The Rise of Offshoring:

It's Not Wine for Cloth Anymore*

by

Gene M. Grossman
Princeton University

and

Esteban Rossi-Hansberg
Princeton University

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1 Introduction

In 1817, when David Ricardo penned his celebrated treatise on *The Principles of Political Economy and Taxation*, communication between England and Portugal was no faster and only slightly less costly than shipping wine or cloth from one country to the other. Most goods were produced in a single location, as fragmentation of the production process was uneconomic in a world in which the coordination of production activities in remote locations was difficult if not impossible. No wonder that Ricardo illustrated his principle of comparative advantage with an example involving the exchange of one good for another.

Almost two centuries later, the core of international trade theory continues to be dominated by thinking about production and exchange of complete goods. Our understanding of the effects of international integration on prices, production patterns, and factor income comes primarily from analyzing models in which goods—sometimes used as intermediate inputs, but often serving final consumer demand—are produced entirely in one location. But times are a-changin'. Revolutionary progress in communication and information technologies has enabled an historic (and ongoing) break-up of the production process. Countries like England and Portugal still produce some goods from start to finish, but increasingly they participate in global supply chains in which the many tasks required to manufacture complex industrial goods (or, increasingly, to provide knowledge-intensive services) are performed in several, disparate locations. To better understand the implications of these trends, we need a new paradigm for studying international trade that emphasizes not only the exchange of complete goods, but also trade in specific tasks, or, what we shall refer to as "offshoring."[1]

The popular press is replete with stories of task trade. Tempest (1996), for example, describes the global process for producing a Barbie doll. The doll is designed in Mattel's headquarters in El Segundo, California. Oil is refined into ethylene in Taiwan and formed into plastic pellets that are used to produce the doll's body. Barbie's nylon hair is manufactured in Japan, while the cotton cloth for her clothing originates in China. The moulds for the doll are made in the United States, as are the paint pigments used to decorate it, and the cardboard used for packaging. Assembly takes place in Indonesia and Malaysia. Finally, the dolls are quality tested in California, and marketed from there and elsewhere around the globe. Burrows (1995) tells a similar story about Texas Instruments' high-speed telecommunications chip, which was conceived by engineers in Sweden, designed in Nice with software tools developed in Houston, produced in Japan and Dallas, and tested in Taiwan. And an annual report of the World Trade Organization (1998) describes the production of a

[1] We prefer the term "offshoring" to the more popular "outsourcing," because the latter suggests that tasks formerly performed in-house are now being purchased at arms-length, whereas the former implies that tasks formerly undertaken in one country are now being performed abroad. In other words, offshoring includes not only foreign sourcing from unrelated suppliers, but also the migration abroad of some of the activities conducted by a multinational firm.

particular “American” car:

> Thirty percent of the car’s value goes to Korea for assembly, 17.5 percent to Japan for components and advanced technology, 7.5 percent to Germany for design, 4 percent to Taiwan and Singapore for minor parts, 2.5 percent to the United Kingdom for advertising and marketing services, and 1.5 percent to Ireland and Barbados for data processing. This means that only 37 percent of the production value ... is generated in the United States. (p.36)

More recently, attention has shifted to the offshoring of a variety of services. Almost daily we read media stories of companies in India that answer customer service calls (Friedman, 2004), read x-rays (Pollak, 2003), develop software (Thurm, 2004), prepare tax forms (Robertson et al., 2005) and even perform heart surgery on American patients (Baker et al., 2006). Blinder (2006) refers to the expanding feasibility of offshoring formerly non-tradable services as the “Third Industrial Revolution.”

Much ink has been spilt on the subject of offshoring.[2] But, so far, we lack a simple analytic framework for investigating how improvements in communication and information technologies that give rise to increased offshoring affect labor markets, production patterns, prices, and welfare in the participating countries. In this paper, we will describe such a framework that we have developed more formally in Grossman and Rossi-Hansberg (2006). Our simple model of offshoring allows us to decompose the impact on wages of any improvements in the technology for offshoring into three components: a *labor-supply effect* that is familiar from the broadcasts and writings of Lou Dobbs and others; a *relative-price effect* that captures the labor-market implications of any movements in relative prices effected by the improved possibilities for offshoring; and a *productivity effect* that seems to have been largely overlooked in earlier discussions. We show that the productivity effect can dominate the others in a familiar trade environment, so that improved possibilities for offshoring low-skilled jobs actually will *raise* the wages of domestic workers who perform these types of tasks. By the same token, improved possibilities for offshoring some high-skilled tasks may boost the wage of domestic white-collar workers. Not only may the offshoring of certain tasks generate gains from trade, as famously noted by Council of Economic Advisors chairman Gregory Mankiw and discussed in the 2004 *Economic Report of the President* and elsewhere (see, for example, Blinder, 2006, and Leamer, 2006), but improvements in communications technologies that make offshoring easier and cheaper might boost the wages of domestic workers with skill levels similar to those used in performing the tasks that migrate offshore.

Our conclusion can best be understood by drawing an analogy between improved prospects for offshoring tasks and factor-augmenting technological progress. When some of the tasks

[2] See Bhagwati, et al. (2004), Samuelson (2004), Dobbs (2004), Friedman (2005), Leamer (2006), Mankiw and Swagel (2005), and Blinder (2006), among many others.

performed by a certain type of labor can more readily be performed abroad, the firms that gain the most are the ones that use this type of labor intensively in their production processes. The augmented profitability of these firms gives them an incentive to expand relative to firms that rely most heavily on other types of labor, which in turn enhances their labor demand. Some of this increased labor demand falls on local workers, who perform tasks that cannot easily be moved offshore. This is quite similar to the process generated by technological progress that improves the productivity of a certain type of worker. Although fewer of these workers are needed to produce a given amount of output, the adjustment in output levels in response to the new technology can lead to a net increase in demand for the type of labor whose productivity has increased.

In the last part of the paper, we perform a "back-of-the-envelope" calculation intended to give a sense of the relative magnitudes of the productivity effect and the labor-supply effect of improved opportunities for offshoring. We examine the evolution of blue-collar wages in the United States from 1997 to 2004. The real wages of the least skilled among the blue collar workers have risen by about 3.7 percent during this period (the real wage of the average blue-collar worker has risen by 6.3 percent over these seven years). Total factor productivity (TFP) has been rising in the United Sates during this period at an average annual rate of 1.6 percent, which alone should have pushed up wages for all workers by 11.8 percent between 1997 and 2004, including the least skilled among them. On the other hand, the relative price of U.S. imports of manufactured goods from non-industrialized countries have dropped precipitously. By itself, this should have depressed blue-collar wages via the Stolper-Samuelson (1941) mechanism (a fall in the relative price of textiles, apparel and other such labor-intensive goods exerts downward pressure on the wage of less-educated domestic labor). We show that what is left after accounting for the estimated effects of TFP growth and terms-of-trade movements is a positive residual. This residual reflects the combined productivity effect and labor-supply effect of improvements in offshoring possibilities, along with, of course, any other considerations omitted from our model. Our observation that the residual is positive amounts to a claim that low-skill wages have not fallen as much as one should have expected given the combined forces of terms-of-trade movement and TFP improvement. A possible interpretation is that the productivity gains associated with U.S. firms' moving some tasks offshore have served to bolster U.S. wages, consistent with our theory but contrary to the fears of Lou Dobbs and others.

In this paper we focus on the international organization of production processes and the effect that this may have on U.S. wages. There are, of course, many other trends in the world apart from the reductions in the cost of trading tasks that we emphasize here. Chief among them are reforms in many developing countries that have converted them into market economies with fast economic and technological growth. The goods and services that these countries produce and consume have a potentially important impact on international prices and on the pattern of production and factor prices in developed economies like the United States. Analyzing the technological catch-up of some of these large emerging economies and its effects on other industrialized countries is, however, beyond the scope of this paper.

2 Offshoring

Adam Smith (1776) famously described the division of labor in a pin factory in late eighteenth century England:

> One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which in some manufactories, are all performed by distinct hands, though in some others the same man will sometimes perform two or three of them. (p. 4)

At the time, the key to high productivity in industrial production was to concentrate the various tasks needed for producing a good under a single roof. By specializing in one or a small number of tasks, each worker could focus his energy and thereby perform most efficiently. But without proximity, it would have been impossible to coordinate the efforts of the various workers or to combine their inputs into a single product. Communication required physical travel. Transportation of intermediate inputs or partially processed goods was slow and costly. The economic geography of the time pointed to agglomeration in production, not fragmentation. Specialization implied geographic concentration. So factories produced goods, which were shipped to final consumers. If the consumers happened to reside in a different country, there was international trade.

This description of manufacturing and trade remained apt for nearly two centuries. But recently, a revolution in transportation and (especially) communication technologies has weakened the link between specialization and geographic concentration. Now, it is increasingly possible to separate tasks in time and space. Instructions can be delivered instantaneously. Detailed information about product specifications and the tasks that need to be performed can be conveyed electronically. And partially processed goods can be transported more quickly and at lower cost than ever before. Indeed, for services like radiology, copy editing, and tax preparation, the work product can be sent electronically, with no loss of time and virtually no cost. Increasingly, international trade involves not only complete goods, but also individual tasks, or relatively small numbers of them. In the new global production processes, specialization can be achieved without geographic concentration. This has allowed firms to take advantage of differences in factor costs and expertise across countries, thereby enhancing the benefits of specialization.

Thomas Friedman (2005) has described these trends in picturesque terms. He lists ten forces that have "flattened" the world. Among them are the birth of the Internet, the development of work flow software, outsourcing, offshoring, "supply-chaining," "in-forming" (Internet searching), and advances in digital, mobile, personal and virtual communication technologies. Clearly, these are forces that facilitate (or reflect) the increasing tradability of tasks.

Yet the world remains far from flat, as Leamer (2006) has emphasized. Proximity matters—in fact, as Hillberry and Hummels (2005) have shown, it still must matter a great deal for many tasks, because most exchange takes place between partners who are located very close to one another. While some tasks can be undertaken remotely with little difficulty, others must be done in face-to-face contact or else the production process suffers greatly. Leamer and Storper (2001), for example, distinguish between tasks that require *codifiable* information and those that require *tacit* information. The former, they argue, is easy to transfer, because it can be expressed in a symbol system, either linguistic, mathematical, or visual. But the latter cannot be conveyed in symbols, requiring instead that the parties "know" each other or have a broad common background. Complex, non-codifiable messages are best communicated in face-to-face interchange, where visual contact provides a basis for building and maintaining relationships.

Levy and Murnane (2004) point to the similarities between tasks that can be performed remotely and those that can be performed by a computer. In order for a computer to perform a task, it must be possible to describe it using rules-based logic. But when this is possible, it will also be possible to have the task done remotely with relatively little risk of miscommunication and a modest cost of monitoring. Autor, Levy, and Murnane (2003), divide tasks into five broad categories according to whether they require expert thinking, complex communication, routine cognitive processes, routine manual labor, or non-routine manual labor. The routine tasks—be they cognitive or manual—are susceptible to computerization and offshoring, because they can be well described in deductive rules. The others are more difficult to computerize or offshore, because they require pattern recognition and inductive reasoning.[3]

Finally, Blinder (2006), focusing on the service sectors, distinguishes between those tasks that must be delivered personally and those that can be delivered electronically. Most personal services cannot be performed remotely, while impersonal services are susceptible to

[3]Levy and Goelman (2005) apply this framework to analyze the future prospects for offshoring in radiology. They argue that radiologist's work requires pattern recognition that defies characterization by rules. Accordingly, they foresee little scope for the offshoring of radiology jobs.

offshoring. But, as Blinder (2006) notes, improvements in information technology will change the calculus, rendering more and more personal services into impersonal ones. Like Levy and Murnane (2004), he emphasizes that the tradability of a task does not correspond perfectly (or even very well) with the skill required to perform it.

3 Evidence of Increased Task Trade

Media interest in offshoring (or, what the press often misleadingly refers to as "outsourcing") exploded during the period before the U.S. presidential election of 2004, as Mankiw and Swagel (2006) have documented and any resident at the time will surely recall. Yet hard evidence on the extent of task trade is difficult to come by, for several reasons. First, task trade either may occur between affiliates of a multinational firm or as arms-length transactions between unaffiliated firms. The reporting requirements for these alternatives forms of trade differ. And when the transaction occurs within a firm, the applicable trade and profit taxes may give the parent company incentive to manipulate the transfer prices and thereby distort the measured trade flows. Second, task trade may or may not involve the movement of physical goods across international boundaries. If the tasks performed offshore involve the production of intermediate goods or components, or the assembly of components into finished products, then goods will be transported across borders, and the transactions will be captured in customs data. But task trade increasingly involves the performance of business functions that do not result in any good passing through a customs house and thus often do not generate a paper trail. Examples of such business functions include software programming and design, call center operations, marketing research, word processing, data entry, accounting and payroll operations, and the like. Such activities are considered to be service trade, which must be measured by statistical agencies using survey instruments. In the United States, the BEA has been asking firms about their service trade with affiliated parties only since 1997.

Third, and perhaps most fundamentally, the concept of trading tasks inherently concerns the disintegration of the production process and the adding of value at disparate locations. Yet, unlike the recording of domestic transactions as value added in the national income accounts, trade data are collected and reported as gross flows. The measurement of trade as gross values of imports and exports was perhaps appropriate at a time when trade flows comprised mostly finished goods. But such measures are inadequate to the task of measuring the extent of a country's international integration in a world with global supply chains and internationally dispersed production processes.[4]

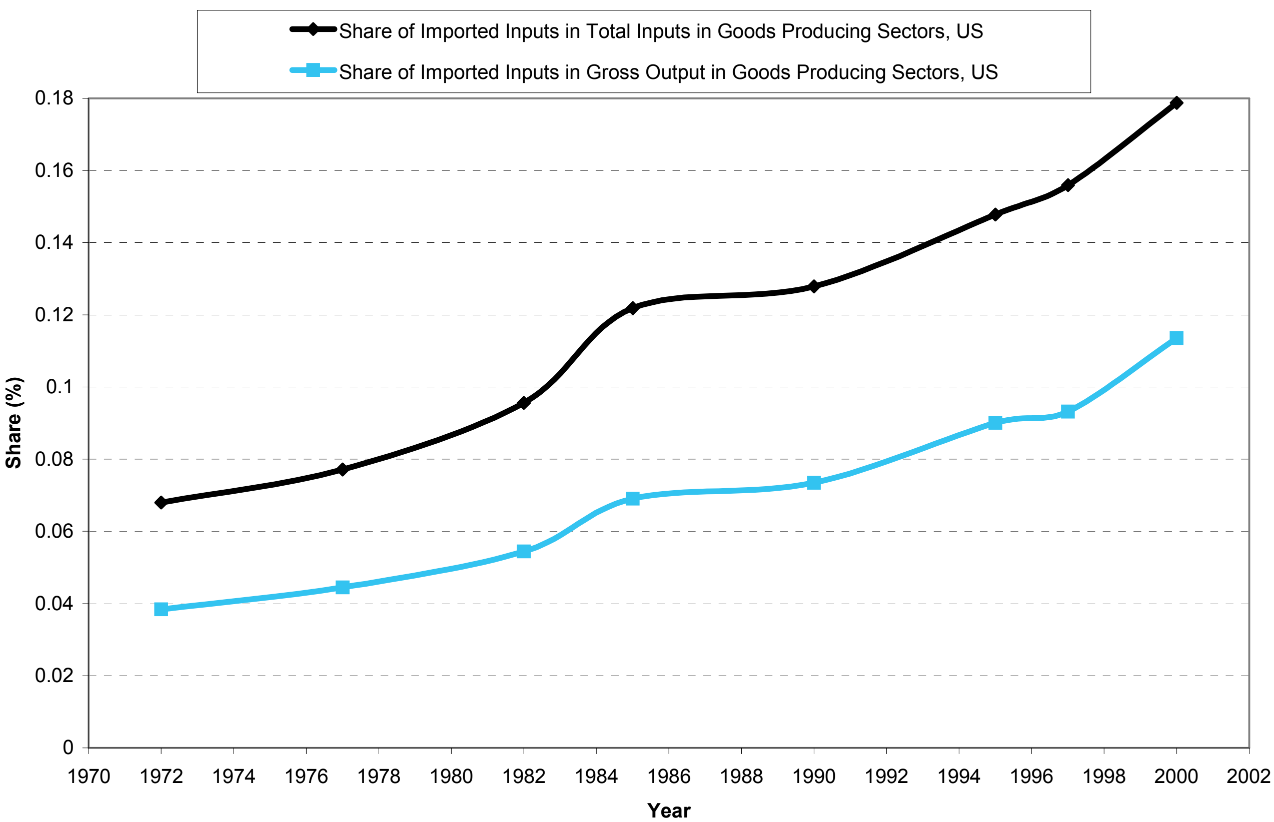
To measure task trade that generates shipments of goods, we would like to know the sources of the value added embodied in the goods and the uses to which the goods are

[4] For more on this point, see National Research Council (2006).

eventually put. But, the statistical agencies have no way to know the national content of goods that are traded, nor do they track the uses of these goods; that is, whether they are destined for further processing or for sale to final consumers. The BEA does inquire about the sectoral source of the intermediate inputs used by each industry to produce its output, but in so doing it does not distinguish between intermediate inputs purchased from local sources and those purchased from abroad.

Figure 1: Imported Inputs

Source: OECD Input-Output Matrices

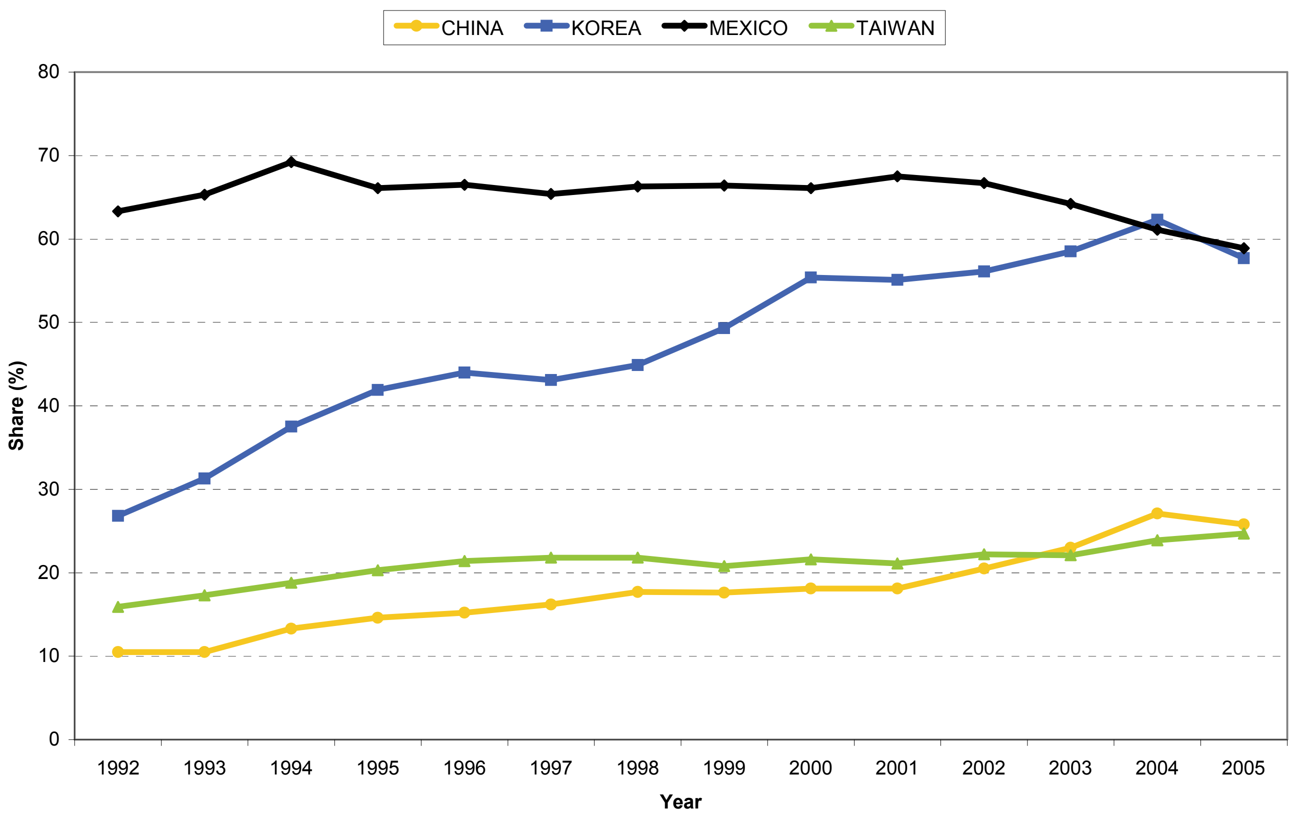


The input-output data collected by the BEA can, however, be combined with disaggregated trade data to give a sense of the growing importance of trade in tasks. The OECD reports an estimate of imported intermediate inputs for member countries by assuming that in every industry in which inputs are demanded, the ratio of imported inputs to domestically produced inputs of a particular good mirrors the ratio of total imports to total domestic output of that good.[5] With this assumption, imported intermediate inputs can be computed

[5]The OECD refers to this as the "proportionality assumption"; see their documentation at http://www.oecd.org/dataoecd/48/43/2673344.pdf. Hummels et al. (2001) make the same assumption in

as the weighted sum of all intermediate inputs used in domestic production, using the import shares in total production plus imports for each product category as the weights. Using the OECD data, we have calculated the estimated share of imported inputs in total inputs used by all goods-producing sectors in the United States and the estimated share of imported inputs in the gross output of those sectors. The graphs in Figure 1 show both measures to be growing steadily over a period of almost three decades, with an apparent acceleration in the most recent period for which data are available.[6]

Figure 2: Related Party Trade as a Share of U.S. Imports
Source: BEA



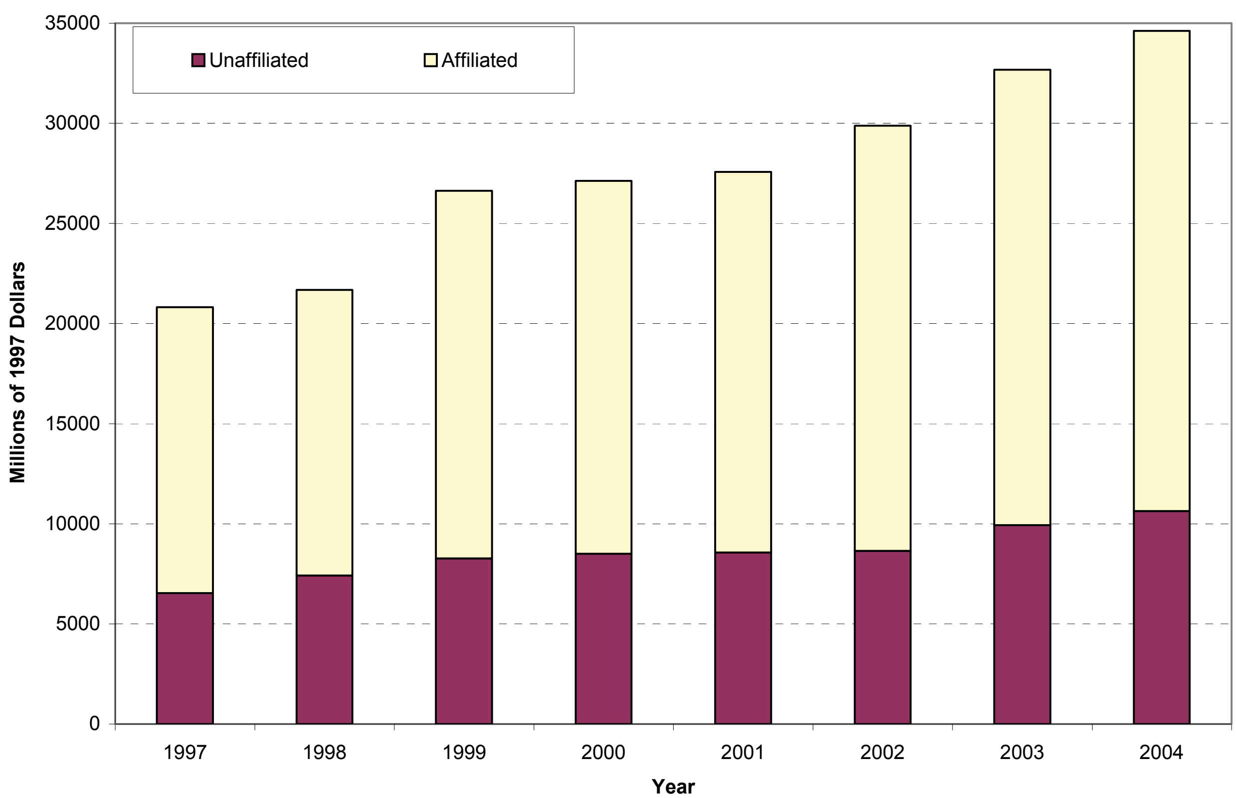
Another indication of the prevalence of task trade and its growing importance in certain trade relationships can be found in the BEA data on trade between related parties. Related party trade is defined as trade between U.S. companies and their foreign subsidiaries plus trade between U.S. subsidiaries of foreign companies and their parent companies abroad.

their measures of "vertical specialization"; see also the discussion of this point in National Research Council (2006).

[6]In constructing Figure 1, we have used unpublished data for 1995 to 2000 provided to us by Norihiko Yamano at the OECD, to whom we express our gratitude.

Much of this trade stems from international division of labor in global production processes. In 2005, related party trade accounted for 47 percent of U.S. imports. Although this fraction has risen only modestly since 1992, when it was already 45 percent, Figure 2 shows that the aggregate experience masks variation across trading partners. The figure shows that related party imports already accounted for more than sixty percent of total U.S. imports from Mexico in 1992, thanks in large part to the *maquiladora* program that provided favorable tariff treatment to partially-processed goods that were exported to Mexico from the United States and then reimported after receiving some additional value. But the figure shows that the relative importance of intra-firm trade has been growing rapidly in the U.S. trade relationships with Korea, China, and Taiwan. Imports from related parties accounted for 27 percent of total U.S. imports from Korea in 1992, and 11 percent of total U.S. imports from China. By 2005, these figures had risen to 58 percent and 26 percent, respectively.

Figure 3: Total Imports of Business, Professional, and Technical Services
Source: BEA



Improvements in information technology have facilitated the offshoring of business services, as we have noted before. Official data on service trade can provide some insight into the extent of such task trade, although the available data do not show whether the imported services are used by firms or by final consumers. Nor do the input-output accounts help much in determining the industry-composition of demand for the various categories of services.[7] We follow the GAO (2004) and others in focusing attention on the category "Business, Professional and Technical" services, which includes many of the activities associated with task trade, such as accounting and bookkeeping services, information and data processing, legal services, computer programming, and management and consulting services. Figure 3 shows total U.S. imports of Business, Professional and Technical (BPT) services for the years from 1997 through 2004, expressed in 1997 dollars, and broken down by trade with affiliated and unaffiliated partners. Imports of BPT services have grown in real terms by more than 66 percent in these seven years. Still, BPT services amounted to only about 16 percent of total imports of private services in 2005 which in turn accounted for about 13 percent of total U.S. imports of goods and services in that year. Apparently, trade in service tasks lags trade in manufacturing tasks, suggesting that there may be room for substantial additional growth in this type of international division of labor.

So far, we have sought hints of task trade in the data on commodity and service trade flows. We can also look to the labor market for corroborating evidence. If task trade has been on the rise due to ongoing improvements in firms' ability to separate functions in time and space, we should see American workers performing fewer of the tasks that can easily be performed at a distance and more of those for which proximity is more valuable. Autor, Levy and Murnane (2003) have paired data on job task requirements from the *Dictionary of Occupational Titles* with samples of employed workers from the Census and the Current Population Survey to construct time series of task inputs in the U.S. economy from 1960 through 2002.[8] They have divided labor inputs in the U.S. economy into five types of tasks, but for our purposes it is more enlightening to aggregate their task categories into two: tasks that are "routine" and tasks that are "nonroutine." Routine tasks include their "routine manual" and "routine cognitive" categories; these are tasks that require methodical repetition of procedures that can be well described by a set of rules. Routine cognitive tasks may require considerable skill and training, whereas routine manual tasks may require less skill. Nonroutine tasks—which incorporates Autor, Levy and Murnane's categories of "nonroutine analytic," "nonroutine interactive" and "nonroutine manual"—are tasks that require visual and motor processing that cannot easily be described by rules. This category also cuts across skill levels. We would expect it to be easier for a firm to offshore routine tasks than nonroutine tasks, independent of the skill level of the job.

[7] A report by the United States Government Accountability Office (GAO, 2004) discusses this and other shortcomings of the available U.S. data on service trade for assessing the extent of task offshoring by U.S. firms.

[8] The published article by Autor, Levy and Murnane (2003) includes data for the years 1960 through 1998. We are grateful to David Autor for providing us with the data for the more recent period up to 2002.

Figure 4: Trends in Nonroutine and Routine Tasks
Source: Autor, Levy and Murnane (2003)

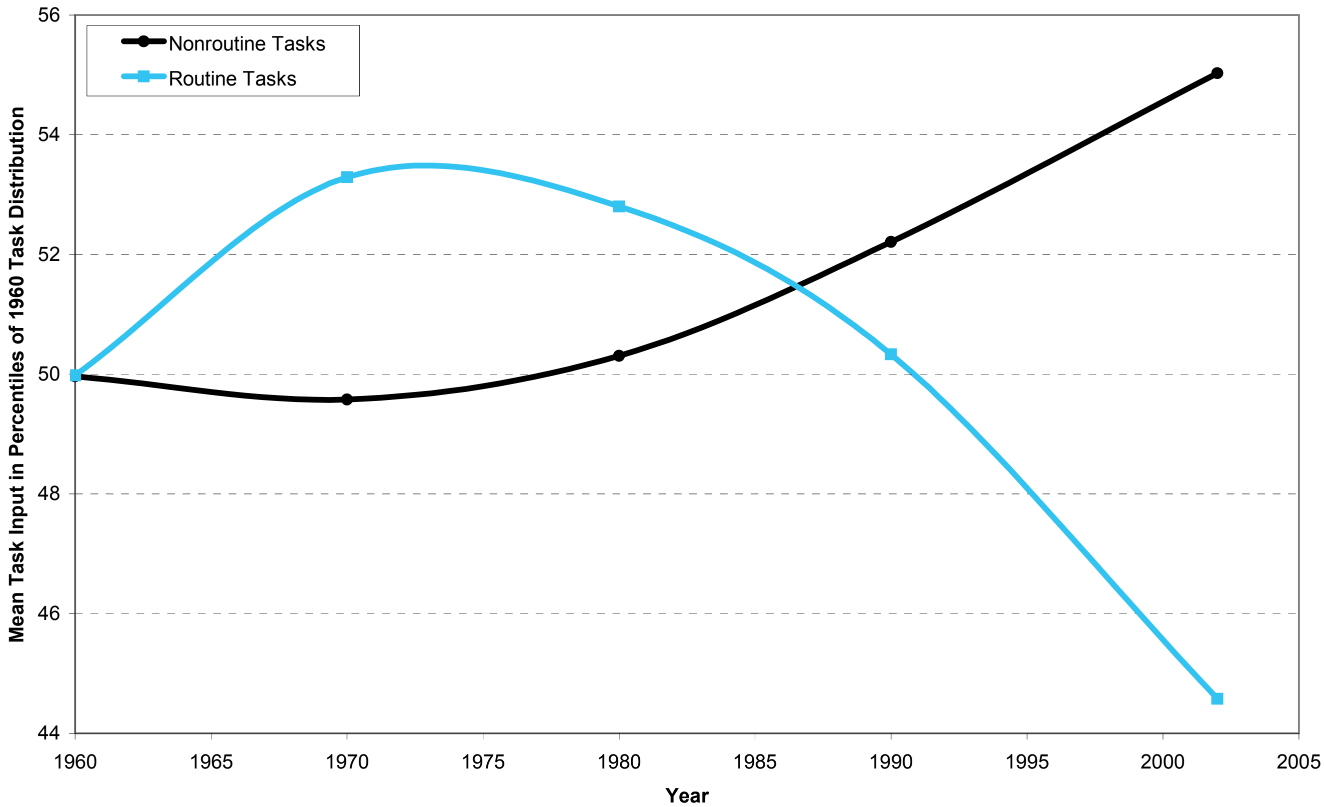


Figure 4 shows the input of routine and nonroutine tasks in the U.S. economy from 1960 through 2002, relative to the 1960 distribution of tasks. By construction, the trends in task input in this figure have been generated by changes in the composition of occupations in the labor force and not by changes in the tasks required for a particular occupation.[9] The measure of routine tasks has been falling since 1970, while that of nonroutine tasks has been rising, with acceleration in each case in the most recent years. What this means is that relatively more U.S. workers are doing jobs that cannot be well described by mechanical rules. The figure is consistent with the hypothesis that the United States has been importing more of the tasks (at all skill levels) that can more readily be moved offshore and increasing its specialization in those tasks that cannot be performed remotely. Of course, there are other possible explanations for the trends revealed in the figure; indeed, Autor, Levy and Murnane

[9] The authors' data do not allow them to identify changes in the tasks required for a particular occupation, but only changes in the aggregate task requirements that result from changes in the industry and occupational composition of the workforce. Their measures of task allocations are not constrained to sum to 100 percent, because the input of each type of task is measured relative to the distribution in 1960 and so the sum of the routine and nonroutine task measures for a given year has no particular meaning.

(2003) constructed their measures of task inputs to examine the possible consequences of computerization.

4 Toward a New Paradigm: Modeling Trade in Tasks

Trade theory has long focused on trade in goods. Countries (or firms) are posited to have access to "technologies" that describe how factors of production can be combined to produce these goods. The technologies are taken as given at a point in time, but may evolve over time. They may be assumed to be identical across countries, although the empirical evidence suggests that they are not (see, for example, Trefler, 1995, or Davis and Weinstein, 2001). The theory emphasizes the consequences of the relatively limited mobility of factors; often it is assumed that factors cannot move across borders, but goods (or at least some set of goods) can be traded costlessly, or at some modest cost.

To capture the recent trends, we wish to extend this traditional framework to allow for trade in tasks, as well as trade in goods. To do so, first we need to represent the production process in terms of sets of tasks rather than simply the combination of bundles of inputs. Then, in keeping with the discussion in Section 2, we need to incorporate the idea that tasks can be performed remotely, but some more easily than others. Finally, the revolution in communications technology can be analyzed as a reduction in the cost of offshoring tasks.

The model that we develop in Grossman and Rossi-Hansberg (2006) begins with the specification of technologies for producing two tradable goods. As in the traditional theory, the home country exports one of these goods and may produce the other in competition with imports. But, in contrast with standard theory, we elaborate the production process by assuming that it involves sets of tasks. Some tasks can be performed by labor with relatively little education or training, while others must be performed by workers that possess more skills. There may be still other tasks that are performed by other factors of production—e.g., capital, or additional categories of labor. We allow for the possibility of substitution between factors by assuming that the set of tasks performed by low-skilled labor (henceforth, "L-tasks") can be operated at different intensities, as can the set of tasks that must be performed by high-skilled labor (henceforth, "H-tasks"), and any others tasks that may be needed for production. That is, when substitution is possible, a firm can achieve a given level of output either by conducting the L-tasks repeatedly and the H-tasks less often, or by performing the H-tasks more frequently and the L-tasks less so. Our model does not require that such substitution be technologically feasible; indeed, the simplest case to consider is one in which each task must be performed exactly once in order to generate a unit of output.[10]

[10]Note that we are assuming complementarity in production between the various L-tasks (and between the various H-tasks). In fact, we assume there is no substitution between L-tasks (or between H-tasks), so that all such tasks must be performed the same number of times. This assumption can be relaxed. As long as

As in the traditional trade models, we assume that the two goods differ in their "factor intensities." Suppose, for example, that a country imports textiles and exports financial services, and that textile production is relatively intensive in its use of low-skilled labor compared to high-skilled labor. Firms in each industry undertake a set of L-tasks and a set of H-tasks to produce their output. Our assumption that textiles are relatively labor intensive means that, in this industry, the ratio of the low-skilled labor employed to perform L-tasks to the high-skilled labor employed to perform H-tasks exceeds the similar ratio of employments used in producing financial services.

For the time being, let us assume that it is only possible to offshore tasks performed by low-skilled labor; all other tasks must be performed in close proximity to a firm's headquarters. In both the import-competing industry and the export industry, the various L-tasks differ in their suitability for offshoring. This may be because some tasks are easy to codify or describe with rules-based logic ("sew this button two inches from the side and four inches from the bottom") and others are less so ("check that the quality of this item meets our standards"). Or it may be because some services must be delivered personally ("clean this room") while others can be performed at a distance with little loss in quality ("answer this customer service call"). For our purposes, we simply need to recognize and incorporate the variation in the costs of offshoring different tasks.

We assign a number (or "index") between 0 and 1 to each of the L-tasks. Since these labels are arbitrary, we may choose them so that tasks with lower indexes can more readily be performed offshore than those with higher indexes. Suppose task i would require some amount of domestic low-skilled labor if performed close to a firm's headquarters. We assume that the same task would require $\beta t(i) > 1$ units of foreign labor per unit of local labor if performed abroad. Here, $t(i)$ is an increasing function of i due to our ordering of the tasks. The parameter β reflects the overall feasibility of offshoring at a point in time. We can represent improvements in transportation and communication technology that make the offshoring of L-tasks more economical as reductions in β.

Tasks can be offshored within or outside the boundaries of the firm. For our purposes, it does not matter much whether the firm opens a subsidiary in a foreign country and employs workers there to undertake certain tasks within its corporate boundaries, or whether it contracts with a foreign purveyor under an outsourcing arrangement. The recent trade literature has examined which organizational form is preferable in different countries and different industries[11], but in either case the effects on production, wages and prices will be roughly the same. For the analytics of this paper, we will not distinguish between offshore outsourcing and intra-firm dealings by multinational corporations.

lower costs of producing some L-tasks (H-tasks) leads to increases in the quantity produced of other L-tasks (H-tasks), the main qualitative implications of our model remain the same.

[11] See, for example, Antràs (2003), Antràs and Helpman (2004) and Grossman and Helpman (2004).

Which tasks will a firm send offshore? The benefit of offshoring a given task derives from the lower wages abroad. The cost derives from instructing and monitoring workers at a distance or from impersonal delivery of services. Clearly, the firm will offshore those tasks for which the benefits exceed the costs. Let w and w^* be the domestic and foreign wage rates for low-skilled labor. Then a firm will choose to offshore those L-tasks (with low indexes i) for which $\beta t(i)w^* < w$ and to keep in close proximity those tasks (with high indexes i) for which $\beta t(i)w^* > w$. We denote by I the index of the marginal task, which is the one that entails a similar cost in either location. Then

$$w = \beta t(I)w^*. \tag{1}$$

Note that I also is the fraction of L-tasks performed offshore, because we have constructed the index of tasks to run from 0 to 1.[12]

Now consider the cost c of producing one unit of some good. This cost comprises the amount paid to domestic low-skilled labor for L-tasks performed at home, the amount paid to foreign low-skilled labor for L-tasks performed abroad, the amount paid to high-skilled labor for performing H-tasks, and the amount paid to any other factors that may be used in production. In symbols,

$$c = wa_L(1 - I) + w^*a_L\beta T(I) + sa_H + \dots\ , \tag{2}$$

where a_L is the amount of domestic low-skilled labor used by the industry to perform a typical L-task, a_H is the amount of high-skilled labor used to perform a typical H-task, and s is the domestic wage of high-skilled labor. The factor intensities, a_L and a_H, may be fixed by the technical requirements of production, or they may reflect the firms' optimal choices in the light of substitution opportunities and prevailing factor prices. The first term on the right-hand side of (2) represents the product of the wage and the amount of domestic low-skilled labor used per unit of output, where the latter is the labor input per task times the fraction of tasks $1-I$ that the firm chooses to undertake at home. The second term on the right-hand side of (2) represents, analogously, the wage payments to foreign unskilled workers. Here, $\beta T(I)$ is the ratio of foreign labor to domestic labor that is needed to perform *all of the tasks with indexes less than or equal to* I.[13] This ratio exceeds one to an extent that reflects the extra costs associated with remote performance of this set of tasks. The third term in (2) is the amount paid to domestic skilled labor per unit of output, considering (for the time being) that the tasks undertaken by these workers cannot be performed offshore. And so on for any

[12] Note that we are implicitly assuming that each L-task (H-task) is performed the same number of times. This is without loss of generality, because we can divide any task that is repeated multiple times into multiple tasks denoted by different indexes. As long as the resulting tasks have (slightly) different trade costs, the function $t(i)$ is increasing.

[13] Technically, $T(I) = \int_0^I t(i)di$.

additional factors.

Substituting (1) into (2), we find that

$$c = w\Omega a_L + sa_H + \ldots \tag{3}$$

where $\Omega < 1$.[14] This way of writing the unit cost emphasizes that the wage bill for low-skilled labor is a fraction of what it would be without the possibility of offshoring, before we take into account any changes in factor prices that result from offshoring and any substitution between factors that might take place. Notice that equation (3) looks just like the cost equation of a firm that has no opportunity to offshore but that employs low-skilled workers whose productivity is (inversely) measured by Ω. If such a firm were to experience an improvement in the productivity of its low-skilled labor, this would generate a direct cost savings for the firm in proportion to the product of its labor use per unit of output a_L and the domestic wage w. Similarly, when offshoring becomes less costly (lower β), so that Ω falls, this generates a cost savings for a firm that conducts some L-tasks abroad of a similar magnitude. In this sense, improvements in the feasibility of offshoring are economically equivalent to labor-augmenting technological progress!

5 The Consequences of a Reduction in Offshoring Costs

As we have discussed above, the revolution in information technology makes it economical for firms to offshore more tasks than ever before. We can examine the implications of this transformation in economic geography using the analytical framework described in Section 4. Recall that we used $\beta t(i)$ to represent the ratio of the foreign labor needed to perform task i in a given industry relative to the domestic labor needed to perform the same task. The costs of offshoring have been falling over time, thanks to the fax machine, E-mail, mobile telephony, video-conferencing, and the like. We can model these trends as a decline in β that shifts the schedule of offshoring costs downward.

Accounting for all the effects of a reduction in the cost of offshoring requires a general equilibrium model of production and trade. We have developed such a model in Grossman and Rossi-Hansberg (2006). As we have noted before, the model has two sectors, one that produces an export good and another that can produce goods that compete with imports. Both sectors are assumed to be perfectly competitive, although our conclusions would be much the same in a model with fixed mark-ups of prices over unit costs. The model allows

[14] It is easy to see that

$$\Omega = 1 - I + \frac{T(I)}{t(I)} \ .$$

Since the least-cost tasks are offshored first the excess labor requirement for the marginal task, $t(I)$, exceeds the average excess foreign labor requirement, $T(I)/I$, so $T(I)/t(I) < I$.

for two, three, or many factors of production.

We have not as yet discussed how the costs of offshoring L-tasks in the import-competing industry compare to those for offshoring such tasks in the export sector. It may be easier to perform remotely a given fraction of the L-tasks used to produce textiles than the L-tasks used in providing financial services. Or the opposite may be true. And improvements in communications and transportation technologies may reduce offshoring costs more dramatically in one industry than the other. We know of no evidence that speaks to whether offshoring of L-tasks is easier in import-competing industries or export industries.[15] Without any data to guide us, we focus first on the neutral case in which offshoring possibilities are similar across industries; i.e., the same $t(i)$ schedule applies to both sectors and the same cost parameter β applies as well. Consideration of other possibilities is postponed until Section 5.4.

A fall in the cost of offshoring L-tasks affects the domestic market for unskilled labor via several channels. First, it reduces the cost of performing the low-skilled tasks, as we emphasized in Section 4. Second, it creates an imbalance between labor demand and labor supply at the initial factor prices, output levels, and techniques of production, because firms will have incentive to substitute foreign labor for domestic labor in performing certain additional tasks. The effects of this imbalance are analogous to those of an increase in the domestic supply of low-skilled labor. Finally, it provides different incentives for the two sectors to expand, which changes the composition of output at the initial prices. If the offshoring country is a large one such as the United States, this would create imbalances in world markets at the initial prices, and so the relative price of goods must respond to preserve market-clearing. Such changes in relative prices have further implications for factor rewards, as we know from traditional trade theory.

In Grossman and Rossi-Hansberg (2006), we show that the change in the domestic wage of low-skilled labor resulting from a decline in β can be decomposed into three components. Using a "hat" over a variable to represent a percentage change, we can write

$$\hat{w} = -\hat{\Omega} - \alpha_1 \hat{p} - \alpha_2 \frac{dI}{1-I} \tag{4}$$

where p is the relative price of the offshoring country's export good in terms of its import good, or its terms of trade.

We call the first term on the right-hand side of (4) the productivity effect. It has been overlooked in much of the previous academic literature and public discussion of offshoring.[16]

[15] Levy and Murnane (2004) suggest that more tasks using low-skilled labor can be offshored economically than tasks requiring high-skilled labor, although some of both can be performed remotely. But this is a different matter than the question of which industry can more efficiently offshore its low-skill tasks. We will discuss the more recent trends toward offshoring of white-collar jobs (H-Tasks) in Section 5.5 below.

[16] Jones and Kierzkowski (2001) find a related effect as a result of the "fragmentation" of the production process into two discrete parts. They consider the effects of technological change that makes it possible to perform these component parts of the process in a different country. They find that importing a component

All else equal, as a decline in the cost of offshoring leads more L-tasks to be sourced abroad, costs fall in proportion to low-skilled labor usage. The fall in Ω tends to boost demand for low-skilled labor and thus push up their wages. The second term on the right-hand side of (4) is a relative-price effect. A change in the ease of offshoring often will alter a country's terms of trade. If the home-country's terms of trade improve (p rises), this typically will exert downward pressure on the low-skill wage, because countries that offshore L-tasks usually export goods that rely more heavily on high-skilled labor than on low-skilled labor. The final term is a labor-supply effect. The expanded offshoring of L-tasks ($dI > 0$, where dI denotes the change in the set of tasks offshored) frees up the domestic labor that otherwise would perform these tasks, and so has effects analogous to an increase in the supply of this factor.

Similarly, the effect of improved prospects for offshoring L-tasks on the wages paid to high-skilled workers can be decomposed, to obtain

$$\hat{s} = \alpha_3 \hat{p} + \alpha_4 \frac{dI}{1-I} \ . \tag{5}$$

Notice that there is no direct, productivity effect; we see in (2) that a change in offshoring of low-skilled tasks has no direct effect on the firm's wage bill for high-skilled workers. To the extent that a change in offshoring improves the terms of trade, this will tend to benefit high-skilled workers in a country that exports skill-intensive goods. Also, the freeing up of domestic low-skilled labor that attends an offshoring of additional L-tasks can have beneficial implications for high-skilled workers.

The decompositions in (4) and (5) help us to think systematically about how improving communications technology and the resultant increase in task trade affects domestic factor markets. In the remainder of this section, we examine the effects of improved prospects for offshoring in various trading environments. In the next section, we use (4) as the basis for assessing the recent history of wage movements for blue-collar workers in the United States.

5.1 Offshoring in a Small Heckscher-Ohlin Economy

The most familiar framework for studying trade between more developed and less developed economies is the Heckscher-Ohlin model. The model features two industries and two factors of production. Each factor is employed relatively intensively in one of the industries. For example, the textile industry employs relatively more low-skilled workers than high-skilled workers, whereas the opposite is true in financial services. In this model, a country exports the good that makes intensive use of its relatively abundant factor.

We can add offshoring to the model in the manner d

5.3 Labor-Supply Effect

Leamer (2006) and others have drawn an analogy between increased opportunities for offshoring (and the increased integration of poor countries into the world economy more generally) and an expansion in the world supply of low-skilled labor. There is an element of truth to this argument, although we have seen that it captures only part of the story. But we have not yet seen any implications of this expanding labor supply for domestic wages. The explanation for this lies in a special property of the Heckscher-Ohlin model with incomplete specialization; factor growth can be accommodated by a change in the composition of output in each country, without any impact on factor prices.

In other trading environments, factor prices do respond to factor supplies. So, there is one further effect of improvements in opportunities for the offshoring of L-tasks that bears discussing. The simplest setting in which to see it is one in which the offshoring economy is specialized in producing a single good.[19]

Consider a small country that produces a single good and takes the world price of that good and the foreign wage as given. As the cost of offshoring L-tasks falls, firms there move more tasks abroad. This raises productivity, but at the same time it increases the total amount of low-skilled labor (foreign and domestic) that is combined with a fixed supply of high-skilled labor. There are offsetting effects on the wage of the country's low-skilled labor. In Grossman and Rossi-Hansberg (2006) we show that the low-skill wage must fall if the initial volume of offshoring is small, but as task trade grows, the adverse effects on low-skill wages may be reversed. The (positive) productivity effect is more likely to dominate the (negative) labor-supply effect if the share of low-skilled labor in total costs is large, the elasticity of substitution between low and high-skilled labor is large, and if the costs of offshoring rise sharply with the fraction of tasks that is sourced abroad. Our calculations in the next section, which are meant to shed some light on the relative size of the productivity and labor-supply effects of task trade, suggest that the former effect may well dominate the latter for American blue-collar workers.

5.4 Offshoring that is Concentrated in Certain Industries

Until now, we have discussed the effects of offshoring when firms in all sectors of the economy face similar costs of moving tasks abroad. This seems to us the natural case to address, because offshoring has become widespread across many different manufacturing and service industries. No doubt it is easier to offshore tasks in some sectors than others. But we see no reason to suspect that the ease of offshoring low-skilled tasks is systematically related to the overall skill intensity of the industry.

[19] More generally, factor prices will respond to factor supplies whenever the number of a country's factors of production exceeds the number of tradable goods that it produces.

But for those whose reading of the (scant) evidence is different from ours, it is easy enough to adapt our framework to study offshoring that occurs predominantly in certain industries. In the special case where offshoring of L-tasks is heavily concentrated in labor-intensive industries such as textiles and apparel, reductions in the cost of offshoring have effects similar to those of technological progress that is concentrated in such industries.[20] Alternatively, if industries that rely heavily on input of highly-skilled labor such as pharmaceuticals and finance are the ones that can most readily move their L-tasks abroad, then reductions in the costs of offshoring will generate wage responses like those of technological progress in these industries. And we know from Jones (1965), Leamer (1998) and others that technological progress in an industry tends to benefit the factors that are used most intensively there. So, improvements in the ease of offshoring L-tasks in labor-intensive manufacturing industries will tend to benefit low-skilled workers even more than in the neutral case described above, whereas high-skill workers will benefit from improved possibilities for offshoring L-tasks in skill-intensive industries.

5.5 Offshoring Tasks Performed by Skilled Workers

The offshoring of white-collar jobs has created even more media frenzy than the migration of blue-collar jobs. Although the evidence suggests that the offshoring of tasks requiring great skill has been modest to date, there can be little doubt that the future holds more of this. What will be the consequences for U.S. labor markets?

The framework developed in Grossman and Rossi-Hansberg (2006) can readily accommodate the offshoring of tasks that require high-skilled labor. We can introduce a schedule analogous to that for L-tasks that represents the extra foreign labor needed to perform a given H-task. Skilled workers in China and India earn less than their counterparts in the United States and Europe, because the state of technology there continues to lag that in the leading economies. Firms in the advanced countries thus have an incentive to offshore those H-tasks that can be performed remotely without significant trade costs.

Our analysis of trade in H-tasks is straightforward, and should hold few surprises at this point. In general, such offshoring generates a productivity effect, a relative-price effect, and a factor-supply effect, much like the offshoring of L-tasks. But the incidence is different. The productivity effect redounds to the benefit of the more educated domestic workers; e.g., the American software engineer who can design more programs because a substantial part of the code is written in India. The relative-price effect works against the high-skill workers—as the skill-intensive sector expands, the relative price of its output falls, which raises wages for low-skilled workers while reducing those for high-skilled workers. And the additional

[20] Jones and Kierzkowski (2001) make this point forcefully in their discussion of the fragmentation of production in one industry into two component parts.

opportunities for offshoring white-collar tasks act like an expansion in the supply of high-skill labor, which may further boost the wages of the less skilled and offset the productivity gains for the more educated parts of the workforce. In sum, the bottom tier of the American wage distribution should benefit from further expansion in the offshoring of high-skill tasks, and the middle and upper tiers may gain as well, if the productivity boost is large enough.

So far we have focused attention on cases in which offshoring costs fall for tasks performed by either low-skilled labor or high-skilled labor. However, a distinct possibility is that the ease of offshoring is independent of skill level (Blinder (2006)). In such circumstances, a decrease in the cost of offshoring all tasks in the economy will generate a productivity effect for both factors. Overall, this fall in offshoring costs will resemble a factor-neutral increase in productivity, without any effect on the relative price or relative factor supplies. The result is a similar increase in the wages of *all* workers.

6 A Back-of-the-Envelope Calculation

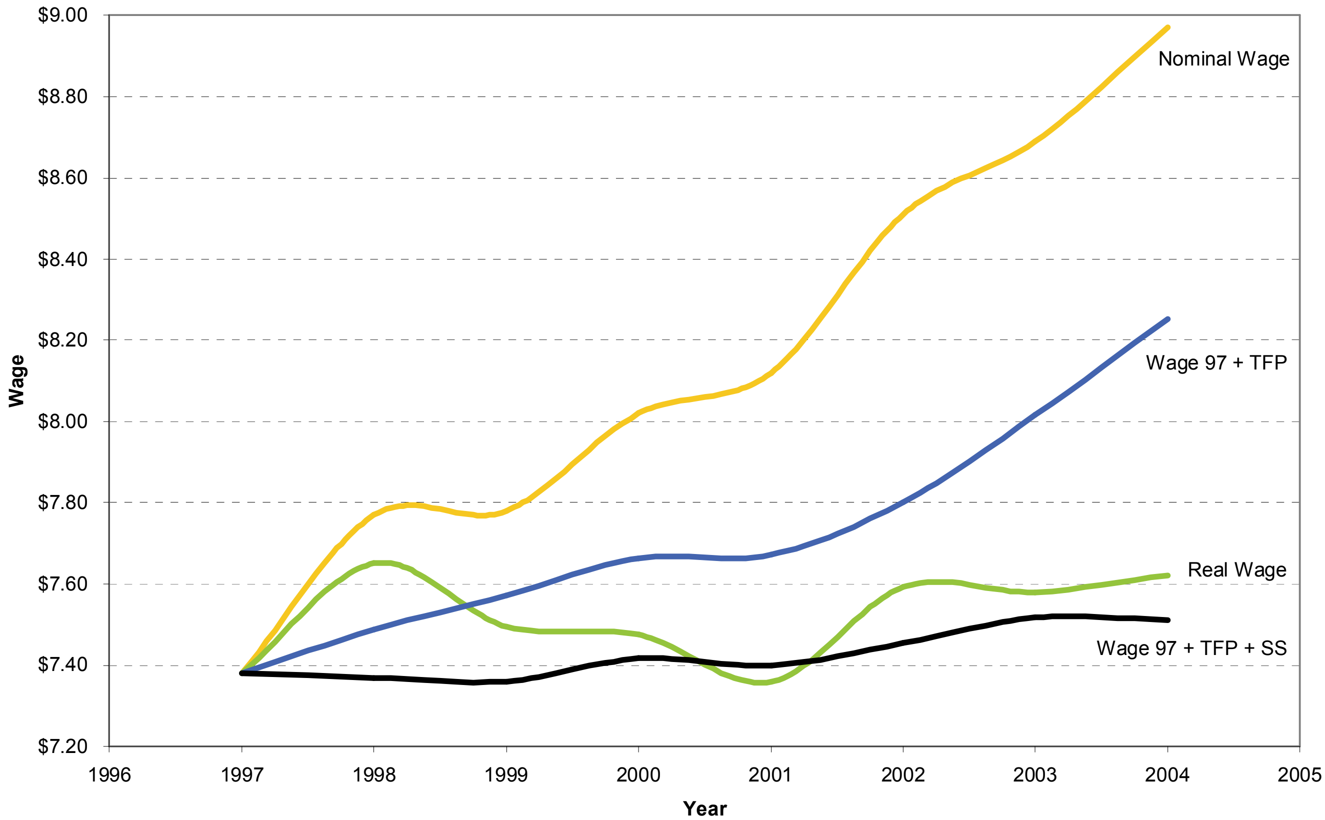
Ideally, we would like to be able to isolate the productivity, relative-price, and labor-supply effects that have resulted from the recent growth in task trade by U.S. firms. However, considering the pitfalls that exist in measuring the extent of such trade, it is difficult if not impossible to distinguish the labor-market effects of increased offshoring from other trends in the world economy. Accordingly, we shall settle for a more modest approach. We shall ask whether recent trends in the wages of low-skilled workers in the United States are consistent with the existence of a positive productivity effect from increased offshoring. We do so by identifying a residual component of real wage movements for low-skilled workers after accounting for the estimated effects of total factor productivity growth and of terms-of-trade changes. In our model, the residual component represents the combined effects of the labor-supply expansion and productivity enhancement that result from improved opportunities for offshoring. We find that the residual has been almost uniformly positive over the period from 1998 to 2004, a finding that is consistent with the existence of a positive productivity effect from increased offshoring that has bolstered the wages of low-skilled Americans.

The lightest curve in Figure 5 shows the movement in hourly wages for low-skill blue-collar workers from 1997 through 2004. We measure the wages of low-skilled blue-collar workers as the compensation of Level 1 blue-collar workers in the National Compensation Survey.[21] As an alternative measure of the wages of American low-skilled labor, we show in Figure 6 the time series for average hourly wages among all blue-collar workers. The wage of low-skill blue-collar workers has risen from $7.38 per hour in 1997 to $8.97 per hour in

[21] The National Compensation Survey assigns levels to different types of jobs depending on their knowledge, supervision received, the type of guidelines available, complexity, scope, contacts required, physical demands and work environment. Level 1 workers do the simplest tasks according to this classification.

2004. The hourly wage of the average blue-collar worker has risen from $12.36 to $15.46 during this period. The second-lightest curve in each figure shows the pertinent real wage after adjusting for inflation of the Consumer Price Index. Real wages of the least-skilled and average blue-collar worker have risen modestly over the period.

Figure 5: Low-Skill Blue-Collar Wage Decomposition



The second-darkest curve in Figure 5 (labelled "Wage 97 + TFP") shows the hourly wages that low-skill blue-collar workers would have earned in each year subsequent to 1997 had the path of wages followed the path of measured total factor productivity (TFP) growth in the United States after 1997.[22] The analogous curve in Figure 6 has a similar interpretation for wages of the average blue-collar worker. In adjusting for TFP growth in this way, we make two implicit assumptions. First, we assume that technological progress in the United States from 1997 to 2004 was "factor neutral," so that the productivity of low-skilled workers increased by the same amount as the productivity of more-skilled workers, and of other factors of

[22] For TFP, we use the Bureau of Labor Statistics calculation of Multifactor Productivity for Private Nonfarm Businesses.

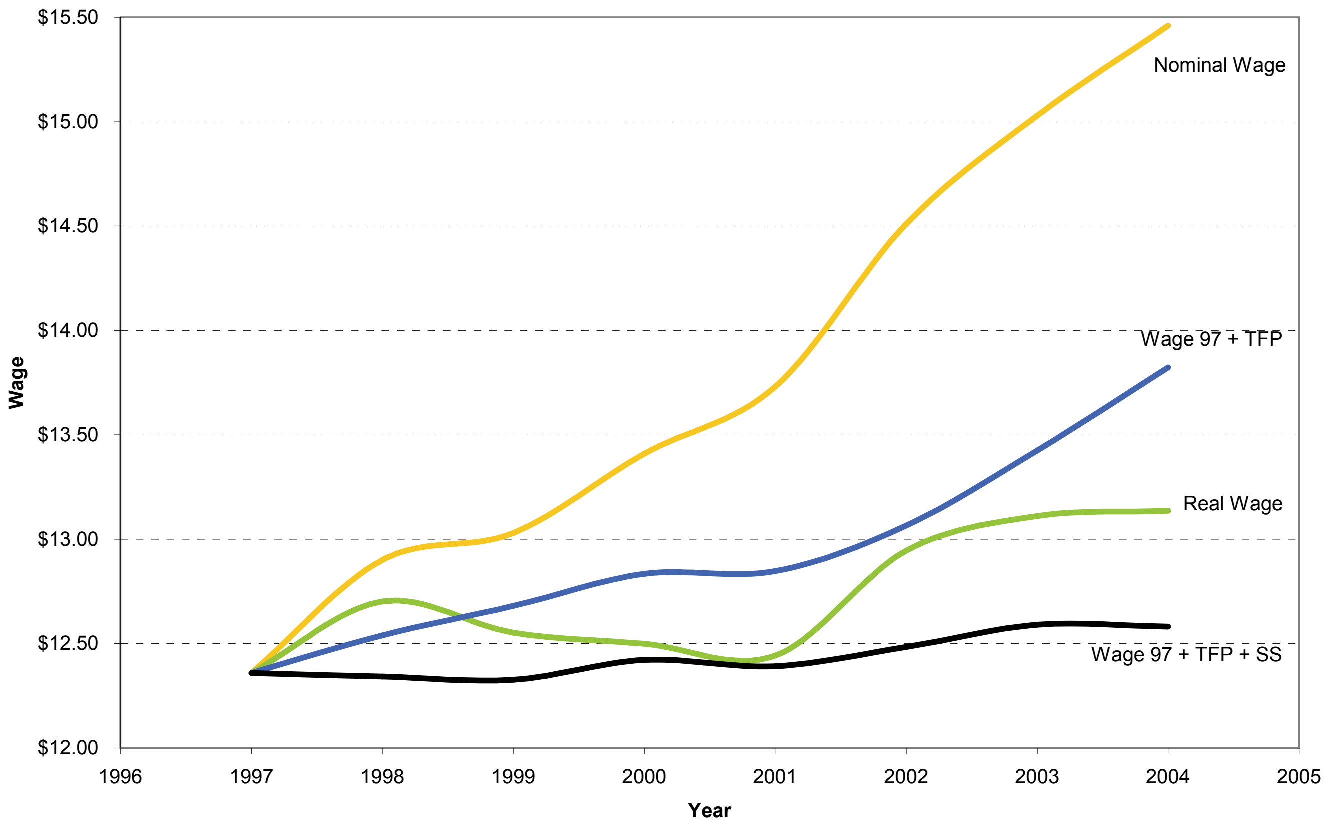
production. These circumstances would justify our use of TFP as a productivity adjustment for low-skilled workers. In fact, many labor economists have argued that recent technological progress in the United States has been "skill-biased," and not neutral. If so, then our method underestimates the beneficial effects of offshoring, as we shall discuss shortly.

Second, we assume that the measured growth in TFP has not been due to offshoring. Observe that we do not adjust wages using a direct measure of labor productivity (such as output per hour), but rather an average measure of the productivity of all factors of production in the U.S. economy. This approach is suggested by our analysis, which shows that the productivity gains from increased offshoring are indistinguishable from (low-skill) labor augmenting technological progress. Therefore, if we were to adjust wages by an ideal measure of the productivity of low-skilled labor, we would eliminate the very effect that we are trying to identify in the data. By instead using TFP to adjust wages, we take out the general trend in American productivity while leaving the impacts of any labor-biased technological change. To the extent that offshoring has been responsible for part of the measured increase in TFP, our approach will understate the productivity effect. We believe, however, that this bias in our measurement is small, because the contribution of increased offshoring of low-skill tasks to TFP is the product of the equivalent labor augmenting technological progress and the income share of low-skilled labor, and the least-skilled blue collar workers capture only a small share of total U.S. factor income.

A further caveat to our approach concerns capital deepening. When the capital-to-labor ratio rises, labor productivity will grow by more than the measured increase in TFP. To the extent that the accumulated capital is complementary to low-skill labor, the capital deepening may bolster low-skill wages in a way that resembles the effect of offshoring that we are trying to isolate. There is some evidence that capital deepening has contributed to *overall* labor productivity and therefore, presumably, to *average* wages during the period under consideration. However, as Corrado, Hulten and Sichel (2005) argue, more than three quarters of the effect of capital deepening on labor productivity can be traced to the accumulation of information technology and software. Labor economists have shown that computers complement high-skilled labor, but substitute for low-skilled labor (see, for example, Krueger, 1993). Therefore, the capital deepening that has occurred probably has contributed mostly to high-skill wages and little if any to low-skill wages, and thus is properly omitted from our analysis.

The figures show that the real wages of low-skill blue-collar workers and of the average blue collar worker have not kept up with overall productivity growth in the U.S. economy. One reason for this might be the labor-market implications of "globalization" as reflected in recent movements in the U.S. terms of trade. Next, we will attempt to account for the effect of the terms-of-trade experience on U.S. wages.

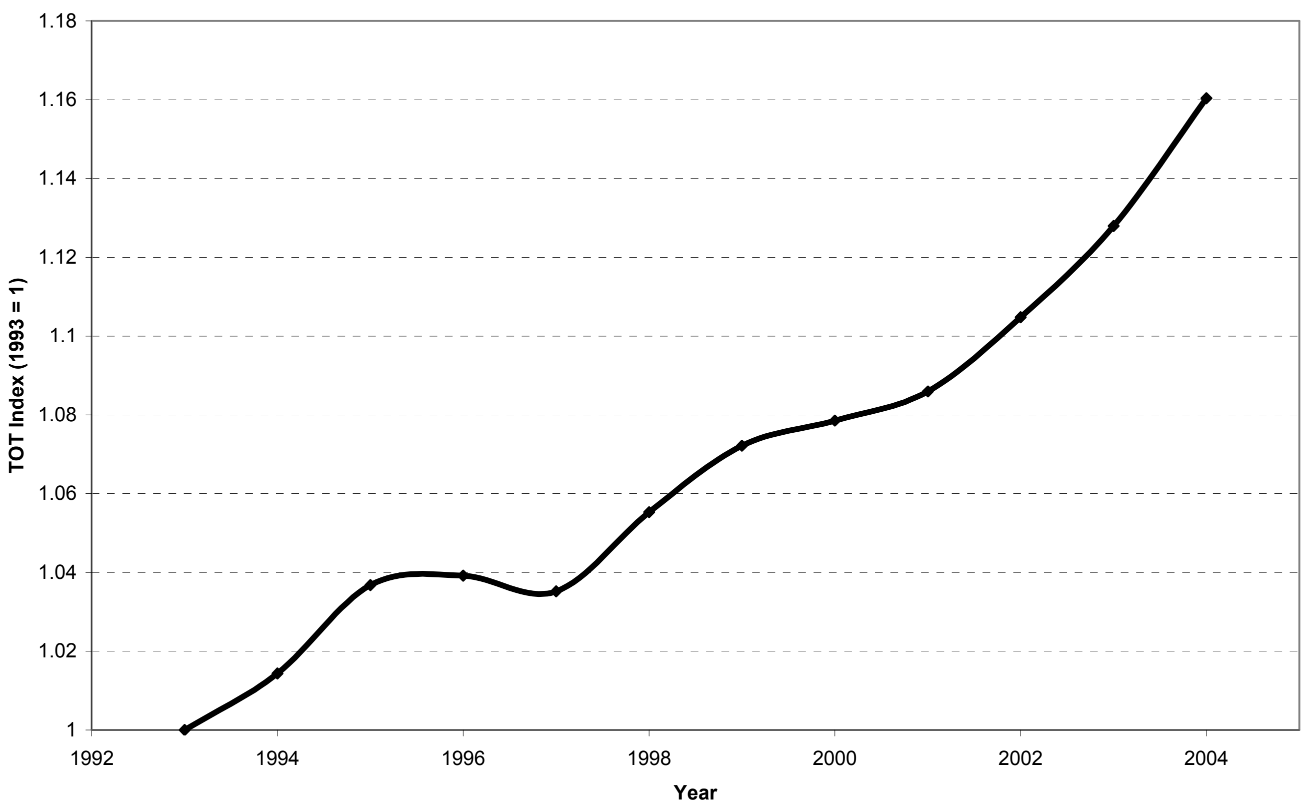
Figure 6: Average Blue Collar Wage Decomposition



As we have noted, part of the movement in terms of trade may have been due to improved possibilities for offshoring. Indeed, the Heckscher-Ohlin variant of our model of offshoring predicts that as the cost of offshoring L-tasks falls, the relative world output of labor-intensive goods should rise, thereby exerting downward pressure on the relative price of these goods. However, the improved opportunities for offshoring are hardly the only—or even the most important—factor that has moved the U.S. terms of trade. For one thing, petroleum prices have risen precipitously during the period under consideration. But as these prices play no explicit role in our model, we can avoid confounding the forces of globalization with those of oil price hikes by choosing a measure of the terms of trade that excludes these prices. Still, movements in the relative prices of goods and services traded between the United States and the labor-rich economies in Asia and Latin American have moved for reasons having little to do with offshoring. As is well known, China and India have experienced dramatic growth in recent years as these countries have improved their regulatory environments, removed impediments to investment and entry, and more fully joined the world economy. Both trade liberalization and productivity growth in these economies could account for an expansion in the relative world supply of labor-intensive goods. Since we cannot separate the part of the terms-of-trade movements due to improved offshoring from that due to productivity growth and trade liberalization in the developing countries, we shall simply lump them together and estimate what combined effect they may have had on U.S. low-skill wages.

Our model highlights trade between advanced economies and developing economies as a source of wage movements. In an attempt to capture this effect empirically, we use a measure of U.S. terms of trade with the non-industrialized countries. The best available measure is the one shown in Figure 7. For the numerator, we use the BLS price index for U.S. exports to all destinations, because indexes for exports to particular countries or regions are not available. For the denominator, we use the BLS price index for U.S. imports of manufactured products from non-industrialized countries. The figure shows a sharp improvement in the U.S. terms of trade vis-à-vis the non-industrialized countries. From 1997 to 2004, the total improvement was 10.8 percent, averaging 1.4 percent per year at an annual, compounded, rate.

Figure 7: US-Non-Industrialized Countries Terms of Trade
Source: BLS



In order to estimate what this terms-of-trade improvement might have meant for the wages of low-skilled American workers, we need to know how domestic wages respond to relative international prices; i.e., the coefficient α_1 in equation (4). In the Heckscher-Ohlin model, which we use as the basis for our calculation,

$$\alpha_1 = \frac{1 - \theta_{LM}}{\theta_{LM} - \theta_{LX}} ,$$

where θ_{LM} is the cost share of low-skilled labor in the relatively labor-intensive import-competing industry and θ_{LX} is the cost share of low-skilled labor in the relatively skill-intensive export industry. We do not have ready access to low-skilled labor shares for the average good imported from non-industrialized countries or the average good exported to such countries. Instead, we calculate the labor share in value added, using data published by the Bureau of Economic Analysis, for some representative industries.[23] Note that α_1 is smaller, and thus the impact of terms-of-trade movements on wages is smaller, the larger is the assumed difference in factor intensities. For our benchmark calculation, we choose two industries, one that competes with imports from the less developed countries and the other that exports to these countries, that have quite different labor shares. These are Textile Mills and Textile Product Mills, where the labor share in value added averages 0.76 over the period, and Chemical Products, where the labor share in value added averages 0.44 over the period. To the extent that these differences in labor shares exaggerate the factor intensity differential for goods that the United States imports from non-industrialized countries and exports to these countries, our proxies will cause us to underestimate the beneficial impact of offshoring on low-skill wages.

In Figures 5 and 6, the darkest curve (labelled "Wage 97 + TFP + SS", where SS is an abbreviation for Stolper-Samuelson) subtracts from "Wage 97 + TFP" the computed adverse impact of terms-of-trade changes on the wages of those with low skills in our baseline case. In other words, these darkest curves illustrate what wages for the low-skilled blue-collar worker and the average blue-collar worker would have been had TFP and the U.S. terms of trade vis-à-vis non-industrialized countries been the only factors affecting wages. As is evident in Figures 5 and 6 the negative relative-price effect almost cancels the positive effect of TFP on real wages, so these two forces together imply that the low-skill wage should have been approximately constant. The gap between the "Wage 97 + TFP + SS" curve and the path of real wages is the part of the wage experience that cannot be explained by changes in total factor productivity and changes in the terms of trade. In our model, this residual reflects the labor-supply effect and the productivity effect (but not the relative-price effect) of increased offshoring by American firms.

[23] Note that although we have thus far grouped tasks into those performed by low-skilled labor and those performed by high-skilled labor, we could instead group taks into those performed by labor and those performed by other factors. Then, our use of labor shares for calculating the Stolper-Samuelson coefficients would be justified, although we would still need to calculate these shares for the representative exported and imported goods.

Notice that "Wage 97 + TFP + SS" lies below the real wage curve of low-skilled blue-collar workers in all years between 1997 and 2004, except 2001, and that it lies below the real wage curve for the average blue-collar worker throughout the period. If we interpret the residual as being the combined labor-supply effect and productivity-effect of offshoring, then the combined effect has been positive, suggesting a beneficial productivity effect that has more than offset any adverse labor-supply effect. In the first row of Table 1, we indicate that on average for the period from 1998 through 2004, the residual has been 0.25 percent per year for low-skill blue-collar workers and 0.65 percent for the average blue-collar worker. The last column shows the result of applying the same methods to the wages of low-skill white-collar workers, which yields an average residual of 0.06 percent per year.

Table 1: Residual = Productivity Effect + Labor-Supply Effect

Industries\Wages	Low-Skilled Blue-Collar	Average Blue-Collar	Low-Skilled White-Collar
Imports = Textile Mills & Textile Product Mills Exports = Chemical Products	0.25%	0.65%	0.06%
Imports = Manufacturing Exports = Finance, Insurance & Real Estate	0.38%	0.78%	0.19%
Imports = Goods Exports = Services	5.49%	5.90%	5.30%

The remainder of Table 1 shows the average residuals that result when alternative measures of the Stolper-Samuelson coefficient are used. In the second row, we measure α_1 using for θ_{LM} the average labor share in value added for all manufacturing industries (as a proxy for the labor share in import-competing industries) and for θ_{LX} the average labor share in Finance, Insurance and Real Estate, which is an exported service for the United States. These labor share differentials are smaller than for textiles and chemicals, so the estimated residuals are larger. Finally, the third row uses the labor shares in all goods as a proxy for the share in import-competing sectors, and the labor shares in all services as a proxy for the share in all export sectors. These values for θ_{LM} and θ_{LX} imply even larger, positive residuals. We conclude that our methods conservatively indicate that American workers are earning more in recent years than can be explained based on realized TFP gains and realized relative-price effects since 1997.

Although the real wage growth for low-skilled workers in the United States has been far from exceptional (and, some might say, "far from acceptable"), the experience apparently has not been as bad as one might have expected based on the sharp improvement in U.S. terms of trade vis-à-vis the non-industrialized countries. Our finding is consistent with the hypothesis that increased offshoring has been a countervailing force that has supported American wages. But are there other factors that have been omitted from our analysis that could have contributed to the residual?

Three omitted factors come to mind. First, we have assumed in our calculations that recent technological progress in the United States has been neutral with respect to productivity growth for different factors of production. In fact, many labor economists believe that recent technological progress has been biased in favor of high-skilled labor.[24] By using TFP growth to adjust for the productivity gains of blue-collar workers, instead of the presumably smaller productivity gains that have been reaped by those with lesser skills, we have overstated the predicted real wages based on productivity and relative-price effects, and therefore understated the size of the residual. Thus, incorporating the bias in technological progress presumably would make our estimated effects of offshoring larger.

Second, the relative supply of skilled workers has been growing in the United States for some time. Between 1997 and 2004 the ratio of the United States labor force with some college education or more and the labor force with high school education or less increased by 16.1 percent from 1.28 to 1.49, according to the Current Population Survey. Much like an inflow of foreign workers, an expansion in the relative supply of skilled workers conceivably can be accommodated without any change in wages, if the skill-intensive sectors can expand to absorb these workers without any reduction in their marginal product. Indeed, the Heckscher-Ohlin model would predict that a change in the relative factor supply has no effect on factor prices, since workers can be absorbed via changes in the relative sizes of labor-intensive and skill-intensive industries.[25] But, if factor supplies do affect American wages, then the growth in the relative supply of skilled labor may be one factor besides the productivity effect of offshoring that has buffeted the wages of the lesser-skilled workers. However, it would be surprising if this were the main factor affecting wages, because an increase in the relative supply of skilled workers should, if anything, reduce the relative wages of those with ample skills, whereas the skill premium has been rising in the United States over time.

Third, we have neglected the effects of illegal immigration of low-skilled workers. The available estimates indicate that in the last decade the growth in the unauthorized population in the United States has averaged around half a million persons per year (Passel, 2006, and Hanson, 2006). If we include illegal immigrants in the calculation, the increase in the ratio of high and low-skilled workers is only 8.9 percent instead of 16.1 percent as we calculated above. However, the net effect is still an increase in the supply of skills and so the arguments

[24] See Katz and Murphy (1992), Autor, Katz and Krueger (1998), Acemoglu (2002), and Autor, Levy, and Murnane (2003), as well as the survey in Hornstein, Krusell and Violante (2005).

[25] The evidence seems to suggest that changes in the relative factor supply have no substantial impact on wages, as Card (1990, 2005), Hunt (1992) and Friedberg (2001), among others, have argued.

in the previous paragraph apply.

To summarize, our simple decomposition of the recent wage experience suggests that the real wages of American low-skilled workers were higher in 2004 than one would have expected based on the growth in total factor productivity and the improvements in the terms of trade that took place after 1997. This positive residual likely would be even larger than what we measured, had we been able to take into account the skill bias in technological progress during the period. The positive residual is consistent with there having been a positive productivity effect from offshoring that more than offset any negative labor-supply effect. However, even if the combined productivity effect and labor-supply effect of offshoring has been positive, we cannot infer that the total effect of offshoring has worked to the benefit of low-skilled workers without incorporating also the relative-price effect. Our calculations suggest that the rise in U.S. terms of trade vis-à-vis the non-industrialized countries has depressed low-skill wages to an extent that exceeds the positive residual. So, if all of this price movement has been due to improved opportunities for offshoring, the total effect of offshoring has been negative. We believe, however, that part of the U.S. terms-of-trade experience can be traced to other causes, such as productivity gains that have occurred in the non-industrialized countries and the further integration of these countries into the world economy. We conclude that the data leave room for a positive effect of offshoring on wages, consistent with the arguments in this paper.

7 Conclusion

The nature of production has changed dramatically since the time that David Ricardo proposed the basic concepts that underlie our understanding of international trade. In the past, countries produced mostly complete products that they consumed and traded with other nations. Producers took advantage of the productivity gains that derive from worker specialization by dividing the production process into a variety of tasks. But these tasks had to be performed in close proximity due to the large transportation and communication costs that prevailed at the time. Today, drastic reductions in these costs have facilitated direct trade in tasks, which has generated a global production process in a wide spectrum of industries. Now, producers and consumers can capture the traditional benefits that derive from worker specialization plus additional gains that are generated when tasks are located where they can be performed most cheaply. We have argued that to understand the consequences of this new way of organizing production we need to move away from the traditional approaches to trade in which only goods can be exchanged internationally, and move toward a new paradigm in which task trade takes center stage.

Within this new paradigm, we have studied the effect that task trade—or offshoring—has on factor prices. Our analysis leads to a very clear, and perhaps surprising, conclusion. If some tasks can be more easily traded than others, the offshoring of tasks produced with a particular factor is equivalent to technological progress that augments the productivity of that factor. For example, the effect on low-skill wages of improved opportunities for offshoring low-skilled tasks is similar to the effect on these wages of improvements in the productivity of low-skilled workers. No reasonable economist, commentator, or policy maker has ever raised her voice against improvements in labor productivity. However, we do find many vocal critics of offshoring. Hopefully, our simple paper will serve to highlight this inconsistency.

To further analyze the implications of increased offshoring for factor prices, we decomposed the effect of offshoring on low-skill wages into three component parts: a productivity effect, a relative-price effect, and a labor supply-effect. Many critics of offshoring have focused exclusively on the last two of these components and have surmised that offshoring of low-skilled tasks surely must reduce low-skill wages or, in the presence of labor-market frictions, increase unemployment. Our analysis indicates that this reasoning is, at best, incomplete. The evidence for the United States for the period from 1997 to 2004 suggests that the combined productivity and labor-supply effect on low-skill wages has been positive and responsible for raising these wages by about a quarter of a percent per year. It is even possible that the overall effect of offshoring on low-skill wages has been positive during this period, if the part of the terms-of-trade movement that has been caused by offshoring has not been too large. Our calculations admittedly are crude and so must be taken with a grain of salt until a more thorough empirical study can be performed.

8 References

Acemoglu, Daron, (2002), "Technical Change, Inequality and the Labor Market," *Journal of Economic Literature*, 40:1, 7-72.

Antràs, Pol, (2003), "Firms, Contracts, and Trade Structure," *Quarterly Journal of Economics*, 118:4, 1375-1418.

Antràs, Pol and Elhanan Helpman, (2004), "Global Sourcing," *Journal of Political Economy*, 112:3, 552-580.

Autor, David, Lawrence Katz and Alan Krueger, (1998), "Computing Inequality: Have Computers Changed the Labor Market?," *Quarterly Journal of Economics*, 113:4, 1169-1213.

Autor David, Frank Levy and Richard Murnane, (2003), "The Skill Content Of Recent Technological Change: An Empirical Exploration," *Quarterly Journal of Economics*, 118:4, 1279-1333.

Baker, Unmesh, Simon Montlake, Hilary Hylton, Chris Daniels and Jenn Holmes, (2006), "Outsourcing Your Heart Elective Surgery in India? Medical Tourism is Booming, and U.S. Companies Trying to Contain Health-Care Costs are Starting to Take Notice," *Time*, May 29.

Bhagwati, Jagdish, Arvind Panagariya and T. N. Srinivasan, (2004), "The Muddles over Outsourcing," *Journal of Economic Perspectives*, 18:4, 93-114.

Blinder, Alan S., (2006), "Offshoring: The Next Industrial Revolution?," *Foreign Affairs*, 85:2, 113-128.

Burrows, Peter, (1995), "The Global Chip Payoff," *Business Week*, August 7.

Card, David, (1990), "The Impact of the Mariel Boatlift on the Miami Labor Market," *Industrial and Labor Relations Review*, 43:2, 245-257.

Card, David, (2005), "Is the New Immigration Really so Bad?," *The Economic Journal*, 115:507, F300-F323.

Corrado, Carol, Charles Hulten, and Daniel Sichel, (2005), "Measuring Capital and Technology: An Expanded Framework," in Carol Corrado, John Haltiwanger and Daniel Sichel, eds., *Measuring Capital in the New Economy*, Chicago, IL: NBER and The University of Chicago Press, 11-45.

Davis, Donald and David Weinstein, (2001), "An Account of Global Factor Trade," *American Economic Review*, 91:5, 1423-1453.

Dobbs, Lou, (2004), *Exporting America : Why Corporate Greed Is Shipping American Jobs Overseas*, New York, NY: Warner Business Books.

Feenstra Robert and Gordon Hanson, (1999), "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the U.S., 1972-1990," *Quarterly Journal of Economics*, 114:3, 907-940.

Friedberg, Rachel, (2001), "The Impact of Mass Migration on the Israeli Labor Market," *Quarterly Journal of Economics*, 116:4, 1373-1408.

Friedman, Thomas, (2004), "What Goes Around...," *The New York Times*, February 26.

Friedman, Thomas, (2005), *The World Is Flat: A Brief History Of The Twenty-first Century*, New York, NY: Farrar, Straus and Giroux.

Government Accountability Office, (2004), *International Trade: Current Government Data Provide Limited Insight into Offshoring of Services*, GAO-04-932.

Grossman, Gene M. and Elhanan Helpman, (2004), "Managerial Incentives and the International Organization of Production," *Journal of International Economics*, 63, 237-262.

Grossman, Gene M. and Esteban Rossi-Hansberg, (2006), "Trading Tasks: A Simple Theory of Offshoring," unpublished paper, Princeton University.

Hanson, Gordon H., (2006), "Illegal Migration from Mexico to the United States," forthcoming in the *Journal of Economic Literature*.

Hillberry, Russell and David Hummels, (2005), "Trade Responses to Geographic Frictions: A Decomposition Using MicroData," unpublished paper, Purdue University.

Hornstein, Andreas, Per Krusell and Giovanni Violante, (2005), "The Effects of Technical Change on Labor Market Inequalities," In *Handbook of Economic Growth 1B*, Elsevier Press: Amsterdam, 1275-1370.

Hummels, David, Jun Ishii and Kei-Mu Yi, (2001), "The Nature and Growth of Vertical Specialization in World Trade," *Journal of International Economics*, 54:1, 75-96.

Hunt, Jennifer, (1992), "The Impact of the 1962 Repatriates from Algeria on the French Labor Market," *Industrial and Labor Relations Review*, 45:3, 556-572.

Jones, Ronald W., (1965), "The Structure of Simple General Equilibrium Models," *Journal of Political Economy*, 73:6, 557-572.

Jones, Ronald W. and Henryk Kierzkowski, (2001), "Globalization and the Consequences of International Fragmentation," in Rudiger Dornbusch, ed., *Money, Capital Mobility and Trade: Essays in Honor of Robert A. Mundell*, Cambridge, MA: MIT Press, 365-383.

Katz, Lawrence and Kevin Murphy, (1992), "Changes in Relative Wages, 1963-87: Supply and Demand Factors," *Quarterly Journal of Economics*, 107:1, 35-78.

Kohler, Wilhelm (2004), "Aspects of International Fragmentation," *Review of International Economics*, 12:5, 793-816.

Krueger, Alan B., (1993), ""How Computers Have Changed the Wage Structure: Evidence From Microdata, 1984-1989," *Quarterly Journal of Economics*, 108:1, 33-61.

Leamer, Edward, (1998), "In Search of Stolper-Samuelson Linkages between International Trade and Lower Wages," in Susan M. Collins, ed., *Imports, Exports, and the American Worker*, Washington, DC: Brookings Institution Press, 141-203.

Leamer, Edward E., (2006), "A Flat World, A Level Playing Field, a Small World After All, or None of the Above?," forthcoming in the *Journal of Economic Literature.*

Leamer, Edward E. and Michael Storper, (2001), "The Economic Geography of the Internet Age," *Journal of International Business Studies*, 32:4, 641-665.

Levy, Frank and Ari Goelman, (2005), "Offshoring and Radiology," *Brookings Trade Forum 2005*, 411-423.

Levy, Frank and Richard Murnane, (2004), *The New Division of Labor*, Princeton, NJ: Princeton University Press.

Mankiw, Gregory and Phillip Swagel, (2005), "The Politics and Economics of Offshore Outsourcing," working paper, American Enterprise Institute for Public Policy.

National Research Council, (2006), *Analyzing the U.S. Content of Imports and the Foreign Content of Exports,* Washington DC: The National Academies Press.

Neary, Peter, (1978), "Short-Run Capital Specificity and the Pure Theory of International Trade," *Economic Journal*, 88, 488-510.

Passel, Jeffrey, (2006), "The Size and Characteristics of the Unauthorized Migrant Population in the U.S." *Pew Hispanic Center.*

Pollack, Andrew, (2003), "Who's Reading Your X-Ray?," *The New York Times*, November 16.

Ricardo, David, (1817), *The Principles of Political Economy and Taxation*, Reprinted in 1996, New York, NY: Prometheus Books.

Robertson Jesse, Dan Stone, Liza Niedewanger, Matthew Grocki, Erica Martin and Ed Smith, (2005), "Offshore Outsourcing of Tax-Return Preparation," *The CPA Journal,* June.

Samuelson, Paul A. , (2004), "Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization," *Journal of Economic Perspectives*, 18:3, 135-146.

Smith, Adam, (1776), *The Wealth of Nations*, Reprinted in 1937, New York, NY: Random House.

Stolper, Wolfgang F. and Paul A. Samuelson, (1941), "Protection and Real Wages," *The Review of Economic Studies*, 9:1, 58-73.

Tempest, Rone, (1996), "Barbie and the World Economy," *Los Angeles Times*, September 22.

Thurm, Scott, (2004), "Tough Shift – Lesson in India: Not Every Job Translates Overseas," *The New York Times*, March 3.

Trefler, Daniel, (1995), "The Case of Missing Trade and Other Mysteries," *American Economic Review*, 85:5, 1029-1046.

World Trade Organization, (1998), *Annual Report*, Geneva: World Trade Organization.