skilled labor world wide for example, by making skill-intensive goods more scarce, will raise their price on world markets. This in turn will raise the skill differential. The point is not that factor quantities cannot matter for factor prices; of course they can. But their effect must work through prices of goods, and at least in some circumstances, recognizing that fact makes one skeptical that this will happen.

As an example of this, consider the possibility that immigration of unskilled labor into the United States might account for the rising skill differential. From Figure 4A, this might seem plausible, since in inflow of unskilled labor reduces the relative supply of skilled labor. However, recognizing that the U.S. is an open economy and that the relative wage will rise on account of immigration only if it also raises the world relative price of skill-intensive goods, the argument sounds much less plausible. The U.S. is an

important player in world markets, but it is hard to believe that the size of the immigration flows into the U.S. are large enough to make much difference to world supplies of unskilled-labor intensive goods. Even more important, however, is to note that world prices of both goods and factors really depend on world factor endowments, and these are not changed by a group of workers moving from one country to another.

This brings us, finally, to consideration of the two causes of increasing inequality that have dominated discussion. Speaking very loosely, we can refer to them as "trade" and "technology." I will start with trade because I am a trade economist.

Trade

I say "trade" because that word has become a shorthand in this literature for a whole list of changes whose effects on local labor markets are viewed as coming from abroad because they are transmitted by increased international trade. As should become clear, however, in each case trade itself is really only an accompanying symptom, not really the ultimate cause.[3] Table 2, then, gives a list of changes that might in theory have caused the relative wage of skilled labor in the U.S. economy to increase, accompanied by an increase in U.S. imports of unskilled-labor-intensive goods. These are not by any means the only changes that could cause both a increased skill differential and increase in trade, but they are the ones for which trade is often viewed as the proximate cause. All are also aspects of what is often called "globalization," which I will sometimes take to be a synonym for "trade."

In all of these changes, the key to why they would increase the skill differential in the United States is that, before the change, unskilled labor is more abundant abroad, and

thus lower paid, in less-developed countries than it is in the United States. This is too well known to require documentation here, especially after the NAFTA debate in which the low wages of Mexican workers compared to U.S. workers were so frequently mentioned as cause for concern by opponents in the United States.

Indeed, the argument for trade as the cause of the increased U.S. skill-differential is both obvious and, at the same time, quite subtle. It seems obvious to many non-economists that competition through international trade with low-paid workers abroad must lower wages here, yet that is *not* the case in general as we know from the theory of (and experience with) comparative advantage. Suppose that all labor is paid less abroad than at home because it is for some reason less productive than domestic labor. Then "competition" between domestic and foreign labor through trade will simply cause both sets of workers to specialize in what they do relatively best, and all of them will gain. This is the message of almost 200 years of trade theory, and it has gradually been learned in recent decades by more and more countries that previously pursued development through self-sufficiency.

But suppose that labor – or a particular kind of labor, such as unskilled labor – is paid less abroad than at home not because it is less productive, but only because it is more abundant there compared to other factors. Then somewhat more recent developments in trade theory[4] do confirm that freer trade will lower the real wage of the corresponding category of labor at home. This is the Stolper-Samuelson Theorem, which takes its simplest form in a neoclassical model with two factors and two goods. There, a fall in the

[3] See Deardorff and Hakura (1995) for more on this point.
[4] But still quite old. Several years ago we held a 50th birthday party for the central theoretical result that made this point. The event was documented in Deardorff and Stern (1994).

price of one of the goods will cause a fall in the real wage of the factor used intensively in producing it, together with a rise in the real wage of the other factor.[5] Such a fall in price is exactly what can be expected from increased trade with producers of unskilled-labor intensive goods. Therefore such trade can be expected to reduce the wage of unskilled labor while raising wages of skilled labor.

This is already partly evident in Figure 5, which illustrates the effect of the relative price of goods on the relative price of factors. However, this is not enough to establish the full Stolper-Samuelson result, which deals in real wages, not just relative ones. One might have thought and hoped that the broader gains from trade – those that I mentioned above as arising from specialization in accordance with comparative advantage – might have allowed both abundant and scarce factors to gain from trade, even as their relative returns are being tilted. But alas no, Stolper and Samuelson showed that this is not the case. When the wage of unskilled labor falls relative to skilled labor due to a fall in the relative price of unskilled-labor intensive goods, these workers actually lose in real terms. Their standard of living actually goes down.

In the list of Table 2, a fall in U.S. trade barriers, especially to the extent that these barriers restricted imports of unskilled-labor-intensive goods, will reduce their price in the domestic market and thus increase the skill differential while reducing the unskilled wage. These are exactly the changes in labor markets that were observed in the 1980s and 90s, as we have seen, and therefore trade theory would seem to support the idea that the cause was trade liberalization. It was, after all, precisely during the 1980s that the tariff reductions of the Tokyo Round of multilateral trade negotiations under the GATT

[5] See Stolper and Samuelson (1941). For more on the history and interpretation of the Stolper-Samuelson

were phased in, followed in the early 1990s by the U.S. Canada free trade area, the NAFTA, and the Uruguay Round.

However, none of these exercises in trade liberalization caused much reduction in U.S. trade barriers in fact. The Tokyo Round reduced the average U.S. tariff from only about six percent to about four percent, and thus could have caused domestic relative prices to change by only a couple of percentage points at most.[6] This was hardly enough to cause the changes in relative wages that were observed. Furthermore, during this same period there actually were increases in other trade barriers, including the voluntary export restraint on automobiles with Japan and, more importantly for the issue here,[7] expansion of the Multi-Fibre Arrangement that restricts imports of textiles and apparel from developing countries. Thus while it is probably true that trade liberalization would have increased the skill differential in the United States if it had happened, it did not happen.

Second in the list of Table 2, however, is trade liberalization by developing countries themselves, and this certainly did happen. Beginning with Chile in 1974 and followed by Argentina, Costa Rica, Colombia and other Latin American countries in the mid-1980s, one developing country after another abandoned policies of import substitution and instead opened their markets to international trade.[8] Even several East Asian economies that had followed export promotion strategies, such as Taiwan, South Korea, and some other Asian NICs, became persuaded to reduce the substantial barriers that still remained on their imports. Finally, and perhaps most importantly, the People's

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Theorem see Deardorff and Stern (1994).

[6] See Deardorff and Stern (1983) for a detailed analysis of the effects of the Tokyo Round. In fact, the changes in U.S. domestic prices that were caused by the Tokyo Round were considerably smaller than these numbers suggest, for a variety of reasons including the limited role of trade in the large U.S. economy and the size of the United States in the world economy.

Republic of China abandoned its previous isolationism in the early 1980s and began both to export and to import. All of this – and especially the entry of China into the world market – has meant that there has been increased supply on world markets of primarily unskilled-labor intensive goods. This change would be expected to reduce the world prices of these goods. Again, as partially illustrated in Figure 5, the Stolper-Samuelson Theorem implies that such a change, now without any reduction in trade barriers by the United States, will cause unskilled wages to fall and skilled wages to rise.

Therefore, we do find a plausible theoretical case for the claim that reductions in trade barriers have caused the increased inequality in the United States and other developed countries. It is not U.S. barriers that have fallen, but barriers elsewhere. Still, these reduced barriers have undeniably led to increased trade, and through that channel U.S. unskilled labor has been exposed to competition with cheaper unskilled labor abroad. Unskilled workers have lost as a result. Trade economists will argue that it is not the trade *per se* that has had this effect, and certainly not the quantities of trade, since as explained above it is only the prices of goods that can cause a change in factor prices. But that is a quibble. The reduction in barriers to trade in developing countries permits them to export more low-skill goods onto world markets,[9] and to the extent that this causes the prices of those goods to fall, it will indeed reduce real and relative unskilled wages in the developed world.

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[7] Since Japanese cars are not intensive in unskilled labor.
[8] See Wood (1997) for a recent discussion of these developments.
[9] Most barriers restrict imports, not exports, so one may wonder how reducing trade barriers promotes their exports. An easy answer is that, as these countries demand more foreign exchange in order to buy imports, their own currencies depreciate, making their exports more competitive on world markets. In practice, other changes amplify this effect, such as the attraction of direct investment by foreign companies that produce for export.

This is only a theoretical case, however. It remains to be seen whether the size of the effect can be large enough to account for the changes in wages observed above. I will look at the evidence in section IV. For now, merely note that while trade barriers really have come down in many developing countries, these countries remain quite small in economic terms. The trade with them, although growing rapidly, is not obviously large enough to have caused such large changes in the developed world.

But now consider reason 3 on the list in Table 2: growth of the economies in the labor-abundant developing world. This growth has happened for a variety of reasons, most of them alluded to in the table, and I will not expand on them here because it is beside the point. Suffice it to say that after several decades when many of us wondered whether economic development would ever get off the ground, it finally did, in many countries, starting in the 1980s. All of the sources of growth listed in Table 2, except for population growth, contribute to rising average per capita incomes in the developing countries. This was the goal that a generation of development advisors had sought to achieve without much success before then, and it led quickly to a new category of nation in the world: the newly industrializing country, or NIC.

But this success has meant that a whole group of low-income countries have been producing more and more. And, appropriately so, what they have produced have largely been unskilled-labor-intensive goods. Indeed, it is because they specialized in this way and were permitted an outlet for their production through international trade that they were finally able to grow. But once again, a clear effect that one would expect from this increasing abundance of low-skill goods is that their price on the world market would

fall. If this happens, then Figure 5 and the Stolper-Samuelson Theorem tell us that wages of low skilled workers will fall too.

So here we have yet another mechanism by which developed-country unskilled wages may fall as a result of trade. The ultimate cause in this case may be called growth, not trade, but few economists would argue that trade had not facilitated both the growth itself and its effects on developed country labor markets. Indeed, it is quite clear that trade was essential for growth in these countries. It was their reluctance to trade prior to the 1980s that kept so many developing countries from succeeding.

Here again, however, to say that developing country growth did occur and that it could have caused increased developed country inequality, is not to say that it did in fact. I will look in section IV at the empirical evidence.

Technology

I turn now to technology as the main alternative cause of increased wage inequality. To an economist, technology means the known methods by which production can take place, as well as the resulting mapping from inputs to outputs. Technological change consists of new production methods (including perhaps simply doing old ones with greater care or ability) that make it possible to do more with less. Such change is important for the obvious reason that it makes it possible for the same economy to produce more output and/or to work less hard for producing the same output. This raises the average well being of the population. Technological progress is also important for the slightly less obvious reason that it changes the relationships among factors of production and may therefore change how the output of the economy is divided among them. Thus

technological change can easily cause relative factor prices to change, and the right kind of change could cause the increased skill differential that we have observed.

In the public mind "technology" is associated, not with knowledge of all manner of production techniques, but with products that are currently undergoing the most rapid and visible progress. I suppose that a century ago "technology companies," if the name were used, would have meant those developing and exploiting the internal combustion engine and the electric motor. Today the term refers mostly to the microchip, as well as to the computer and information technologies that depend on it. Thus "technology" is not in popular parlance a general term, but a very specific one, with possibly specific implications for factor markets. Indeed, when technology is posed as an explanation for the increased skill differential, what is usually meant is the computer revolution that seems to have begun (or at least accelerated and reached the desktop) around 1980.

According to neoclassical economic theory, wages and other factor prices are presumed to be determined by the "marginal products" of the factors – that is, the value of the additional output that an additional unit of the factor makes possible.[10,11] Very loosely speaking, we can say that wages reflect a factor's productivity. The effect of

[10] This will not be the case if factor markets are imperfect, most obviously if either the factors themselves have market power, as through unions, or if their employers do, as in the case of a single dominant employer in a town. These "distortions" cause wages to depart systematically up or down from the factors' marginal products. But marginal products continue to play a decisive role, so that our discussion in the text of effects on marginal products is just as relevant, even when these distortions are present. These possibilities and others like them have sometimes been mentioned on their own in explaining the wage differential, pointing for example to the decline in union power over recent decades.

[11] Outside the mainstream of economics, wages are sometimes thought to be determined independently of factor productivity, by the countervailing powers of different groups in society. Thus the increased wage differential paid to high-skilled workers could be attributed to a shift in power and influence away from rank-and-file workers toward the more educated elite, if one believed that wages are somehow set on that basis. I do not know this literature myself well enough even to cite it, let alone make use of it for further analysis, if that is possible.

technology on factor prices can therefore be examined in terms of its effects on productivity.

There are two ways that technology can affect a factor's productivity. One is through the direct effect on the amount that the factor is able to produce in a particular industry. The other is more indirect, as factor and goods markets throughout the economy adjust to keep all industries and factors viable. The second effect is somewhat subtle, and it is not what leaps to mind when thinking of technology and wages. But it may be more important than the direct effect.

To take the direct effect first, it is straightforward that technology can make certain factors more productive. The argument with regard to the wage differential can then be simply put. The computer revolution has made it possible for highly skilled workers, manipulating their environments with electronic devices, to produce far more than equally skilled workers could have previously, also replacing to a large extent the unskilled workers whose tasks are taken over by more intelligent machines. As a result, the productivity and wages of skilled workers rise, while those of unskilled workers do not.

A careful telling of this story is not that simple, and there are several possible ways that it could go wrong. Output per worker may go up, for example, without the marginal contribution of an additional worker rising, in which case the increased productivity and remuneration may go primarily to capital, not skilled labor. Or, computers may simplify tasks sufficiently that even unskilled workers can run them, in which case it may be they who benefit, not those with skills. And finally, the cost reductions that computers permit may to a large extent accrue to buyers, not sellers, in the

form of lower prices. In that case, while physical productivity has increased, its value has not, and wages would not rise. All of these possibilities must be considered, and they make an unambiguous prediction based only on theory impossible. But the idea that this sort of technological change may have motivated much of the increased skill differential remains very plausible.

Turning now to the indirect effect of technology, this can be most easily understood, perhaps, by example. Suppose that technological progress occurs in some industries and not others. Suppose specifically that it happens in industries that employ higher than average proportions of skilled labor compared to unskilled labor, but that within those industries it raises the productivity of both kinds of labor. That would seem to raise the wages of both skilled and unskilled workers by the same amount, and indeed it would if it were not necessary to keep other industries from shutting down. Other industries that have not enjoyed the technological improvement, however, will find their costs raised above their prices when they have to pay these higher wages to keep their workers. Some of the firms in these industries will instead cut back production and lay off workers. Since by assumption these firms employ a relatively large number of unskilled workers, this will put downward pressure on the unskilled wage. Equilibrium will be restored when skilled wages have risen and unskilled wages have fallen, compared to the higher levels that both first achieved after the technological improvement. With both wages changing, the technology-favored skill-intensive industries will still cover their costs, while the fall in the relative wage of unskilled workers will keep the low-skill industries in business. This argument is rather

convoluted,[12] but the bottom line – that progress in skill-intensive industries raises the skilled wage relative to the unskilled wage – may be plausible on its own. It is also very similar to the result displayed for changes in relative prices in Figure 5.

It is worth noting that both of these changes in technology, in addition to increasing the skill differential, could also cause significant changes in the volume of trade. These changes in trade due to technology might look very much like the changes in trade that would arise from trade liberalization or from foreign growth, as discussed above. Particularly if technology changes primarily in the developed countries, Deardorff and Hakura (1994) showed that one would observe exactly the same increases in both exports and imports that would follow from globalization. Therefore one cannot just look at changes in trade in order to determine whether "trade" or technology has been the cause of a change in wages.

Instead, what we really need to know in order to assess whether technology can account for the increased skill differential are two things about the technology change itself. First, how does it affect the productivities of skilled and unskilled workers within the industries where it occurs? If technological progress has raised the productivity of skilled workers more than (or instead of) unskilled workers, and especially if it has done so across the board in all industries, then it can easily account for an increased skill differential. Second, in what kinds of industries has technology improved the most? If progress has occurred primarily (or only) in skill-intensive industries, then this too could account for an increased differential. Unfortunately, these are hard questions to answer at all, let alone to quantify the changes sufficiently to connect them to the changes in the

[12] It attempts to replicate in words the mathematics of the two-sector trade model. It is shown

skill differential that have been observed. There is therefore not much empirical work along these lines to be reported in Section IV.

IV. Empirical Evidence

There have been several surveys of empirical work on this issue, including Deardorff and Hakura (1994), Burtless (1995), and most recently Johnson and Stafford (1998). I will not attempt to cover the same ground, but will only try to indicate what kinds of things have been done and what main conclusions have emerged.

The first to address this topic were labor economists, such as Murphy and Welch (1991), Borjas et al. (1992), and Bound and Johnson (1992). Their method was to build on the supply and demand approach to labor markets shown here in Figure 4. They estimated the amounts of different kinds of labor needed to produce goods that entered into international trade, and used this to estimate shifts in supply or demand for labor due to trade, then to infer changes in wages. Their findings were not all, of course, quite the same, but the consensus from these and other contributions by labor economists was that observed changes in trade could account for a significant part, but far from all, of the observed increase in the U.S. skill differential. Unfortunately, as noted above, since changes in trade can themselves be caused by changes in technology, these results really do not tell us whether the cause was "trade" – in the sense used here of globalization – or technology.

Trade economists such as Lawrence and Slaughter (1993), Bhagwati and Dehejia (1994), and Krugman and Lawrence (1993) also noted as stated above that one should

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diagrammatically in Deardorff and Hakura (1994).

look at prices, not quantities, in assessing effects on wages. According to the data that these investigators looked at, relative prices of unskilled-labor-intensive goods did not in fact fall over the 1980s. Therefore, one could not blame the decline in the unskilled wages on world markets.

Unfortunately, data in international markets are never very good, and these findings too were criticized. Sachs and Shatz (1994) found much to criticize, but most especially the price series used by Lawrence and Slaughter. Using what they argued to be better data, they did find a decline in the world prices of low skill goods. Attacking the problem from a variety of different perspectives, they concluded, like the labor economists before them, that "trade" could account for a significant portion of the rise in the skill differential. A second critic has been Leamer (1994) who found much to object to in all of the other papers mentioned. While he claimed that the "jury is still out" regarding the sizes of the effects of trade and technology on wages, he has been much more sympathetic than most to the idea that events in world markets may have had large effects on wages in the United States.

With few exceptions, this still growing literature has focused almost exclusively on various aspects of trade, and hardly at all on technology. Bound and Johnson (1992) set the pattern when they constructed empirical measurements not only of trade but of all the other potential causes of the skill differential that they could find, with the exception of technology. Having failed by then to explain the entire increase in the differential, they concluded that the rest must be due to technology.

Few have attempted to confront technology directly, and none have done so successfully in the sense of measuring the location and nature of technological change

that may have occurred, so that we could infer its effects on factor markets. Leamer (1994) noted this problem and provided his own empirical analysis of the effects of technological change, but he was himself unsatisfied with the ability of available data to address its effects on inequality. Feenstra and Hanson (1997) provide one of the few attempts to measure the effects of technology empirically in this context, using the shift toward high-technology capital such as computers. They find this, as well as a particular aspect of trade in the form of outsourcing, to be significant determinants of the increased skill differential.

Where does all this leave us? Leamer is correct that we are still largely in the dark. But if I had to characterize our ignorance, I would do so as follows. It seems likely that both trade and technology have contributed to the increased skill differential, both in substantial amounts, with technology probably contributing a bit more than trade. I am skeptical of other causes having contributed to it at all, but my range of uncertainty around each of these statements is very large.

V. Does It Matter?

Two assumptions often seem implicit in this debate. One is that the increased skill differential itself is bad, and that we should try to do something with public policy to reduce it. The other seemingly implicit assumption is that what we should do to reduce it depends on the cause. To the extent that trade has been the cause of the increased skill differential, then we should restrict trade. If the cause has been technology, then we should do something else. It seems to me that the first of these assumptions is questionable, while the second is simply wrong. If that is the case, then this debate over

the causes of the increased skill differential is largely of academic interest only. The important policy question is what, if anything, should be done about it, and this is independent of the cause. Given our ignorance, that is fortunate.

The Skill Differential

Consider first the increased skill differential itself. It has certainly contributed to an increase in inequality, and I do see that as undesirable. Not that all inequality is bad, by any means. Without some inequality of incomes, nobody has an economic incentive to do anything that will raise their income, and productivity in our economy would slow down substantially, if not come to a complete halt. I do believe that there are all sorts of incentives besides income that keep many of us working long and hard. But there are also plenty of unpleasant jobs that need doing that would surely not get done without financial incentives. Thus some inequality is necessary in a successful economy, but I believe – subjectively, to be sure – that we in the United States have more than enough.

For there are costs as well as benefits to inequality, and not only to the poor themselves. The poor suffer psychologically as well as economically, as do their children, who have not themselves participated in any contributing cause for the poverty that some might blame on their parents. The suffering of the poor also spills over onto the rest of society in the form of crime and other forms of social disruption.

But granted that inequality in the United States is excessive, and that it is increased by a higher differential wage paid to skilled workers, is it then true that reducing that differential is a good way to bring down inequality? Perhaps not. Inequality arises not only from unequal incomes, but also from unequal wealth. The best hope for a person with low wealth to raise it is first to acquire a higher income and then to

save it. High returns to skilled labor may actually be the best opportunity available for the poor to move up in the distribution of income and wealth. To reduce the skill differential may therefore only close off this avenue toward enrichment and thus lock the distribution of wealth into its current pattern.

Furthermore, quite aside from the issue of inequality, we also have the issue of the productivity and growth of the economy as a whole. As recent writings on the theory of economic growth have stressed,[13] these depend largely on the willingness and ability of the population to increase their "human capital," which is just another word for skill. The larger the skill differential, the larger the incentive to become skilled, and the more rapidly is the whole economy likely to grow.

These arguments are rather obvious, but they are no less valid on that account. It may well be that we should applaud the increased relative wage paid in recent years to skilled workers, even though most of us writing about it have undoubtedly benefited from it. If so, then the issue of trade versus technology in causing the increase may be an exercise of assigning credit, rather than blame.

Trade Versus Technology

But let me now assume for the sake of argument that the increased differential is undesirable. What then are we to make of the trade versus technology issue?

At one level the answer seems obvious: if you have a problem, attack the cause. That certainly is good advice in many contexts, where addressing the symptoms instead of the cause may be ineffective or worse. Sometimes it is not possible, but in this case, at least if the cause is increased trade, we could easily stop it. Just erect trade barriers. You

[13] See Barro and Sala-I-Martin (1995).

will not expect me, as a trade economist, to favor that course of action, but it does seem to make sense.

Furthermore, there actually is quite a respectable body of economic thought that seems to argue the same thing. Throughout economics we deal with "distortions," such as externalities, imperfections in competition, etc., by noting the principle of the Second Best: that in the presence of distortions policies that otherwise would be optimal may be sub-optimal, or even make things worse. The important corollary of this is that the best way to deal with distortions, wherever possible, is to attack them directly, using policies that will offset them and, thereby, effectively remove them from the scene. Thus for example we derive the "polluter pays" rule for dealing with negative externalities, taxing those who cause pollution in an amount that reflects its social cost.

Trade economists use this principle to argue against restricting trade for all sorts of purposes, where trade restrictions might conceivably be beneficial, but are never optimal. A tariff on agriculture, for example, can keep small farmers in business. But a better way to keep them from failing (if that is the problem being addressed) is to subsidize them directly. A restriction on imports of oil can keep marginal drillers of oil from capping their wells and retain a domestic oil industry in case of war. But economic welfare will be greater if that problem is addressed more directly by subsidizing oil production or, better still, by stockpiling oil.

Thus trade economists are accustomed to telling others to attack directly the true source of their problems, in order to deflect them from interfering with trade. But what if the true source of the increased skill differential (now assumed to be a problem) is trade

itself? Then does not consistency require that we accept trade restriction as the most appropriate policy for dealing with this problem?

I think not. For while trade may be the cause of the increased differential, it has other effects as well, and these are desirable. This is not pollution, which presumably is unambiguously and only harmful. Rather, this is trade, which provides cheaper imports to consumers and revenues to exporting producers, among other effects. Indeed, on the whole and aside from the assumed adverse effect on the skill differential, trade theory tells us conclusively that (under certain assumptions that need not concern us here[14]) freer trade is desirable for a country. Therefore, if the increased skill differential had resulted from our own reduction of trade barriers, as in the first of the listed causes given in section III, then to prevent it by keeping trade barriers in place would cost us the gains from trade. There must be a better way to deal with the problem of the increased differential.

Put differently, the principle of attacking the cause of a problem only makes sense when the cause itself is at best welfare neutral. If the cause yields other benefits, then one should think again. Likewise the corollary of the Second Best does not really say that first-best policy should attack the cause. Rather, it should attack the distortion, that is, the part of the economy that is out of whack. In the case of the skill differential, once we decide that an increased differential is undesirable, it is that we should address with our policy, as directly as we can manage, precisely in order to avoid the adverse consequences of dealing with it indirectly and making other matters worse. Restricting trade would do the latter.

[14] See Deardorff (1997) for more on these assumptions.

If this is hard to see, then it is only because many are so accustomed to viewing trade with distrust, in spite of the best efforts of we trade economists. Suppose I had turned the discussion around and asked: If the cause of the increased differential has been exclusively technological progress, should we therefore restrict technology? Most would surely answer "No," for they understand that technology is on the whole beneficial. It is only because they forget this about trade that many would have the opposite response for it.

So what policy should be used for dealing with the increased skill differential if we do indeed believe it to be undesirable? My argument so far only says that the best policy should not depend on the cause, but it does not say what that policy is.

Could it be a trade restriction, which then should presumably be used even if it is technology that has caused the problem? In principle, yes it could. If the social cost to society of the increased differential is large enough compared to the gains from trade, then it might be beneficial on net to restrict trade in order to reduce the differential. This would be equally true, even if the increased differential had been caused solely by technology. We only require that a trade restriction have this effect on the differential at all, which it surely would in a skill-abundant developed country like the United States. Could a trade restriction be the best policy for this purpose? I will argue in a moment that this is unlikely, but of course if it were somehow the only policy available, then it would be the best by default.

However, pursuing the usual reasoning of the second best, it is easy to argue that other policies are preferable to a trade restriction, even for reducing the skill differential. Suppose that one has identified a certain trade restriction – say a 10% tariff on all imports

– as generating a reduction in the skill differential that creates greater benefits than the accompanying lost gains from trade. This 10% tariff reduces the relative wage of skilled labor by some amount, say 15%.[15] Then it can be shown that either a 15% tax on the wages of skilled labor, or a 10% tax on the production of skill-intensive goods, will yield the same reduction in the take-home wage differential as the tariff, without as great a cost to consumers.[16,17]

Therefore, if we really believe that the increased relative wage paid to skilled workers is undesirable, then the optimal policy for correcting it is a direct tax on skilled wages, or perhaps a tax on production of skill intensive goods. This is true regardless of whether the increase in the relative skilled wage has been caused by changes in technology or by changes in "trade," whatever that second term may mean. If these policies do not sound as attractive as restricting trade, it is because the full effects of restricting trade are not being taken into account. And if the policies do not sound desirable in their own right, then one should rethink whether the increased skill differential was so bad after all.

[15] Typically, though not important for this argument, in the standard model of international trade a percentage price change (such as is caused by a tariff) causes a larger percentage change in relative factor prices. This has been called the magnification effect by Jones (1965) and is at the heart of why the Stolper-Samuelson Theorem tells us about real, not just relative, factor prices.

[16] This assumes that the tariff would not have changed world prices. If the tariff does change world prices, then its effect on domestic prices of goods and factors will be smaller, and smaller domestic policies will do the job.

[17] The factor tax is preferable to the production tax since it causes a smaller distortion of producer behavior. I mention both, however, because it may be impossible for the taxing authorities to distinguish skilled from unskilled workers once they start taxing one group and not the other. This is a point made in another context by Naito (1996), who shows that once such incentive problems are allowed for, taxes on production may do better at redistributing income than taxes on factors.

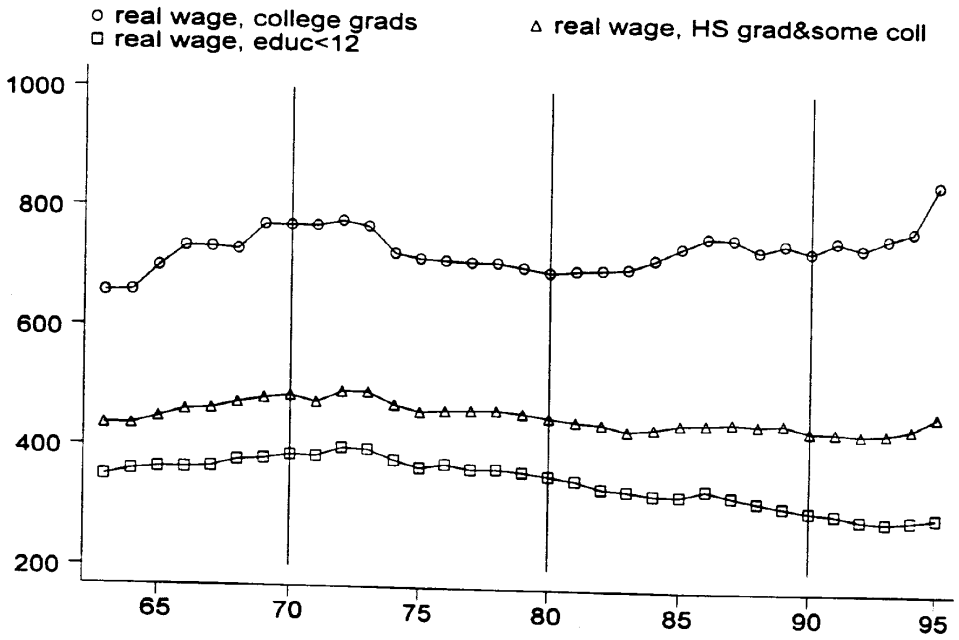
Table 1
Percent Change in Mean Earnings, 1980-1990,
Relative to the Mean Earnings of Operators,
United States (full time workers)

Managers	24
Technical	21
Service	14
Precision	3
Farm	2

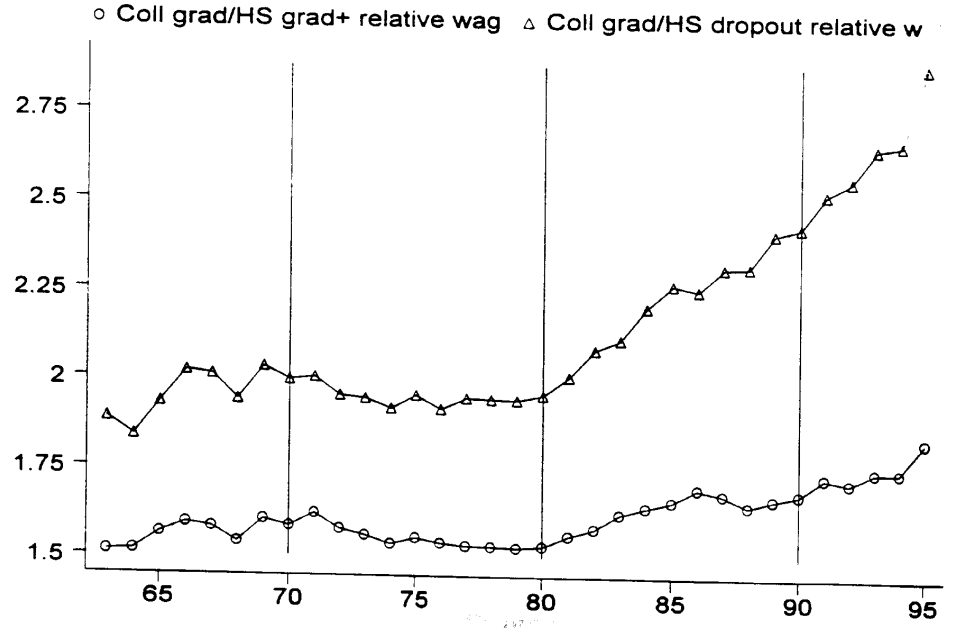
Source: Lawrence (1995), from CPS Tapes

Table 2
"Trade": Sources of Globalization

1. Reduction in United States barriers to imports such as tariffs and non-tariff barriers (quotas, voluntary export restraints, etc.)
2. Reduction in trade barriers in less-developed countries abroad
3. Increased capacity to produce in less-developed countries abroad, due to
    - Population growth
    - Capital accumulation
    - Transfer of technology from developed countries
    - Foreign direct investment by developed countries
    - Outsourcing by developed countries



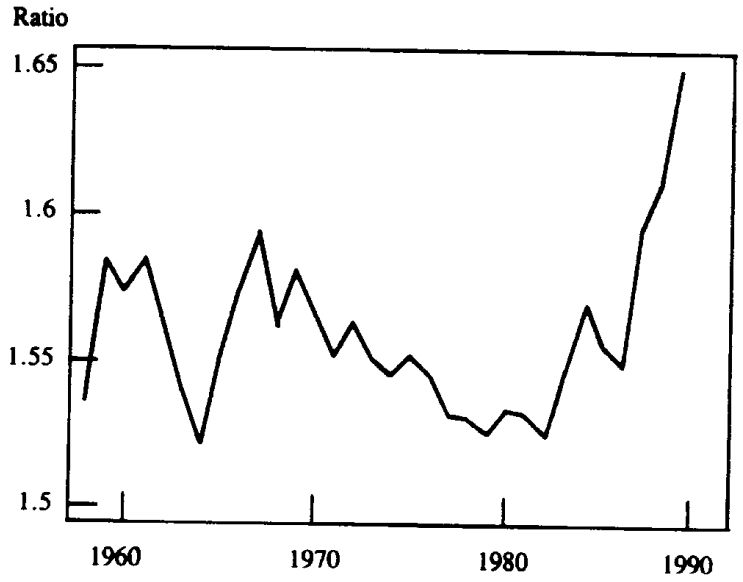
A: Real Weekly Wages



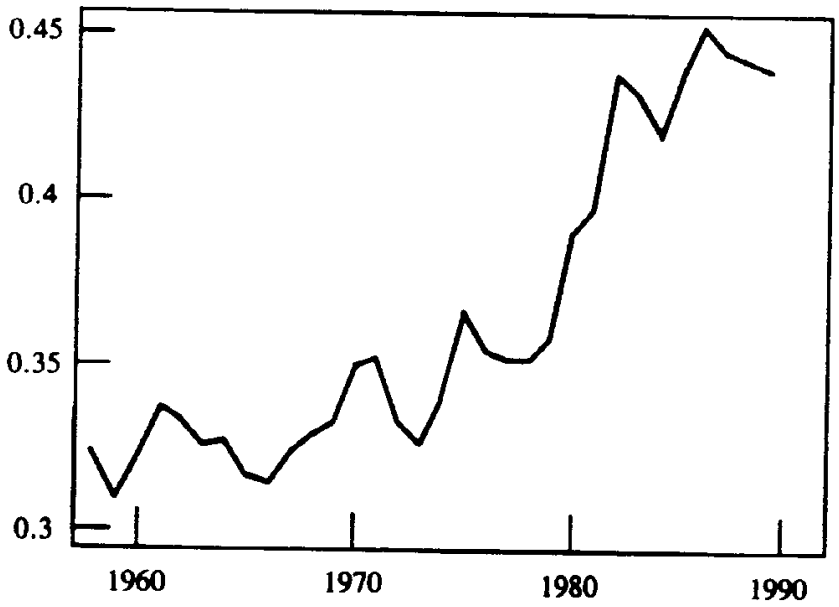
B: Relative Wages

Source: Harrigan and Balaban (1997, Figures 1 and 2). Based on data from March Current Population Survey.

Figure 1
Real and Relative Wages, 1963-1995



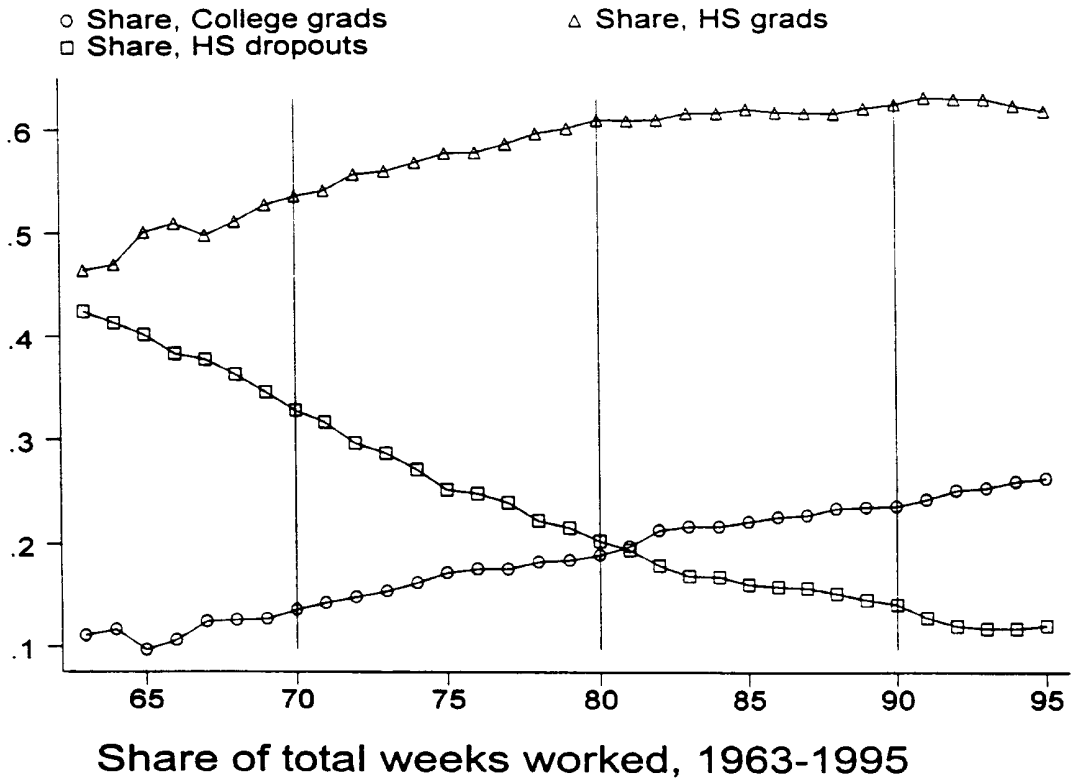
A: Ratio of Nonproduction to Production Wages



B: Ratio of Nonproduction to Production Employment

Source: Lawrence and Slaughter (1993). Taken from the Trade and Immigration Database of the National Bureau of Economic Research.

Figure 2
Relative Wages and Employment
of Production and Nonproduction Workers,
1958-1989



Source: Harrigan and Balaban (1997, Figure 3). Based on data from March Current Population Survey.

Figure 3
Shares of Employment by Education Level,
1963-1995

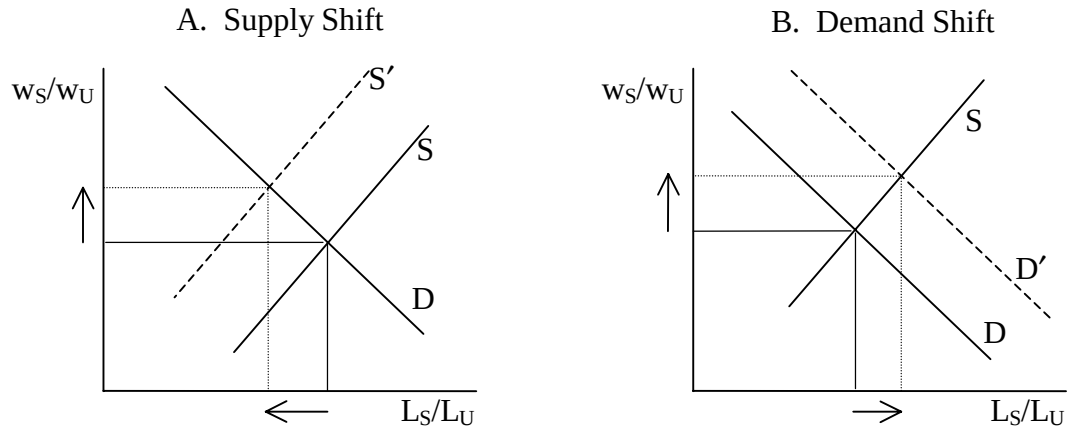


Figure 4:
Responses of Relative Wages
to Shifts in Relative Supply
and Demand

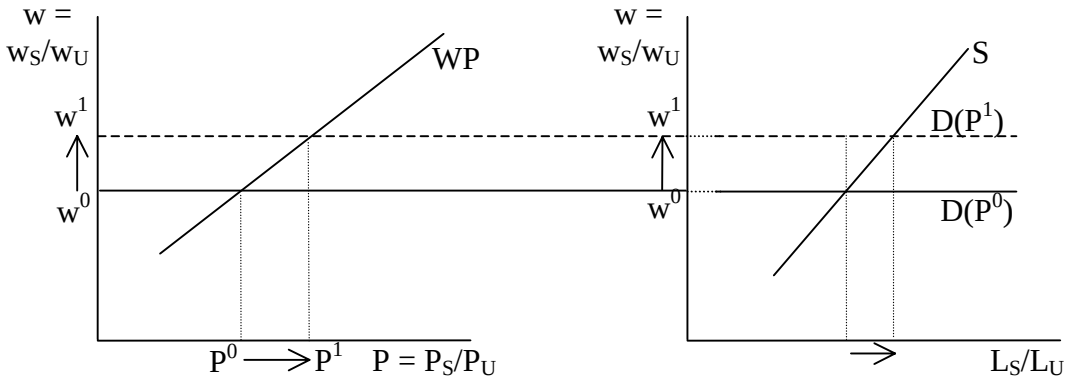


Figure 5:
Response of Relative Wages
to a Change in Relative Prices

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