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## Topic

*What effects will increasing globalization have on America's knowledge workers?*

## Relevance

The February 5th, 2003 cover of *BusinessWeek* questioned:

> **Is Your Job Next?** A new round of GLOBALIZATION is sending upscale jobs offshore. They include chip design, engineering, basic research—even financial analysis. Can America lose these jobs and still prosper?

A recent report from Forrester Research, a leading researcher of technology and its impact on business, predicted that 3.3 million jobs and $136 billion in wages will migrate from the U.S. to countries such as India, Russia, China, and the Philippines in the next thirteen years. Many dot-com survivors are wondering what will become of their jobs and wages in the face of falling demand for their labor and the increasing availability—and visibility—of exceptional foreign talent. Call centers in Bombay provide recent Indian college graduates with English linguistic and cultural skills, an exceptional opportunity for career growth, and excellent pay. U.S. firms are taking advantage of India's call centers, architects, programmers, and PhD-trained scientists of equal or better quality than U.S. workers for forty to sixty percent of U.S. wages.[1] For example, nearly twelve years ago, Boeing hired unemployed aerospace engineers in Russia at salaries as low as $5,400 per year. In the past two years, Boeing has laid off 5,000 U.S. engineers and refuses to make any agreement with its U.S. labor unions about its hiring practices.[2]

Many skilled service workers spend years learning their crafts, which may entail a decade of post-secondary education. Therefore, shifting their focus and skills into another specialty can be costly and difficult. In response to the seemingly insatiable demand for high-tech labor during the mid to late 1990's, many students and workers began studies in computer science, biotechnology, physics, and other high-tech knowledge fields. Indeed, the number of U.S. graduates receiving degrees in potentially exportable knowledge-based fields (such as information technology) exploded between 1996 and 2000. Today these workers are having difficulty finding employment in their area of expertise.

In this paper, I analyze some of the theoretical models of trade in goods, related macroeconomic indicators, and current policies. Ultimately, I conclude with some reservations that the concerns of workers are justified. I suggest some measures to remediate the impact upon this important group of workers, noting the importance of balancing those suggestions against the needs of the firm and the best interests of the U.S. consumer.

**Background and History**

What is a knowledge worker? How are they different from other workers such as industrial workers or other service workers, and why are they important?

Peter Drucker coined the term in the 1950's to describe:

> …participants in an economy where information and its manipulation are the commodity and the activity. Contrast this with the industrial age worker who was primarily required to produce a tangible object. Examples of knowledge workers

> include--but are not limited to--marketing analysts, engineers, product developers, resource planners, researchers, and legal counselors.[3]

Another definition of 'knowledge worker' is: "A person whose primary work responsibilities involve one or more of the creation, production, storage, or delivery of information."[4] Therefore, the knowledge worker is an individual who utilizes their substantial stock of human capital to provide services based on the manipulation and discovery of ideas and concepts. Often, these workers work in an arena in which the marginal cost of sending their product to another consumer is nearly zero; once the first client has paid for the research or work, there is little or no cost to disseminate the product to additional parties. Finally, knowledge workers and their products make up a large component of U.S. GDP and employment. According to Peter Drucker, knowledge workers make up approximately 40% of the work force among developed nations.[5]

Plummeting technology prices, rapid gains in productivity, and strong consumer confidence tripled the NASDAQ composite index from 1500 points in 1996 to 4500 points in 1999. The Dow Jones Composite Average soared from 1500 points in 1996 to nearly 3500 points in 1999. High-technology industries, particularly industries connected to the Internet, were responsible for most of these gains. The striking increase in productivity created by the rapid development of the Internet sent shockwaves of growth across the world. Knowledge workers made up a large percentage of the work force for these industries, and many knowledge workers enjoyed incredible salaries, exciting work environments, and fast-track career growth.

These euphoric highs have since fallen, as has the need for the labor that drove much of the growth. Between 1996 and late 2000, U.S. technology firms demanded large numbers of skilled information technology professionals. Despite skyrocketing wages, unemployment rates for engineering and science technicians was well below the national average, even below 2% in 1997 (Figure 1). As a result, many firms began to look abroad for additional workers. When the information technology bubble burst, U.S. firms searched for cost-cutting measures. Cheaper immigrant workers became even more attractive, and many firms laid off nonimmigrant labor in disproportionate numbers. Today, many of those foreign workers have returned home and are starting outsourcing operations that they hope will be utilized by U.S. firms. The reduced cost of living and abundance of skilled labor in their home countries has created an extremely competitive global knowledge workforce.

**Review of Theory**

**The Heckscher-Ohlin Model**

The classic Ricardian model of international trade describes the flow of trade between two countries solely by analyzing the differences in relative labor productivity. Clearly, this sole metric is insufficient; countries have widely varying endowments of capital, labor, land, infrastructure, human capital, and other important factors of production. Indeed, a good that may require a great deal of labor and very little capital to produce in one country may require virtually no labor and substantial capital (and infrastructure) to produce in another.

Given the considerable differences in productivity, technology, and relative resource endowments between countries and the fact that the same goods can be produced with different factor intensities, we need another model. The Heckscher-Ohlin model is based on the relative differences in factor endowments for two factors of production between two countries. The model states that if country X is relatively abundant in one factor of production when compared to another country Y, then country X will export the good that utilizes the abundant factor most intensively in production. These two countries trade until the relative costs of the two goods are equal. The Heckscher-Ohlin model further implies that because the costs of the two goods are equal, wages and capital rents will converge across the two countries. This is known as the *factor price equalization*, and it is an important component of my investigation. Put simply, the Heckscher-Ohlin model predicts that if the U.S. begins the trade of knowledge services with relatively labor-abundant countries, U.S. knowledge services wages will fall.

However, data on international manufacturing wages reveals that even when there is relatively free trade between countries, there is weak evidence for factor price equalization. For example, the total U.S. trade (sum of total imports and exports) with Canada and Mexico was approximately $684 billion in 2002.[6] The average 2001 hourly manufacturing wage in the United States is approximately 129% of the prevailing manufacturing wage in Canada, and approximately 868% of the prevailing manufacturing wage in Mexico.[6] In some cases, there is evidence of factor price divergence: wages in the United States, while higher, have been growing faster than wages in Canada (the latter have actually decreased 2.6% in 2001). This evidence contradicts the canonical Heckscher-Ohlin model. How is this possible? The answer lies in the numerous assumptions of the Heckscher-Ohlin model:

*Two countries*. The model utilizes just two countries to simplify calculations.

*Two goods*. Countries produce the same two goods to simplify calculations.

*Two factors*. Only two factors are used in production: labor and capital.

*Bartering only*. Instead of exchanging money for each good, the two countries exchange the goods in question.

*Productivity is identical between countries*. Unlike the Ricardian model, neither country has any type of technological advantage in the production of any good, so both countries possess the same technology.

*Absolute advantage is irrelevant*. The model is exclusively interested in the relative abundance of one factor to another. For example, Canada is relatively abundant in forests compared to Saudi Arabia, while Saudi Arabia is relatively abundant in oil fields compared to Canada. The U.S. is relatively capital-abundant compared to India and China.

Two countries freely bartering homogeneous products produced using identical technologies under perfect competition will experience an equalization in the prices of the goods and of the costs of the factors of production. However, productivity is not identical between two countries—the manufacture of jet engines, for example, requires a substantial supportive infrastructure, advanced technologies, and a highly skilled labor force. The cultivation of rice is extremely water intensive, and would be extremely inefficient in the dry deserts of Libya compared to the fertile Yellow River Valley of China. Technology inherently allows a firm or country to be more productive with fewer resources, and there is no guarantee that technological levels are at any moment identical between countries. In fact, the shortage of fully developed international intellectual property laws prevents some countries from enjoying technological advances made in other countries.

Moreover, countries do not barter wheat for oil or good X for good Y. They exchange dollars and pesos, euros and yen. The relative values of these currencies are not always at their equilibrium level. The current value of the US dollar may be unsustainably high and may contribute to the imbalance in factor prices. Furthermore, wages are more sensitive to differences in the real exchange rate than capital rents. In comparison to manufactured goods, less of the cost components of the service good are internationally traded. Capital-intensive operations depend primarily on raw materials that are tradable commodities in and of themselves. For example, a ton of steel is likely to have a similar price in the U.S. as in India. On the other hand, wages are quite dependent on the cost of living and other external factors. As a result, unlike the globalization of U.S. manufacturing, the real exchange rate will play a much greater role in the globalization of U.S. knowledge services.

Furthermore, the prices of the two goods in question are unlikely to completely converge due to transportation costs, import quotas, tariffs, imperfect competition, and other trade barriers. Even in the absence of these restrictions, the prices of two goods are unlikely to completely converge. For example, in their article “How Wide is the Border,” Charles Engel and John H. Rogers report that even while holding distance and exchange rates constant, there was a greater variance in goods prices between US and Canadian cities than between two cities in the same country.[7] This may simply occur due to a home-country bias, where U.S. firms and consumers prefer U.S. goods and services simply because they are produced in the U.S. Regardless of the reasons, because good prices never fully equilibrate, factor prices never fully equilibrate.

One could argue that as trade restrictions disappear, the goods prices should converge. The most relevant question then becomes, "what prevents service goods prices from converging, and how are those restrictions changing?"

To answer this, I will use an example from manufacturing. In manufacturing, restrictions have generally taken the form of insufficient infrastructure, high transportation costs, imperfect competition, and legal issues such as international trade agreements. As these barriers have decreased, the total transaction costs have decreased, permitting a smaller differential between U.S. factor costs and foreign factor costs. Furthermore, as the domestic price of goods increases, our willingness to pay for foreign products also increases. For example, assume that in 1965, one ton of hot rolled sheet steel cost $116 dollars to produce in America. Assume that there is no inflation in any country and total transaction costs (including tariffs, transportation costs, and differences in the real exchange rate) for transferring a ton of manufactured steel from Mexico to the United States in 1965 was $80. Therefore, a firm in Mexico must produce the same ton of steel for $36 or less for U.S. firms to consider importing steel from abroad. If technological or other issues make it impossible for Mexican firms to produce steel for less than $36 per ton, they will not produce steel or employ steel workers, and therefore Mexico will not export steel to the U.S. However, if policy makers reduce tariffs, if technological changes reduce the transportation costs, or if the dollar appreciates in real terms compared to the peso, transaction costs will fall. Suppose that the transaction costs fell by $30 between 1965 and 1970 to $50, and the price of a ton of steel has increased from $116 per ton in 1965 to $124 per ton in 1970. Now Mexican firms must produce the same ton of steel for $74 or less, which is much more likely to occur. With trade U.S.

steel manufacturers and workers must compete with steel manufacturers and workers from abroad. Because of increased competition, the price of steel will begin to fall and the U.S. output of steel will also fall. The wages and employment of U.S. steel workers will fall due to reduced output and increased productivity. Empirical data suggests that this has actually occurred: the simple correlation coefficient between U.S. steel imports and U.S. total employment in blast furnaces and basic steel products manufacturing is moderately high and negative ($r = {}^{-}0.685655$) for quarterly data between $1^{st}$ quarter 1978 and $4^{th}$ quarter 2002 (Figure 2).

In services, the major barriers to trade have been communications technology and a lack of foreign intellectual property regulations. These barriers may have prevented the trade of services because the transaction costs of trade would outweigh any possible cost savings for U.S. firms and set import prices for services far too low for foreign firms compete. However, the rapid growth of communications technology beginning in 1992 has decreased many of those barriers.[8] Wireless communications technology has enabled less developed countries to gain access to telecommunication services at prices far below those of traditional “landlines.” The nearly exponential growth in Internet service providers and telecommunications capacity has created an exploding international high-speed network in which the marginal costs of data transmission are practically zero. Between 1998 and 2002, the number of Internet users in India has soared from 700,000 to over 10,000,000. Thanks to voice-over-Internet-protocol (VOIP) technologies, it is intrinsically no more expensive to place a phone call from Los Angeles to Bombay than it is to place the same call from Los Angeles to Dallas. Domestic Internet service provider prices dropped by over 55% between 1988 and 2002 (Figure 3). The transaction cost of transmitting information internationally—whether voice, images, software code, or other data—has been falling rapidly for ten years. Furthermore, this increased capacity for communication has placed a face on globalization and has enabled countries to begin solidifying intellectual property rights, the last barrier to trade in services.

Thus decreasing transactional costs, decreasing technology costs, and increasing service prices have made it feasible for foreign firms to begin to export service goods and to compete with U.S. firms. The "wedge" that has separated domestic prices from foreign prices is decreasing. For the time being, it seems that the key equilibrating effect is the increased presence of foreign competition, meaning that the service price after transaction costs has begun to exceed the foreign marginal cost of business, thereby giving birth to a nascent foreign service industry. So long as transaction costs continue to decrease and intellectual property regulations enable the safe foreign development of knowledge products, we should expect a continuing equalization of service prices and wages.

**The Stolper-Samuelson Theorem**

In their classic 1941 paper, "Protection and Real Wages,"[9] Wolfgang Stolper and Paul Samuelson prove that in perfectly competitive markets with full employment, there is a perfect correlation between the ratio of the price of capital to the price of labor and the ratio of the price of the capital-intensive good to the price of the labor-intensive good. They assume that each country manufactures two products: the labor-intensive good X and the capital-intensive good Y. Each good has only one ratio of inputs that results in zero economic profits, as we would expect in long-term perfect competition. The supply of labor and capital are fixed and divided between the production of both goods. So long as the ratio of the input ratios for the two goods are distinct, there will be only one quantity of labor and capital that will satisfy the zero profit condition in both industries simultaneously. An increase in the price of the labor-intensive good increases demand for both factors used in its production.

According to the Stolper-Samuelson theorem, raising the price of the labor-intensive good increases the price of labor but decreases the price of capital. The mechanism for this is quite subtle. Recall that the Stolper-Samuelson theorem assumes that the economy is operating under full employment. An increase in the price of the labor-intensive good creates demand for more labor, which producers of the labor-intensive good can only obtain at some cost from the capital-intensive good's relatively scarce labor force. The reduction in the capital-intensive good's labor force leaves some capital under-utilized, resulting in a surplus of capital in the market. As a result, the price of capital will decrease. It follows that there is a direct relationship between the price of a good and the price of the intensive factor utilized in its production. Therefore, an increase in the price of a good will not only increase the price of the intensive factor of production, it will also tend to lower the price of the non-intensive factor of production.

The impact of this theorem on services is simple in principle but difficult to observe. If services became cheaper, possibly due to greater international trade and competition, wages paid to service workers would decrease while the prices of service related equipment (such as retail equipment and computers) would increase. In fact, just the opposite has occurred. Interestingly enough, the (chain-type) price indexes of service imports and domestic services production have been recently increasing—meaning the prices of all services are in general increasing. Theoretically, it would follow that as services are typically labor intensive, services wages in general should be increasing, while the prices of service related capital should be decreasing. Between 1980 and 2000, both the real average wage in services and the service producer price index have been increasing steadily. Coincidentally, between 1990 and the present, computer prices have dropped dramatically. The PPI for electronic computers in December of 1990 was 331.4 (Dec. '98=100). In February of 2003, the PPI was 64, just 19.3% of the December 1990 price.[10]

There is a strong positive correlation (r=0.76900) between the real average service wage and the U.S. balance on services. There is also a strong positive correlation (r=0.87650) between the total wages paid to service workers and the U.S. balance on services. While correlation does not imply causality, the high correlation between U.S. service wages and the U.S. trade balance on services is consistent with the Stolper-Samuelson Theorem.

**The Magnification Effect**

The magnification effect is a generalization of the Stolper-Samuelson theorem. The Stolper-Samuelson theorem provides information about the effect of the change of price of a good X on the prices of its factors. The magnification effect enables one to observe the magnified effects of price changes for both goods on the prices of both factors simultaneously. Assume that W and r are the prices paid for one unit of labor and capital respectively, and $P_L$ and $P_K$ are the prices of the goods that use labor and capital intensively, respectively. For positive changes, the magnification effect states that $\%\Delta W > \%\Delta P_L > \%\Delta P_K > \%\Delta r$ for a country that is labor-abundant, and $\%\Delta r > \%\Delta P_K > \%\Delta P_L > \%\Delta W$ for a country that is capital-abundant. In the case of negative changes, the order of the terms is reversed. Put more simply, the percentage increase in the nominal wage is greater than the percentage increase in the price of the labor-intensive good in a labor-abundant country, so the real wage rises, and so forth.

This model has an interesting implication: wages in labor-abundant countries are more elastic than wages in capital-abundant countries. Remember that the U.S. is capital abundant, and services are typically labor intensive. In theory, a small increase in the price of service goods should cause a smaller increase in the price of domestic labor and a greater increase in the price of foreign labor. This means that it is entirely possible for a small increase in the price of services in the U.S. to have a nominal effect on domestic service wages, while having a tremendous effect on foreign service wages.

I attempted to confirm the empirical validity of this effect using long-term quarterly time series. Unfortunately, accurate and sufficiently extensive data about the prices of labor in the countries that I wanted to analyze were unavailable. As a result, I was only able to measure the domestic aspect of the magnification effect. I compared changes in the price of services to the changes in domestic service wages. I obtained quarterly data for both consumer price indexes for services and service wages between 1995 and 2000. I then calculated the percentage changes for each series and each quarter, and compared the results (Figure 4). Because the U.S. is capital intensive, we would expect the change in service prices to exceed the change in the service wage in most observations. The change in service prices exceeded the change in the service wage in only seven out of twenty comparisons (Figure 5). There was weak correlation ($r=0.07495$) between these two series across the twenty-observation data set. This is not particularly surprising, however, as there is typically a lag between the increase in the services price and the resulting adjustment in the service wage.

One recent example of the magnification effect comes from India's jewelry industry. Recently, the U.S. has lifted its 5.7% tariff on the imports of finished jewelry from India. The small increase in the export price available in India should cause only a miniscule reduction in the U.S. price of diamonds and the wages of U.S. diamond workers. However, even this slight change will bring magnified effects to India. India's jewelry exports to the U.S. are now likely to double over the next two years to about $1.2 billion. Greater effects are occurring at the worker's level, and increased productivity often brings higher wages. The increased potential value created by slightly higher prices has encouraged some India-based jewelers to move their high-value operations from Mexico and New York to India where the labor is cheaper:

> As recently as a year ago, the 15,000 factory hands … [worked] with tiny gems and small, inexpensive settings, which required little skill and didn't add much profit to the factory owners' bottom line. Now, they're working with larger stones, creating more complex settings, using newer equipment—and pumping up the industry's profits. … "Finally, it has become economical to do it out of India," says Amar Kothari, Intergold's sales director in Bombay. [11]

These results are entirely consistent with the predicted effects of the magnification effect. In India, where labor is abundant, the magnification effect states that: $\%\Delta W > 5.7\% > \%\Delta P_K > \%\Delta r$. Therefore, wages paid to diamond workers in India should increase by more than 5.7% in the long term. Conversely, in the U.S. where capital is abundant, the magnification effect states that $\%\Delta r > \%\Delta P_K > -5.7\% > \%\Delta W$. Therefore, wages paid to diamond workers in the U.S. should decrease by less than 5.7%.

**The Rybczynski Theorem**

In order to understand issues relating to immigration of highly skilled knowledge workers and inflows of capital investment, I will use the Rybczynski theorem. This theorem provides a strong foundation for analyzing the change in one country's factor endowment, assuming full employment of factors and holding all other variables constant. It is an effective means of studying migration and capital investment within the Heckscher-Ohlin model. The Rybczynski theorem states that if a country's factor endowment of labor (for example) increases, the country will produce more of the labor-intensive good and produce less of the capital-intensive good. This occurs because the country becomes more labor abundant, and therefore is more competitive when it produces more labor-intensive goods.

This theorem can be applied not only to physical changes in the factor endowments (increases in population, changes in capital investment) but also to the increasing possibility of factor utilization. For example, India's population is mostly comprised of unskilled laborers. However, India's strong secondary educational system produces a significant number of highly skilled technical workers. If these workers are unable to find skilled work or immigrate to the United States (or anywhere where their skills are better utilized), India may be suffering from a masked unemployment. It is easy to see this masked unemployment in the previous jewelry example. If a worker possesses extensive human capital, such as a PhD, it is inefficient for them to be working in an unskilled position where their human capital is simply wasted. If changes in infrastructure or immigration laws enable these skilled workers to find work, then it is likely that India will begin producing more skill-intensive goods. This change will occur regardless of whether newly hired knowledge workers are employed by domestic Indian firms or U.S.-based multi-nationals.

**The Distributive Effects of the Heckscher-Ohlin Model**

In the Heckscher-Ohlin model, there are two types of activity: earning income from selling labor (workers), and earning income from renting capital (capitalists). We can determine the effects of trade on real incomes by analyzing the trade flow that would result from a shift from autarky to free trade between two countries. Suppose country X is abundant in labor; country Y is abundant in capital; good X is labor intensive; and good Y is capital intensive. In autarky, each country must produce enough of each good to satisfy their domestic demand. Workers in country Y, where capital is abundant, are better off in autarky because they are relatively scarce in country Y and because an isolationist policy protects them from the large labor supply in country X. Incidentally, capitalists in country X are also better off, because they are protected from a large capital supply in country Y. Capitalists in country Y and laborers in country X are worse off in autarky, because there is a large supply of their factor but relatively limited demand for it.

I will define the wages of laborers and capitalists as follows: $W_X$ for country X laborers, $r_X$ for country X capitalists, and $W_Y$ and $r_Y$ for country Y laborers and capitalists respectively. If country X and country Y begin to trade, due to changes in trade policy, trading costs, or technology, then $\frac{r_Y}{W_Y}$ in country Y and $\frac{W_X}{r_X}$ in country X both rise. This occurs because $r_Y$ and $W_X$ are increasing and $W_Y$ and $r_X$ are decreasing simultaneously due to trade. An increase in $\frac{r_Y}{W_Y}$ in country Y implies that $r_Y$ is increasing at a faster rate than $W_Y$. We can analyze the effect of these changes on laborers and capitalists in country Y by using the magnification effect described earlier: $\%\Delta r > \%\Delta P_K > \%\Delta P_L > \%\Delta W$. Therefore, the real $r_Y$ increases because $\frac{P_{YK}}{P_{GK}}$ and $\frac{P_{YK}}{P_{GL}}$ are increasing. Furthermore, the real $W_Y$ decreases because $\frac{P_{YL}}{P_{GK}}$ and $\frac{P_{YL}}{P_{GL}}$ are decreasing. Ultimately, laborers in a capital-intensive country do worse (because their real wage decreases) and capitalists in a capital-intensive country do better (because their real wage increases) because of free trade. In a sense, workers in the capital-intensive country now must compete with laborers in the labor-abundant country.

We can also apply this effect to exportable services, which typically utilize skilled workers because most exportable services are based in information and human capital. Two effects occur simultaneously: skilled workers abroad, previously working in unskilled jobs (masked unemployment), are increasingly finding jobs that utilize their skills. America's ability to utilize these skilled workers is increasing due to changes in technology that enable trade. For example, only the most recent advances in telecommunications technology and excess telecommunications capacity have enabled the development of foreign call centers for domestic companies.

The changes in technology, then, have reduced the barriers to trade in services in the same way that new cargo ships reduced the barriers to trading of manufactured goods. The United States is relatively abundant in skilled labor in comparison to unskilled labor. Most of the foreign countries where this change is taking place are less developed and abundant in unskilled labor.

It would seem that the skilled workers in the United States would therefore be *better* off as a result from trade. But this assumes a type of bilateral trade. For instance, it assumes that India will import more skilled-worker-intensive goods from the United States and export more unskilled-worker-intensive goods to the United States. This has already occurred—the United States has been exporting manufactured goods to India in exchange for agricultural goods for decades. What, then, is the difference between the impact between manufactured goods and service goods?

First, migration. It is certainly true that the immigration of skilled workers to the United States has increased the number of people in the U.S skilled labor force in the affected fields. Additional entrants into the dot-com labor market may have lowered already inflated wages. For example, during the dot-com era, thousands of skilled knowledge workers with H-1B visas migrated to Silicon Valley to take advantage of a seemingly insatiable demand for their skilled labor (Figure 6). Most of these H-1B workers migrated from India and China to participate in computer science employment. Of the 136,787 H-1B admissions in FY2000, 74,551 migrants were entering "computer-related" industries. Of those, 50,827 and 5,275 were from India and China respectively.

Ultimately, however, there can be no comparison between the foreign worker performing a task in the United States, and the same foreign worker performing the same task abroad both in terms of price and quality implications. For example, call center employees in Bombay earn about $12,500 per year. In a country where forty percent of the population earns less than one dollar per day, the call center employee's salary is a small fortune. Employee morale and motivation is quite high—skilled employees work in what would otherwise be an unskilled job because they see a great deal of potential for education (such as improving their English skills), growth, and mobility. In fact, thanks to relatively high pay and the opportunity for growth, many Indian call centers are capable of attracting extremely skilled employees for a relatively unskilled position.

On the other hand, the U.S. call center is typically regarded as a dead-end job; a $12,500 salary approximates the minimum wage. In India, however, $12,500 is a small fortune. There is a marked difference in the CPI between the United States and India. The current CPI in India as of Nov. 2002 (1982=100) is 489 overall, and 460 in Bangalore.[12] The current CPI in the U.S. as of Feb. 2003 (1982-1984=100) is 183.3. As of Feb. 2003, the nominal exchange rate between India and the U.S. is 47.75 rupees to the dollar. To convert from nominal exchange rate to real exchange rate, one would calculate

$\dfrac{\frac{\text{Rs}}{\text{US\$}} * \text{CPI}_{\text{US}}}{\text{CPI}_{\text{INDIA}}}$ or $\dfrac{47.75 * 183.3}{489}$ to get a value of ~17.889. This means that one dollar in India will purchase about 18 times the relative quantity of "market basket" in India. Therefore, a wage of $12,500 in India is roughly similar to a $223,613 wage in the U.S, and is approximately 10,677,520 rupees per year. In a nation where approximately 25% of the population lives on less than 17,400 rupees per year (2002 estimate), these wages are extremely attractive.[13]

**Empirical Research**

The paper "Forecasting U.S. Trade in Services" by Robert Stern et al. constructed an econometric forecasting model for the U.S. trade in services based on data and forecasts of the U.S. economy produced at the Research Seminar in Quantitative Economics at the University of Michigan.[14] It provided a calculated table of estimated elasticities for cost, income, and relative price variables on four types of services: travel, passenger fares, transportation, and other services. Based on this elasticity data, it was possible to construct a reasonable forecast of the U.S. balance of trade for a variety of service types. In general, Stern predicted a slight decrease in the nominal balance of service trade between 1999 and 2000, and a slight increase between 2000 and 2001. The actual balance of services has decreased steadily since 1999, excepting 3rd quarter 2001 (Figure 7).

I had hoped to provide a similar econometric model using knowledge-worker related data. Unfortunately, the disaggregated service data necessary to run such a regression was unavailable. Instead, I chose to run regressions based on services in general to analyze some of the greater macroeconomic implications following Stern, et al. Stern et al. mention running a regression on the price and quantity of imports and exports of total services, but did not publish the results. Data was compiled at great lengths from a number of sources, including OECD's "Main Economic Indicators"[15] and Economagic[10]. I chose 1st quarter 1981 as my starting point because it provided the best balance between data availability and foreign country selection, ultimately providing a total of 85 samples.

Ultimately, I ran the following four regressions using a double-logged functional form (to create constant elasticities):

1. Price of U.S. Exports: $p^X = S^X (c^U)$
2. Quantity of U.S. Exports: $q^X = D^X (I^W, E^X)$
3. Price of U.S. Imports: $p^M = S^M (c^W)$
4. Quantity of U.S. Imports: $q^M = D^M (I^U , E^M)$

Equation 1 describes the price of U.S. exports $p^X$ as a function of the U.S. consumer price index for all items as a proxy for the costs of services production.

Because services are labor intensive, the CPI is a good indicator of wage costs $C^U$ (following the short- and long-term adjustment mechanisms of the basic AS/AD model). $S^X$ represents the supply-price function. In theory, this equation is a reasonable measure of the price of U.S. exports, because it calculates the price of our service exports based on the major cost related to its production (wages via CPI).

Equation 2 describes the quantity of U.S. exports $q^X$ as a function of foreign income measured in U.S. dollars $I^W$ and the price-adjusted real exchange rate $E^{X,}$ which factors the real exchange rate, the domestic CPI, and the average foreign CPI as $\frac{e^{\$} \cdot p^X}{p^W}$. I calculated real foreign income and CPI using data for Great Britain (as a proxy for Europe), Japan (as a proxy for East Asia), and Canada (our largest trading partner). For the ease of comparisons, I converted each country's GDP from its native base year to a 1995 base year using that country's GDP implicit price deflator (or CPI when the GDP deflator was not available). A basic demand function incorporates both income and price. Because this function measures both foreign income and the foreign price of U.S. exports, it is a reasonable model for the foreign demand of U.S. exports.

Equations 3 and 4 are similar to 1 and 2. Equation 3 describes the price of U.S. imports $p^M$ as a function of $c^W$, the average foreign CPI (of Great Britain, Japan, and Canada). $S^M$ represents the supply-price function. Again, this is reasonable because it measures the cost of foreign production of services (again, CPI is a reasonable measure of wage costs).

Equation 4 describes the quantity of U.S. imports $q^M$ as a function of U.S. income measured in dollars $I^U$ and the inverse price adjusted real exchange rate $E^M$: real exchange rate, the domestic CPI, and the average foreign CPI for calculated as $\frac{p^W}{e^\$ \cdot p^X}$. This is reasonable because it measures U.S. income versus the U.S. dollar cost of imports.

I used a simplified version of Stern's error-correction model for time series. This model uses the double-logged form as follows: $\Delta ln y_t = \square a_0 + a_2 a_1 \Delta ln x_t + \square a_1 ln x_{t-1} - \square ln y_{t-1} + \square$. This functional form has several important effects. It is worth noting that I failed to reject the null hypothesis that $\square$=0 for each of my variables at the 90% or 95% confidence level using the Dickey-Fuller critical t-statistic ($t_c = -2.57$ and $t_c = -2.93$, respectively), implying that each variable had a unit root (see the "Regression Results" appendix for details). In the short run, there may be some variation in the relationship between the variables. However, over the long run, the relationship between the two variables should be reasonably consistent, and I hypothesized that the dependent variables and the independent variables were co-integrated. This error-correction model attempts to compensate for the short-term variation in the relationship between the dependent and independent variables by adding a lagged logged dependent variable as an independent variable, namely $\square ln y_{t-1}$. The coefficient of this term is negative. As a result, if an observation of $y_t$ is significantly different from the expected long-run baseline, the next period will have a significant negative term that will explain the trend of the dependent back to its long-run equilibrium relationship.

Running a regression based on this basic error-correction model gives us two valuable estimated elasticities for each independent variable: the long-run elasticity and the short-run elasticity. We can obtain the short-run elasticity of the independent variable simply by obtaining the matched coefficient $\square a_1$. I calculated the long-run elasticity of the independent variable by dividing □$a_1$ by the absolute value of □, or $\frac{□a_1}{|□|}$, to obtain an isolated $a_1$. In theory, □ must be negative and is typically less than 1 in absolute value. The absolute value of □ is also an indicator of the speed of adjustment of the dependent variable back to its equilibrium relationship with its independent variables. A high $|□|$ would imply a short adjustment period. A $|□|$ greater than one would imply some type of unusual over-correction. As a result, the isolated long-run elasticity of a given independent variable will be larger and in the same direction as the short-run elasticity of the same variable. Because we expect the change of an independent variable to have a small short-run effect and a larger long-run effect, the results of this model are consistent with our hypotheses.

I ran the regressions for equations 1 through 4 using Microsoft Excel X. I have included the results of the regressions in an appendix. The overall significance of my regression equations were quite low, with $R^2$ values ranging from 0.019 to 0.286 and $\bar{R}^2$ values ranging from –0.016 to 0.260. F-test values ranged from 0.544 to 10.842. None of the □ t-scores were significant. I believe this problem may have resulted because of some data formatting issues. Only seasonally-adjusted data for U.S. imports and exports were available, however, the remainder of my data are not seasonally-adjusted. This may have affected the overall fits of the equations but should not have affected their theore

The expected long- and short-run elasticities are as follows:

| | Quantity Equations | | | | Price Equations | |
|---|---|---|---|---|---|---|
| | Income | | Relative Price | | Cost | |
| | Short-Run | Long-Run | Short-Run | Long-Run | Short-Run | Long-Run |
| Imports | 0.16740151 | 1.384835657 | -0.02909908 | -0.240723298 | 0.10453382 | 0.886197885 |
| Exports | 0.10118942 | 1.240242427 | 0.04626781 | 0.567087952 | 0.03215103 | 0.61328136 |

The estimated equations are as follows (standard errors in parentheses):

1. $p^{X}{}_{\%\square} = 0.090 + \underset{(0.035)}{0.032}\ln c^{U}{}_{t\square 1} + \underset{(0.190)}{0.727}c^{U}{}_{\%\square}\ \square\underset{(0.045)}{0.052}\ln p^{X}{}_{t\square 1}$

2. $q^{X}{}_{\%\square} = \square 0.930 + \underset{(0.065)}{0.101}\ln I^{W}{}_{t\square 1} + \underset{(0.159)}{0.214}I^{W}{}_{\%\square} + \underset{(0.067)}{0.046}\ln E^{X}{}_{t\square 1} + \underset{(0.222)}{0.158}E^{X}{}_{\%\square}$
$\square\underset{(0.042)}{0.082}\ln q^{X}{}_{t\square 1}$

3. $p^{M}{}_{\%\square} = 0.059 + \underset{(0.083)}{0.105}\ln c^{W}{}_{t\square 1} + \underset{(1.278)}{0.626}c^{W}{}_{\%\square}\ \square\underset{(0.094)}{0.118}\ln p^{M}{}_{t\square 1}$

4. $q^{M}{}_{\%\square} = \square 1.982 + \underset{(0.115)}{0.167}\ln I^{U}{}_{t\square 1} + \underset{(0.690)}{1.498}I^{U}{}_{\%\square}\ \square\underset{(0.040)}{0.029}\ln E^{M}{}_{t\square 1}\ \square\underset{(0.157)}{0.020}E^{M}{}_{\%\square}$
$\square\underset{(0.091)}{0.120}\ln q^{M}{}_{t\square 1}$

The isolated □ observations are as follows:

| | Quantity | Price |
|---|---|---|
| Imports | -0.12088186 | -0.11795765 |
| Exports | -0.08158842 | -0.0524246 |

The expected long- and short-run elasticities are as follows:

| | Quantity Equations | | | | Price Equations | |
|---|---|---|---|---|---|---|
| | Income | | Relative Price | | Cost | |
| | Short-Run | Long-Run | Short-Run | Long-Run | Short-Run | Long-Run |
| Imports | 0.16740151 | 1.384835657 | -0.02909908 | -0.240723298 | 0.10453382 | 0.886197885 |
| Exports | 0.10118942 | 1.240242427 | 0.04626781 | 0.567087952 | 0.03215103 | 0.61328136 |

It is possible to obtain a number of interesting comparative observations from these results. However, one regression result is particularly surprising. In equation 4, the coefficients of relative price $E^M$ are negative, which is consistent with theory: as the relative price of foreign service goods decreases, we will import more foreign service goods. One might also expect the coefficients of $E^X$ to also be negative; after all, $E^X$ is the reciprocal of $E^M$, meaning that as $E^X$ rises, $E^M$ must fall. Empirically, as foreign products become relatively cheaper, U.S. firms become relatively more expensive. However, the coefficients of $E^X$ in equation 2 are positive but not significant. I would expect a different result with better data.

The values for □ are somewhat surprising. Recall that the □ value indicates the speed of adjustment of the dependent variable back to its equilibrium relationship with its independent variables. We can calculate $\frac{1}{|\square|}$ to obtain the number of periods (quarterly in this case) that it would take for a dependent variable to return to equilibrium:

| | Quantity | Price |
|---|---|---|
| Imports | 8.272539817 | 8.477618874 |
| Exports | 12.25664132 | 19.0750144 |

One can make three noteworthy observations from these figures. First, the quantity adjustment periods are unsurprising: these figures imply that the long-term adjustment process of the dependent variable requires between 25 and 37 months. Due to the length and complexity of many contracts, it seems reasonable that there may be a delay in equalization. Second, both the absolute and relative length of the price adjustment periods are surprising. It seems strange that it would require more time for prices (which are principally determined by the real exchange) than for quantity to equilibrate. It is also quite strange that the long-term price adjustment process for exports is significantly longer than the import process. Finally, it seems strange that it would require nearly five years for export prices to return to a long-run equilibrium after any rapid change in U.S. service costs.

Each short-run elasticity value is smaller than its long-run counterpart, which makes sense because prices and quantities are less elastic in the short run and more elastic in the long-run. Of note, the U.S. imports of foreign services were substantially less sensitive to relative prices in the long run when compared to U.S. exports. This is not particularly surprising, as foreign countries have choice in their selection of imports. It is also interesting to note that the long-run elasticity of cost for the price function is higher for imports than in exports. This supports the magnification effect: a slight change in the cost of a service good in a labor-abundant country (as are most foreign countries in comparison to the U.S.) will have a larger effect on the price of the labor-intensive good than would be expected in the U.S.

**Review of Current Policy**

The only current policy that affects the high-technology industries' labor supply is the H-1B visa program. The H-1B visa program permits foreign nationals to work within the U.S. in certain key industries, largely coinciding with the skill areas that I believe will undergo the greatest labor changes in the next decade.

**H-1B Visas**

An H-1B visa is a nonimmigrant entry permit widely used for the temporary employment of skilled foreign nationals in certain specialty occupations. H-1B visas are for use only in an occupation "which requires the theoretical and practical application of a body of highly specialized knowledge requiring the attainment of a Bachelor's or higher degree as a minimum for entry into the occupation."[16] Therefore, H-1B visas may be a valuable proxy with which to investigate changing U.S. policies and attitudes towards foreign knowledge workers. The H-1B visa program originated from the 1990 Immigration Act, which permitted up to 65,000 new H-1B workers per year. This is called the "visa cap." In September 1997, the H-1B visa cap was met for the first time, forcing the INS to suspend new applications for the remainder of the 1997 fiscal year. Clever accounting enabled the INS to authorize many of the rejected 1997 visa applications in 1998. The continuing and extreme shortage of information technology professionals in 1997 and 1998 encouraged Congressional legislation that increased the INS cap to from 65,000 to 195,000 visas per year until 2003. The cap will fall back to 65,000 in 2004 absent additional legislation. A proposal to permanently increase the H1-B visa cap to 195,000 is expected in Congress in 2003, although the demand for H-1B visas has dropped dramatically since 2001. WTO agreements prevent the U.S. government from lowering the cap below 65,000.

H-1B visas are for temporary work only. The visas expire after three years, although the employee and employer may renew the visa for an additional three years. H-1B visas are generally employer-specific. However, changes during the late 1990’s makes it quite simple for existing H-1B visa holders to migrate to new employers. New regulations permit foreign nationals to retain their visa status by allowing them to join a new firm as soon as the firm submits the new H-1B petition. Furthermore, while Congress intended H-1B visas only for the temporary employment of foreign nationals, most H-1B visa holders intend to secure permanent residence, and they are typically successful. The H-1B visa program bears a number of characteristics designed to protect the U.S. knowledge worker. The employer must submit a “Labor Condition Application” (LCA) with the H-1B visa application that ensures that the use of H-1B labor is necessary and will not affect the jobs or wages of U.S. workers. Of the five major conditions, four are particularly relevant:

1. That the H-1B employee will be paid the prevailing industry wage or the actual wage at the place of employment, whichever is higher,

2. That the H-1B employee will be paid for nonproductive time and will enjoy the same benefits and privileges as other employees in his or her position,
3. That the working conditions of other employees within the firm will not be adversely affected by the employment of the H-1B employee, and,
4. That there is no strike or similar event occurring at the H-1B employee's planned place of employment.

Many labor advocates argue that despite these numerous regulations, there are abundant loopholes. Many domestic high tech employees feel that they have been unable to secure jobs due to the availability of H-1B workers. For example, Walter Kruz, a 52-year-old former employee of Sun Microsystems Inc., filed a lawsuit on March 17th, 2003 in the state of California alleging that Sun was significantly biased towards hiring H-1B visa labor. He contends that Sun laid off nearly 2,500 employees (very few of whom were of foreign descent) and concurrently submitted 2,400 visa applications. It is uncertain whether Kruz will be successful; Guy Santiglia, a former Sun Microsystems systems administrator, filed discrimination complaints with the Department of Justice, Department of Labor, and the U.S. Equal Employment Opportunity Commission, who ruled "Sun's use of the H-1B program was appropriate."[17]

Yet, despite the controversy surrounding the H-1B program, it is becoming less of an issue. Even if the visa cap were to remain at 195,000, there has been a significant decrease in demand between 2001 and 2002, and the trend appears to be continuing. In 2001, the INS issued 163,000 standard visas and 342,000 "exempt" (for educational or non-profit institutions, etc). Those numbers decreased to 79,100 and 215,000 respectively in 2002.[18] Estimates for the number of H-1B workers currently in the U.S. range from

500,000 to 1,000,000, although the true figure is most likely near the low end of the range. Many H-1B workers have returned home after the high-technology “bubble” burst. Facing increasing competition and tightening budget constraints, firms are looking to reduce labor costs, and they are seeking foreign labor. H-1B labor was attractive to firms despite its protectionist aspects because there were enough loopholes to save firms upwards of 30% on their labor costs. Foreign labor wage savings of 50-95% are common, without the risk of lawsuits.

While many labor advocates still consider the H-1B visa to be a major source of unemployment for U.S. knowledge workers, it is trivial compared with increasing globalization. U.S. companies are no longer looking for inexpensive foreign labor within the U.S. when similar labor is available to work overseas for even lower wages and with a reduced risk of lawsuits. Labor advocates will need to champion other new policies to protect the interests of knowledge workers.

**Policy Recommendations**

I will analyze the policy implications from three different perspectives: the U.S. knowledge worker, the U.S. knowledge-oriented firm, and the U.S. consumer including other firms that use these products as intermediaries.

**Needs of the U.S. Knowledge Worker**

U.S. knowledge workers, including chemists, programmers, accountants, and other skilled laborers, clearly would like to retain their jobs and maintain their high salaries. After all, many of these workers have spent several years earning post-secondary degrees, including masters and PhDs, and owe thousands of dollars of educational loans. The vast majority of U.S. knowledge workers are not unionized. To protect the interests of these employees, any change in policy must target one or more of the following: command and control, market forces, or acceptance and education.

In the first case, command and control, one could postulate regulations to prevent an U.S. firm from hiring foreign workers or firms, or to limit how much money the domestic branch can send abroad to their multinational partners. In theory, the H-1B visa program attempted to protect knowledge workers limiting the number of foreign workers that could enter knowledge-based firms in the U.S. to 65,000 per year. Unfortunately, the INS repeatedly breached this cap thanks to clever accounting practices (by some reports aided by KPNG, a major employer of H-1B labor) and constant lobbying by U.S. knowledge firms demanding skilled labor. Whatever the H-1B visa limits turned out to be, actually enforcing those limits was straightforward: the majority of H-1B workers entered the country through airports, where it is easy to confirm identity and visa possession.

However, it is no easy matter to restrict overseas hiring. U.S. multinational firms can hire foreign workers both directly and indirectly, using foreign consulting firms (sometimes called “body shops”) and other ploys. Any limits would be virtually impossible to enforce. It would be even harder to reliably limit the flow of the services “product,” which is often technical knowledge that is easily transfered across the globe in a matter of seconds. An alternative is preventing the transfer of money abroad and limiting the flow of capital. For example, one could limit the total value of net foreign investment of any particular knowledge-based firm to a small percentage of their total revenue. However, this too would be quite difficult to enforce. Furthermore, this may violate WTO restrictions and cause retaliation by other countries.

Another option is to limit the net benefits of hiring foreign workers to less than those of domestic workers by placing an artificial price floor on the service good. Many U.S. industries enjoy protectionist tariffs that raise the price of foreign imports relative to similar U.S. goods. However, as with command and control, any efforts to tax either foreign labor, trade of services, or the trade of related capital would be quite difficult to enforce: there is no reliable means of measuring the use of foreign labor or the import of service goods.

Neither command and control nor taxation will genuinely help U.S. knowledge workers in the long-term, just as very few protectionist polices truly assisted the U.S. manufacturing. In the face of increasing competition from abroad, the demand for U.S. knowledge workers is dropping (Figure 8). Productivity in India, China, and other countries is rising rapidly. However, U.S. knowledge workers have one relative advantage over their foreign competition. Many foreign professionals have extensive educational experience, often surpassing those of their U.S. counterparts. However, because of foreign underemployment, many do not possess extensive the extensive on-the-job experience that is common among the seasoned U.S. knowledge workers affected by globalization. Therefore, it is advisable that U.S. knowledge workers utilize their relative advantage in concert with their knowledge of U.S. business and integrative skills to find new areas within their existing industries where they may be even more productive.

The question is, how to do this.

Speaking at the September 2002 Brainstorm Group Inc.'s Nearshore and Offshore Outsourcing conference, a number of panelists asserted that many of the basic technology jobs have been "commoditized," implying that a job that once earned $100 an hour can now pays only $20 to $25 per hour abroad. They recognize, however, that many of these workers have extensive skills beyond their programming ability, and recommended that workers who are under pressure from either H-1B or foreign labor attempt to:

- *Seek* to establish a position in IT as a technology liaison to a business unit.
- *Become* a planner or an organizer of conceptual projects within an IT organization.
- *Leverage* existing communications and technical skills to help integrate e-business and other business process applications throughout an organization.[19]

To anyone who has worked as an animator in the past twenty years, what is happening within much of the knowledge services industry would seem like a repetition of history. It is well-known that increasingly over the past fifteen years, animators in Eastern Europe and East Asia have drawn a steadily increasing percentage of animation frames, or 'cels' (originally a reference to celluloid), for U.S. television-based animations, as well as some feature-length films. By some estimates, over 90% of frames for today's U.S. television animations are drawn abroad. During the shift in how animations were produced, a number of less skilled animators lost their employment to cheaper, foreign animators. The remaining animators perform three functions: story-boarding, drawing key frames, and correcting mistakes in foreign animators' production.

The parallels between animation and the current shift in knowledge services are remarkable. The cost of sending animation frames from abroad to the U.S. has dropped dramatically over the past fifteen years, especially now that a large number of frames are digitally rendered from the beginning or converted into a digital format before export.

Successful U.S. animators have become liaisons between their U.S. managers and their foreign counterparts. They are planners of projects in the sense that they draw key frames, the animation equivalent of a blueprint or project requirements document. And they leverage their skills to perform a quality assurance function. The total U.S. employment of animators has decreased, but real wages have remained constant or even increased because their job functions have changed and their productivity has only improved.

Rapidly declining transaction costs are effectively lowering the cost of using foreign labor, and as a result, many U.S. service workers are suddenly becoming more relatively expensive (and therefore less productive) compared to their foreign counterparts. However, I believe that successful workers will migrate their skills to equally or more productive functions. Unsuccessful workers will lose their employment within the particular industry and migrate to other industries, possibly those that are less subject to export. Empirical evidence supports that high employment does not mean higher wages: for computer and data processing services, the short-run simple correlation coefficient between wages and employment is high (r=-0.796) but in an unexpected direction. I also compensated for short-term fluctuations that may artificially increase the correlation between wages by calculating annual averages for my monthly data, and was surprised to find a slightly higher correlation (r=-0.807) (Figure 9).

**Needs of the U.S. Knowledge Firm**

In order to stay competitive with foreign firms—including those in developed countries—the U.S. knowledge firm must utilize the factors in its production that provide the greatest return on investment. For the firm to do so, policy must permit the firm to consider every possible source of labor without substantial restrictions. Furthermore, policy should act progressively to enable the U.S. firm to compete and produce in a variety of markets.

One of the major areas of current discussion is intellectual property law. Content and software have become extremely important and strategic sources of U.S. GDP. The U.S. is home to some of the strictest patent and copyright regulations in the world, including the stringent (some would say draconian) Digital Millennium Copyright Act. Media conglomerates and representatives, including the Motion Picture Association of America, championed many of these laws. However, bootlegged videos are abundant in Hong Kong. Pirated software is absolutely rampant in Israel, where Microsoft Windows 2000 was sold at bus stops in homemade packaging for about $25, a fraction of the legal software's price.[20] India and China possess very few intellectual property laws. Because the service product is often an intangible bit of knowledge or code, it is quite easy for foreign employees to illicitly transfer the product to other firms or individuals without permission or cost. This has led to passionate debate. For example, one of the major outsourced knowledge services is biotechnology (such as the design of new drugs and vaccines). Developing a suitable vaccine or treatment for AIDS will cost billions of dollars, which firms hope to recuperate by selling their product. Many research firms would like to do some of this research abroad, where the labor is less expensive. The global AIDS epidemic, however, affects low-income countries the most—where intellectual property laws are lax. It is no surprise that many foreign governments express an interest in assisting with AIDS research yet acknowledge that they would be quite unlikely to honor related patents.

Many U.S. firms are working diligently to promote intellectual property rights abroad, both to increase sales (by limiting content piracy) and to foster new sources of inexpensive labor. Former Microsoft C.E.O. Bill Gates announced in November 2002 that Microsoft and the philanthropic Bill and Melinda Gates Foundation would invest $500 million in India over the next three years. Of that $500 million, $400 million will be spent expanding its operations, increasing computer literacy, encouraging telecommunications capacity growth, and bolstering intellectual property laws. The other $100 million will be spent on AIDS research. But, the foundation's philanthropy may be a paper-thin veil; Microsoft has made it explicitly clear that it wants effective intellectual property laws and is willing to pay dearly for it, especially if it has a better chance of gaining monopoly powers through favorable policy.

Ultimately, U.S. firms have a significant stake in the development of robust intellectual property laws. Without them, it will be difficult for firms to effectively utilize foreign knowledge workers because they will be unable to protect their product from dissemination to competitors. However, U.S. firms should not be the sole source of pressure for change in foreign policies because they may encourage the growth of either prohibitively draconian or monopoly-favoring intellectual property laws. Therefore, to optimally serve the needs of the U.S. firm, domestic officials should take a laissez-faire approach to labor and service trade policies but work actively to promote the development of equitable intellectual property regulations abroad.

**Needs of the U.S. Consumer**

U.S. consumers, including both individuals and firms as consumers of intermediate products, need a market that operates smoothly and delivers a wide variety of low-cost goods. Indeed, a balance must exist between the needs of the worker and the needs of the firm to create a atmosphere that is amenable to U.S. society as a whole. The U.S. consumer, therefore, needs two approaches to policy: gradualism and effective adaptation.

It is easier for individuals and firms to adjust to change if there is a delay between the onset of a condition and its full effects. The change in the employment of U.S. knowledge workers has been quite abrupt except within a few unique firms such as Boeing. The ever-increasingly rapid advances in technology have taken the Internet industry on a roller coaster of changes from nascence in the early 1990's, to the industry's electrifying zenith in 1999, and to a humiliating aftermath in 2000 and beyond. These rapid changes occurred faster than the industries could realistically adapt, causing an unmet demand for labor and hyper-inflated wages in 1999 and high unemployment in 2000 and beyond. Those hyper-inflated wages encouraged thousands of people to migrate to Silicon Valley and begin high-tech careers or begin study in technical majors. Both activities had long-term implications based on what turned out to be short-term returns. In addition, firms are struggling to adapt with new processes and international competition. Although a contributing factor, labor issues did not cause the downturn in the high technology sector, but ultimately the downturn affects all workers and firms involved. It is for these reasons that a gradualist policy towards the international trade of knowledge services would be useful.

For the betterment of the entire society, knowledge workers need encouragement and assistance to capitalize on their work experience and migrate to liaison or management positions in which they are more productive. However, there should be no attempts to artificially protect their industries from international competition in the long term. Many of these service goods are intermediary goods, meaning that they are not used by the final consumer but in the production of other goods. For example, customer relationship management and enterprise resource planning are two intensely growing areas in the international service sector. Service providers and manufacturers use these applications primarily as a value-added component for future goods. Artificially inflating the prices of these key service goods will artificially raise all other prices. Protecting the jobs of U.S. knowledge workers will have far-reaching effects through higher prices and costs, making U.S. firms less competitive relative to foreign firms. Ultimately, attempting to protect the jobs of knowledge workers may result in the loss of many more jobs in other industries. Therefore, the U.S. consumer must not accept policies that will attempt to keep U.S. knowledge workers employed in their current job functions at their current wages. The only policy that will truly help the U.S. knowledge worker and respects the needs of the U.S. consumer is one that provides educational and vocational assistance to America's knowledge workers.

**Conclusion**

In this paper, I provided several broad sources of information to address my topic: background, economic theory, original empirical research, and policy recommendations. I will provide a brief conclusion for each, then summarize my findings.

A number of less-developed countries have taken advantage of recent advances in communications technology that has brought remarkable change and economic growth to entire regions. Thanks to their relatively low cost, cellular telecommunication services have become more common than land-line phones in over two-dozen countries. The

Indian state of Bangalore has undergone an incredible transformation from relative rural impoverishment to becoming a center of high-tech knowledge services. U.S. firms are capitalizing on highly skilled overseas workers, especially in India and China, who perform services based on concepts and knowledge at wages far below those of their equally skilled U.S. counterparts. These “knowledge workers” are members of a new type of labor force first described merely fifty years ago by Peter Drucker.

The new trade in knowledge services is both similar and different from previous trade developments. The U.S. workers that it may displace are mobile and have often invested several years and thousands of dollars in the pursuit of their skills. Unlike the trade of manufacturing, transaction costs are rapidly approaching zero. This means that the “price wedge” that separates the price that U.S. firms are willing to pay and the price that foreign firms receive is decreasing and will become quite small. Furthermore, unlike manufacturing, the trade of services is much more sensitive to differences in consumer price levels because it is labor intensive.

I introduced several economic models that relate best to the U.S. trade in services: the Heckscher-Ohlin Model, the Stolper-Samuelson Theorem, the magnification effect, the Rybczynski Theorem, and the distributive effects of the Heckscher-Ohlin Model. For each of these models I demonstrated its relevance to my topic by utilizing a related empirical example to show the implications of the model. Ultimately, each model provides a representation of international markets in equilibrium. I demonstrate that as the conditions and factors of trade move closer to the stated assumptions of each model, the predicted results of each model appear. For the Heckscher-Ohlin model, we have seen that as transaction costs continue to decrease and intellectual property laws permit the foreign development of knowledge products, the prices of goods, services, wages, and capital rents between two countries will equilibrate. For the Stolper-Samuelson Theorem and the magnification effect, I demonstrated that a large increase in wages in LDCs entering into the service trade would have a minor effect on domestic wages. For the Rybczynski Theorem, I demonstrated how changes in a country's factor endowments and productivity would affect how much of each type of good the country produces. Finally, I illustrated some of the potential distributive effects of the Heckscher-Ohlin model and showed that there may be some downward pressure on U.S. service worker wages.

The models, taken as a summation, provide a number of insights into my topic. First, as technology and policy begin to permit near-zero transaction costs and safe trade of intellectual property, we should expect to see increased trade in services. With this increased trade, countries will move from autarky, and the prices of service goods will come quite close to—but not equal to—each other. Because U.S. service workers are competing with foreign service workers, it would seem that there would be pressure for wages to also equilibrate. However, this makes the inappropriate assumption that U.S. knowledge workers will continue to earn wages by performing the identical job function. In reality, U.S. knowledge workers will make slight shifts in their job duties. Using animators as an example, I have shown that some U.S. knowledge workers will successfully migrate to a position as supervisors and liaisons for their foreign counterparts. Successful knowledge workers will act as project planners, technology liaisons, and quality assurance specialists. In a sense, successful knowledge workers will become *meta-knowledge workers*, who no longer actually manipulate information themselves, but instead facilitate its manipulation by foreign workers. Unsuccessful knowledge workers will lose their employment and migrate to other industries. Total U.S. employment of knowledge workers *will* decrease, but less than would be predicted by the models because of worker adaptability. I do *not* expect wages to decrease—consistent with the models—because productivity is still increasing and workers are typically paid based on their marginal productivity plus an efficiency wage bonus. Furthermore, the price of labor may not equalize between two countries with different costs of living, because the efficiency wage necessary to ensure full productivity between a LDC and a MDC are quite different. For example, the absolute minimum wage in the U.S. is an extremely attractive wage in India because of the wide disparity in the cost of living.

We can expect many of these employment effects to also occur at the corporate level as well—successful U.S. firms will capitalize on their unique connections to foreign countries and communications capabilities to effectively compete in an increasingly global market place.

Internationally, especially in India and China, I expect the increased trade in services to be a harbinger of and mechanism for increased growth and well-being. There is an enormous opportunity for LDCs to capitalize on a large source of trade that is relatively high-profit, progressive (as opposed to manufacturing or "sweat shops"), and friendlier on the environment. Futhermore, the increased opportunity for employment of skilled workers abroad will raise the expected benefits of education and encourage increased public and private domestic investment in education, a major factor in an LDC's growth. LDCs will need to balance the value of the services trade against the expected benefits of continuing to ignore intellectual property regulations. I expect that countries that possess the telecommunications infrastructure necessary to capitalize on knowledge-trade will choose to develop strong intellectual property laws in alignment with the wishes of the WTO and foreign knowledge-intensive firms. With luck, policy makers will design intellectual property regulations and enforcement to provide equal support for all firms; there is a risk of large U.S. firms "purchasing" near-exclusive intellectual property regulations and gaining a foreign monopoly, just as the pioneers of telephones and telegraphs secured their monopolies.

Ultimately, I believe that an optimistic approach is necessary. The globalization of knowledge services will be profitable for all parties involved, including LDCs and knowledge workers. The U.S., domestic firms, and LDC governments should focus on further developing the structural foundation of a modern and robust infrastructure for the trade of services, including telecommunications capacity and effective intellectual property regulations. U.S. knowledge workers ust realize that many of their job functions have become tradable commodities, and work to differentiate themselves and act as conduits for the trade in services. Finally, the U.S. consumer should not fear the increase in knowledge services trade but recognize it as a means of lowering costs and increasing productivity.

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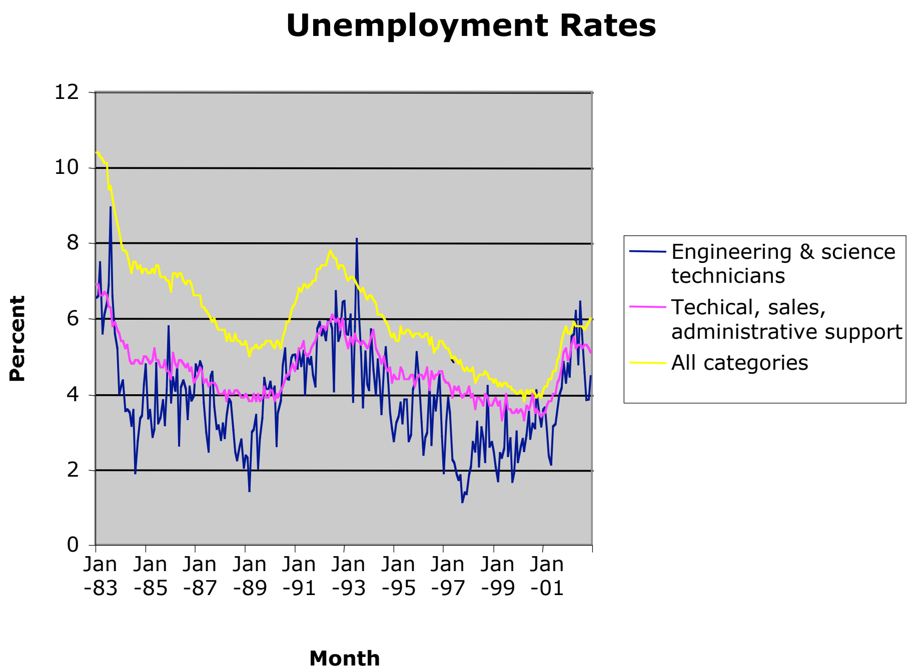
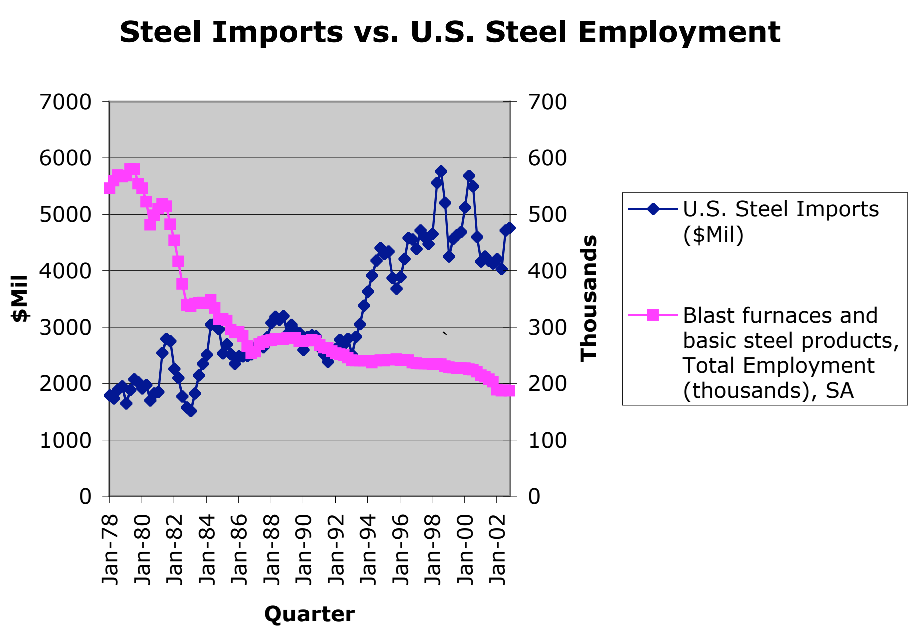
## List of Figures

### Figure 1. Unemployment rates.




Data source: http://www.economagic.com

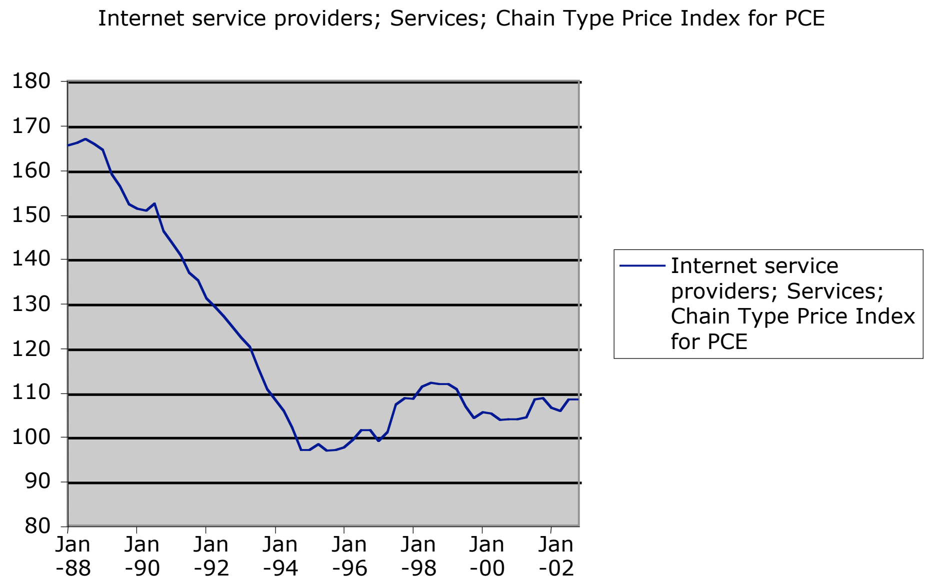
### Figure 2. Steel Imports vs. U.S. Steel Employment




Data sources: Import data:
http://www.bea.gov/bea/international/bp_web/simple.cfm?anon=196&table_id=2&area_id=3

Employment data: http://www.economagic.com

**Figure 3. Internet service providers; Services; Chain Type Price Index for PCE**



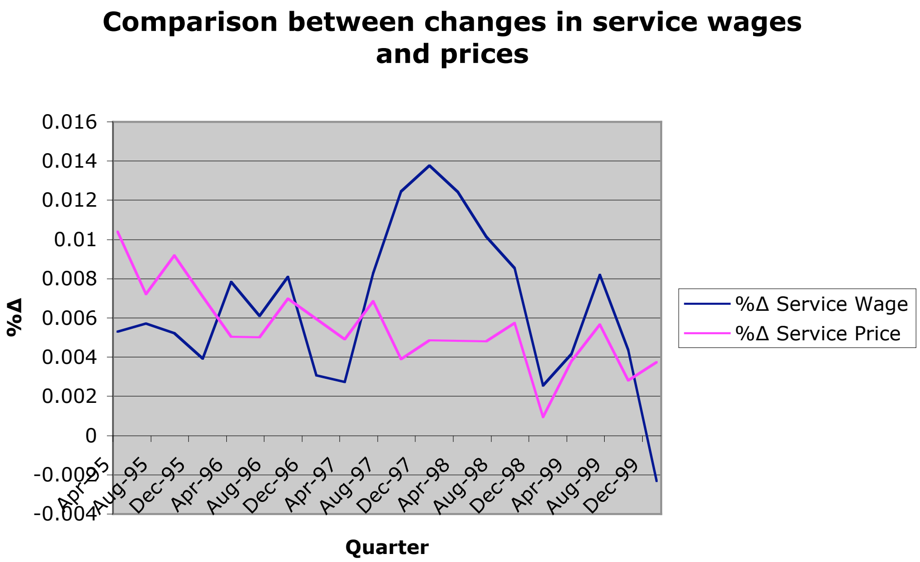

Data source: http://www.economagic.com

**Figure 4. Magnification effect test**

| Quarter | %Δ Service Wage | %Δ Service Price | Magnification Test |
|---|---|---|---|
| **Apr-95** | 0.00530241 | 0.01039501 | Positive |
| **Jul-95** | 0.00571553 | 0.00721278 | Positive |
| **Oct-95** | 0.00521429 | 0.00919775 | Positive |
| **Jan-96** | 0.00393946 | 0.00709579 | Positive |
| **Apr-96** | 0.00783615 | 0.00503778 | Negative |
| **Jul-96** | 0.00611593 | 0.00501253 | Negative |
| **Oct-96** | 0.00809695 | 0.00697559 | Negative |
| **Jan-97** | 0.00308462 | 0.00594059 | Positive |
| **Apr-97** | 0.00273909 | 0.00492368 | Positive |
| **Jul-97** | 0.00828415 | 0.00685267 | Negative |
| **Oct-97** | 0.0124526 | 0.00389484 | Negative |
| **Jan-98** | 0.01378058 | 0.00484731 | Negative |
| **Apr-98** | 0.01242668 | 0.00482393 | Negative |
| **Jul-98** | 0.01013823 | 0.00480077 | Negative |
| **Oct-98** | 0.008544 | 0.00573066 | Negative |
| **Jan-99** | 0.00255943 | 0.00095193 | Negative |
| **Apr-99** | 0.00416457 | 0.00379867 | Negative |
| **Jul-99** | 0.008199 | 0.00567108 | Negative |
| **Oct-99** | 0.00437454 | 0.00282353 | Negative |
| **Jan-00** | -0.0023076 | 0.00375235 | Positive |

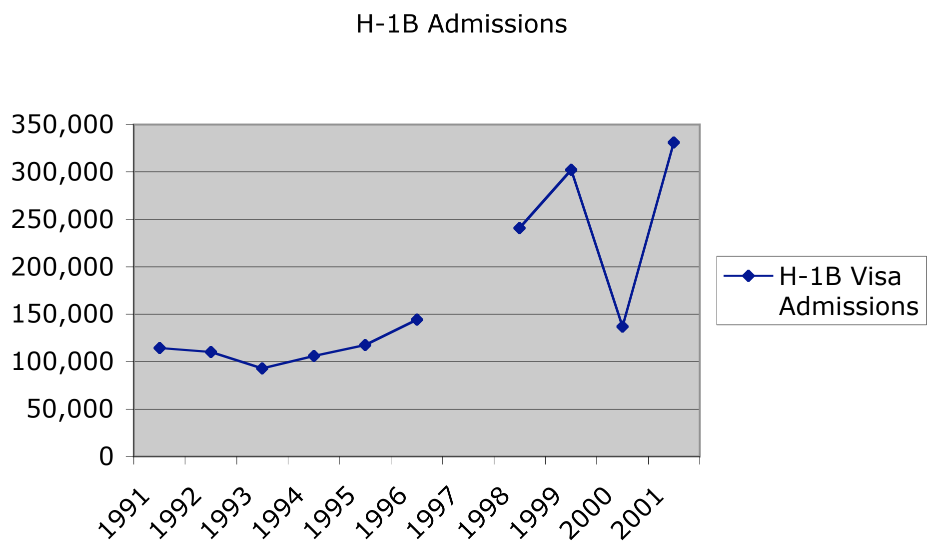
Data source: http://www.economagic.com

**Figure 5. Comparison between changes in service wages and prices**




Data source: http://www.economagic.com

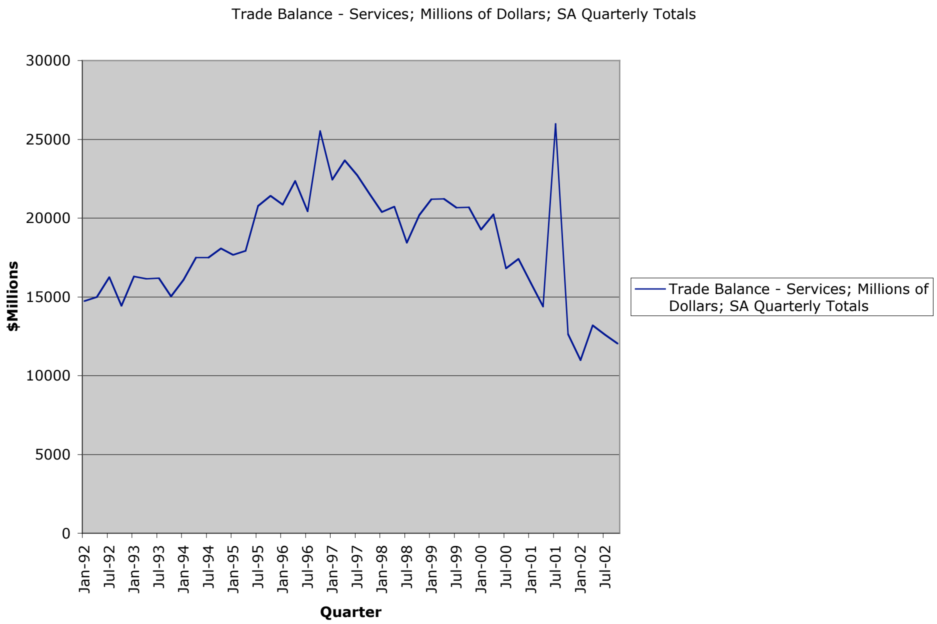
**Figure 6. H-1B Admissions by year**




Data source: manually compiled from various volumes of the INS Statistical Yearbook: http://www.immigration.gov/graphics/aboutus/statistics/ybpage.htm

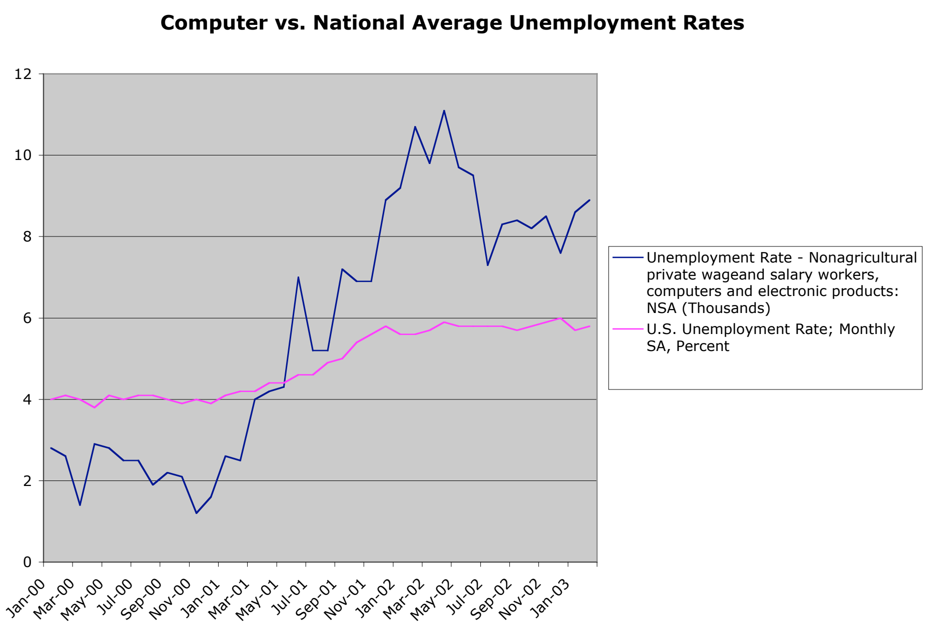
Note: Official data for 1997 is unavailable.

**Figure 7. U.S. Trade Balance in Services**



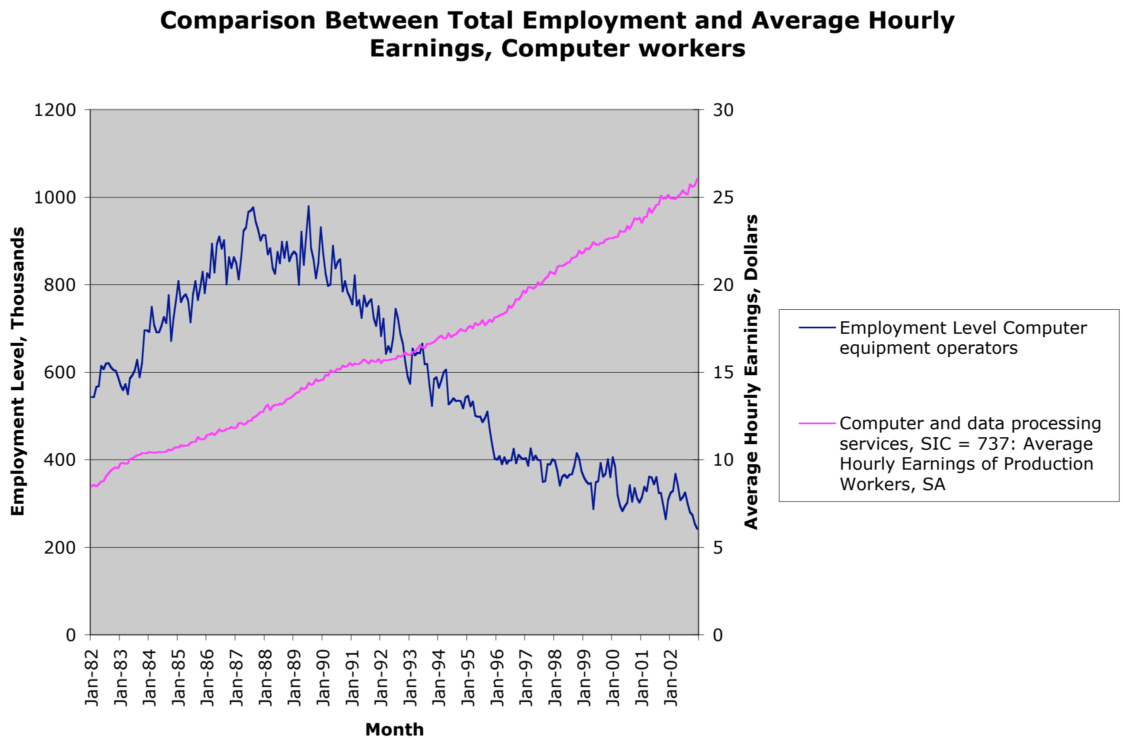

Data source: http://www.economagic.com

**Figure 8. Computer-Related vs. National Average Unemployment Rates**




Data source: http://www.economagic.com

**Figure 9. Comparison Between Total Employment and Average Hourly Earnings, Computer workers**




Data Source: http://www.economagic.com

# Regression Results

**Import Price Regression**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.140612926 |
| R Square | 0.019771995 |
| Adjusted R Squar | -0.016532746 |
| Standard Error | 0.039203325 |
| Observations | 85 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 0.002511043 | 0.000837014 | 0.544611931 | 0.653172033 |
| Residual | 81 | 0.124488954 | 0.001536901 | | |
| Total | 84 | 0.126999997 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.059022146 | 0.173169777 | 0.340833988 | 0.734111027 | -0.285531668 | 0.403575959 | -0.285531668 | 0.403575959 |
| CW LN t-1 | 0.104533815 | 0.083043185 | 1.258788613 | 0.21172259 | -0.060696206 | 0.269763836 | -0.060696206 | 0.269763836 |
| CW %Δ | 0.625676117 | 1.278444139 | 0.489404345 | 0.625878199 | -1.918028739 | 3.169380973 | -1.918028739 | 3.169380973 |
| PM LN t-1 | -0.117957653 | 0.09498412 | -1.24186709 | 0.217869473 | -0.306946409 | 0.071031103 | -0.306946409 | 0.071031103 |

**Import Quantity Regression**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.325477949 |
| R Square | 0.105935895 |
| Adjusted R Squar | 0.04934956 |
| Standard Error | 0.042731724 |
| Observations | 85 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 5 | 0.017092375 | 0.003418475 | 1.872110888 | 0.108609172 |
| Residual | 79 | 0.144254019 | 0.001826 | | |
| Total | 84 | 0.161346394 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -1.982059364 | 1.334899876 | -1.484800021 | 0.141576231 | -4.639113348 | 0.67499462 | -4.639113348 | 0.67499462 |
| IU LN t-1 | 0.167401505 | 0.11495258 | 1.456265757 | 0.149282137 | -0.061406074 | 0.396209085 | -0.061406074 | 0.396209085 |
| IU LN %Δ | 1.498464982 | 0.689774779 | 2.172397466 | 0.032823818 | 0.125501468 | 2.871428496 | 0.125501468 | 2.871428496 |
| EM LN t-1 | -0.02909908 | 0.040745007 | -0.714175363 | 0.477223629 | -0.110200055 | 0.052001895 | -0.110200055 | 0.052001895 |
| EM LN %Δ | -0.020802058 | 0.156613266 | -0.13282437 | 0.894670025 | -0.332533231 | 0.290929114 | -0.332533231 | 0.290929114 |
| QM LN t-1 | -0.120881864 | 0.090861216 | -1.330401131 | 0.187213886 | -0.301736743 | 0.059973014 | -0.301736743 | 0.059973014 |

**Export Price Regression**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.535276272 |
| R Square | 0.286520687 |
| Adjusted R Squar | 0.260095528 |
| Standard Error | 0.0073533 |
| Observations | 85 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 0.001758832 | 0.000586277 | 10.84272301 | 4.60458E-06 |
| Residual | 81 | 0.004379753 | 5.4071E-05 | | |
| Total | 84 | 0.006138585 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.090425491 | 0.050021755 | 1.807723291 | 0.074361746 | -0.00910219 | 0.189953172 | -0.00910219 | 0.189953172 |
| CU LN t-1 | 0.032151029 | 0.035142097 | 0.914886461 | 0.362966788 | -0.037770777 | 0.102072836 | -0.037770777 | 0.102072836 |
| CU %Δ | 0.727782678 | 0.190133276 | 3.827750156 | 0.000253555 | 0.349476795 | 1.10608856 | 0.349476795 | 1.10608856 |
| PiX LN t-1 | -0.052424599 | 0.045128159 | -1.161682621 | 0.248776145 | -0.142215552 | 0.037366355 | -0.142215552 | 0.037366355 |

**Export Quantity Regression**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.295648158 |
| R Square | 0.087407833 |
| Adjusted R Squar | 0.029648835 |
| Standard Error | 0.028973609 |
| Observations | 85 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 5 | 0.006351933 | 0.001270387 | 1.513319766 | 0.195147327 |
| Residual | 79 | 0.066318132 | 0.00083947 | | |
| Total | 84 | 0.072670065 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -0.930316051 | 1.140097696 | -0.815996782 | 0.416955598 | -3.199625667 | 1.338993565 | -3.199625667 | 1.338993565 |
| IW LN t-1 | 0.101189416 | 0.06548121 | 1.545319885 | 0.126265611 | -0.029147782 | 0.231526614 | -0.029147782 | 0.231526614 |
| IW LN %Δ | 0.214395913 | 0.159046766 | 1.348005487 | 0.181509294 | -0.102179023 | 0.530970849 | -0.102179023 | 0.530970849 |
| EX LN t-1 | 0.046267808 | 0.067589945 | 0.684536848 | 0.495639614 | -0.088266726 | 0.180802343 | -0.088266726 | 0.180802343 |
| EX LN %Δ | 0.157995007 | 0.222047413 | 0.711537257 | 0.478847205 | -0.283979686 | 0.599969699 | -0.283979686 | 0.599969699 |
| QiX LN t-1 | -0.081588418 | 0.042177174 | -1.934421148 | 0.056641621 | -0.165540054 | 0.002363218 | -0.165540054 | 0.002363218 |

# Regression Results, continued
# Unit root tests

pX Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 2.6966E+308 |
| R Square | -0.056561711 |
| Adjusted R Square | -0.068326417 |
| Standard Error | 0.815134732 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | -3.023468112 | -3.023468112 | -4.550368786 | #NUM! |
| Residual | 85 | 56.47779369 | 0.664444632 | | |
| Total | 86 | 53.45432558 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| pX t-1 | 0.004987269 | 0.000989835 | 5.038484237 | 2.60699E-06 | 0.00301921 | 0.006955327 | 0.00301921 | 0.006955327 |

cU Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 2.6966E+308 |
| R Square | -1.49937569 |
| Adjusted R Square | -1.511140396 |
| Standard Error | 0.298170628 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | -4.533436842 | -4.533436842 | -50.99150726 | #NUM! |
| Residual | 85 | 7.556986492 | 0.088905723 | | |
| Total | 86 | 3.02354965 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| cU t-1 | 0.008833866 | 0.000370923 | 23.81591353 | 2.26316E-39 | 0.008096372 | 0.009571361 | 0.008096372 | 0.009571361 |

pM Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 2.6966E+308 |
| R Square | -0.000336509 |
| Adjusted R Square | -0.012101215 |
| Standard Error | 3.517405139 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | -0.353764758 | -0.353764758 | -0.028593662 | #NUM! |
| Residual | 85 | 1051.631808 | 12.37213892 | | |
| Total | 86 | 1051.278043 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| pM t-1 | 0.005148879 | 0.004295121 | 1.198773911 | 0.233947314 | -0.003390977 | 0.013688735 | -0.003390977 | 0.013688735 |

cW Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.066008451 |
| R Square | 0.004357116 |
| Adjusted R Square | -0.00740759 |
| Standard Error | 10.90473091 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 44.23278815 | 44.23278815 | 0.371975562 | 0.54357577 |
| Residual | 85 | 10107.61829 | 118.9131563 | | |
| Total | 86 | 10151.85108 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| cW t-1 | -0.012000629 | 0.014792238 | -0.811278795 | 0.41947152 | -0.041411579 | 0.017410321 | -0.041411579 | 0.017410321 |

QX Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 2.6966E+308 |
| R Square | -0.021882425 |
| Adjusted R Square | -0.03364713 |
| Standard Error | 6049593052 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | -6.6614E+19 | -6.6614E+19 | -1.820176219 | #NUM! |
| Residual | 85 | 3.11079E+21 | 3.65976E+19 | | |
| Total | 86 | 3.04418E+21 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| QX t-1 | 0.009853844 | 0.003244935 | 3.036684222 | 0.003175459 | 0.003402039 | 0.016305649 | 0.003402039 | 0.016305649 |

IW Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.063261332 |
| R Square | 0.004001996 |
| Adjusted R Squar | -0.00776271 |
| Standard Error | 2.47903E+11 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2.09894E+22 | 2.09894E+22 | 0.341536502 | 0.56050999 |
| Residual | 85 | 5.22373E+24 | 6.14557E+22 | | |
| Total | 86 | 5.24472E+24 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| IW t-1 | -0.011080376 | 0.015280524 | -0.725130605 | 0.470363494 | -0.041462169 | 0.019301418 | -0.041462169 | 0.019301418 |

EX Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.040314091 |
| R Square | 0.001625226 |
| Adjusted R Squar | -0.01013948 |
| Standard Error | 10.51898848 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 15.31041722 | 15.31041722 | 0.138369084 | 0.71084453 |
| Residual | 85 | 9405.175092 | 110.6491187 | | |
| Total | 86 | 9420.485509 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| EX t-1 | -0.013218754 | 0.011631706 | -1.136441573 | 0.258965665 | -0.036345716 | 0.009908207 | -0.036345716 | 0.009908207 |

QM Unit Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 2.6966E+308 |
| R Square | -0.001001622 |
| Adjusted R Squar | -0.012766328 |
| Standard Error | 7003642060 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | -4.17192E+18 | -4.17192E+18 | -0.085052708 | #NUM! |
| Residual | 85 | 4.16934E+21 | 4.9051E+19 | | |
| Total | 86 | 4.16516E+21 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| QM t-1 | 0.010843191 | 0.005384539 | 2.013763957 | 0.047197404 | 0.000137278 | 0.021549104 | 0.000137278 | 0.021549104 |

IU Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.071532923 |
| R Square | 0.005116959 |
| Adjusted R Squar | -0.006647747 |
| Standard Error | 1.00727E+12 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 4.43555E+23 | 4.43555E+23 | 0.437178543 | 0.510296916 |
| Residual | 85 | 8.62397E+25 | 1.01459E+24 | | |
| Total | 86 | 8.66833E+25 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| IU t-1 | -0.013159694 | 0.015589779 | -0.844123192 | 0.400970051 | -0.044156369 | 0.017836982 | -0.044156369 | 0.017836982 |

EM Unit Root Test

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.020456007 |
| R Square | 0.000418448 |
| Adjusted R Squar | -0.011346258 |
| Standard Error | 0.001201507 |
| Observations | 86 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 5.13683E-08 | 5.13683E-08 | 0.035582989 | 0.850834257 |
| Residual | 85 | 0.000122708 | 1.44362E-06 | | |
| Total | 86 | 0.000122759 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| EM t-1 | -0.010634046 | 0.012121526 | -0.877286062 | 0.382804134 | -0.034734903 | 0.01346681 | -0.034734903 | 0.01346681 |