Volume Title: The Impact of International Trade on Wages

Volume Author/Editor: Robert C. Feenstra, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-23936-2

Volume URL: http://www.nber.org/books/feen00-1

Conference Date: February 27-28, 1998

Publication Date: January 2000

Chapter Title: What Are the Results of Product-Price Studies and What Can We Learn from Their Differences?

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Chapter URL: http://www.nber.org/chapters/c6192

Chapter pages in book: (p. 129 - 169)

4

What Are the Results of Product-Price Studies and What Can We Learn from Their Differences?

Matthew J. Slaughter

4.1 Introduction

In recent years many economists have analyzed whether international trade has contributed to rising U.S. wage inequality by changing relative product prices. In this paper I survey and synthesize the findings of these product-price studies.

The theoretical framework guiding this research is the Stolper-Samuelson (SS) theorem linking product-price changes to factor-price changes. The research discussed in this paper constitutes the first large body of empirical work applying the SS theorem to the data. Before these studies there was relatively little empirical research on the SS theorem. Deardorff's (1984) chapter in the *Handbook of International Economics,* entitled "Testing Trade Theories and Predicting Trade Flows," does not cite a single empirical study of it. And in a famous book commemorating the 50th anniversary of the landmark paper by Stolper and Samuelson (Deardorff and Stern 1994), of the 10 essays reprinted as "seminal contributions to the Stolper-Samuelson literature" (5), only one is empirical (Magee 1980).

My survey and synthesis of the product-price studies has three parts. First, borrowing language from Deardorff (1994) I lay out several theoretical statements of the SS theorem to preview some of the empirical issues involved in applying it to data.

Second, I survey the product-price studies on rising U.S. wage inequal-

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For helpful comments the author thanks Robert Baldwin and conference and preconference participants. The author thanks the Russell Sage Foundation for financial support through grants no. 85-96-18 and no. 85-97-18.

ity. In the following order I cover Bhagwati (1991), Lawrence and Slaughter (1993), Sachs and Shatz (1994), Feenstra and Hanson (1995), Leamer (1998), Baldwin and Cain (1997), Krueger (1997), Feenstra and Hanson (1999), and Harrigan and Balaban (1997). Together these nine studies demonstrate how the methodology has evolved. By surveying these papers in this order I can relate each study to those preceding it.

Finally, I synthesize the findings of these nine studies and draw two main conclusions. The first conclusion is that this literature has refined a set empirical strategies for applying the SS theorem to the data from which important methodological lessons can be learned. To preview some of the main results, the "facts" about product prices are relatively sensitive to the selection and weighting of industries sampled and to the decade considered. In contrast, the "facts" are relatively insensitive to the extent of data aggregation and the measurement of skills.

The second main conclusion is that despite the methodological progress that has been made, research to date still has fundamental limitations regarding the key question of how much international trade has contributed to rising wage inequality. Most importantly, more work needs to link the various exogenous forces attributable to international trade to actual product-price changes. Stated alternatively, the literature to date has made substantial progress understanding how to relate a given change in relative product prices to changes in relative factor prices. But it has made less progress understanding whether these product-price changes have anything to do with international trade. Two other important areas needing further work are the need to explore how slowly the Heckscher-Ohlin clock ticks and the need to complement product-price data with other data that might overcome potential limits of the product-price data.

The rest of the paper is organized as follows. Section 4.2 presents the theoretical framework for understanding the product-price studies. Section 4.3 surveys each of the nine studies. Section 4.4 synthesizes the studies and highlights the overall methodological progress. Section 4.5 discusses the limitations of these studies. The conclusions are stated in section 4.6.

4.2 Theory Guiding the Data: Alternative Statements of the Stolper-Samuelson Theorem

Deardorff (1994) surveys alternative statements of the SS theorem that have appeared during the past 50-plus years. Each articulation requires a different set of assumptions and thus applies to different contexts. Below I quote (verbatim) Deardorff's six versions. This list serves two purposes. First, it provides some theoretical context for judging how well researchers have related theory to data. Second, it previews some of the major empirical issues that researchers have had to address.

General Version: An increase in protection raises the real wage of the scarce factor of production and lowers the real wage of the abundant factor of production.

Restrictive Version: Free trade lowers the real wage of the scarce factor and raises that of the abundant factor compared to autarky.

Essential Version: An increase in the relative price of a good increases the real wage of the factor used intensively in producing that good and lowers the real wage of the other factor.

Strong Version with Even Technology: A rise in the price of any good, all other prices remaining constant, causes an increase in the real return to the factor used intensively in the producing that good and a fall in the real returns to all other factors.

Friends and Enemies Version: Every good is a friend to some factor and an enemy to some other factor.

Correlation Version: For any vector of goods-price changes, the accompanying vector of factor-price changes will be positively correlated with the factor-intensity-weighted averages of the goods-price changes.

Deardorff very clearly discusses the theoretical relationships among all six versions; the interested reader is strongly encouraged to read this discussion. To complement this, I make four points about applying these versions to the empirical issue of rising wage inequality.

First, only two of the versions mention anything about international trade. This underscores that the essence of all SS versions is the link between product prices and factor prices imposed by the zero-profit conditions equating price with average cost that must hold in all perfectly competitive industries with actual production.[1] These zero-profit conditions imply a systematic relationship between the entire set of product prices facing domestic producers and the entire set of factor prices paid by these producers. Analytically, the economy's entire set of zero-profit conditions can be written as follows:

$$P = A \times W, \tag{1}$$

where P is an $(N \times 1)$ vector of N domestic product prices, W is an $(M \times 1)$ vector of M domestic factor prices, and A is an $(N \times M)$ technology

1. Actually, product markets need not be perfectly competitive for the SS theorem to apply. What is truly essential is not perfect competition, but rather the existence of a systematic link between product prices and factor prices. Perfect competition is only one way of obtaining this systematic link: It restricts price to be just equal to average cost. An alternative might be imperfect competition that fosters a positive—but unchanging—price-cost markup. Another alternative, analyzed extensively in Helpman and Krugman (1985), is monopolistic competition in which sufficient entry by new firms ensures zero profits in equilibrium.

matrix (which might also depend on W) whose a_{ij} element tells the number of units of factor i required to produce one unit of product j. Each row of equation (1) corresponds to one of the N products, and in words the equation says that for each product price equals average costs. It is important to notice that factor prices are not indexed by industry; with the assumption of perfect interindustry factor mobility, each factor has only one national price. This is a key aspect of all versions of the SS theorem.

Holding constant technology, equation (1) can be rewritten in terms of percentage changes for (sufficiently small) changes. This yields the following equation:

$$P^* = \theta \times W^*, \tag{2}$$

where P^* is an $(N \times 1)$ vector of N domestic product-price changes, W^* is an $(M \times 1)$ vector of M domestic factor-price changes, and θ is an $(N \times M)$ initial cost-share matrix (which depends on technology and, perhaps, W), whose θ_{ij} element tells the share of factor i in the average costs incurred producing one unit of product j.[2] Changes in product prices faced by domestic firms generate changes in domestic factor prices paid by firms as described by equation (2). This is true whether the product-price changes are caused by international trade or any other force. Indeed, many SS versions apply even to countries in autarky with all products nontraded. The empirical implication of this is the need for a way to determine what portion of observed product-price changes are attributable to international trade. Equation (2) will be an important reference point.

It is worth emphasizing that the phrase "caused by international trade" must be treated carefully. As Deardorff and Hakura (1994) discuss, this phrase can be misleading in that international trade (i.e., the flows of goods and services across countries) is the endogenous outcome of (among other things) international differences in tastes, technology, endowments, and barriers to trade. International trade and product prices are simultaneously caused by things; trade does not cause product-price changes. Thus, attributing causality from international trade to domestic product prices requires a bit more precise language. Specifically, it requires reference to some aspect of the international-trade equilibrium that can be plausibly taken as exogenous to domestic product prices.

Following Deardorff and Hakura, I propose four distinct restatements of the phrase "international trade can change domestic product prices," each of which elaborates on "international trade."

1. A change in domestic political barriers to trade can change domestic product prices.

2. Note that going from equation (1) to equation (2) uses the fact that cost minimization implies that $dA \times W = 0$. This says that any small changes in factor use must not change costs, given that costs were initially minimized.

2. A change in foreign political barriers to trade can change domestic product prices.

3. A change in international natural barriers to trade can change domestic product prices.

4. A change in foreign tastes, technology, and/or endowments can change domestic product prices.

Think of domestic product prices as depending both on international product prices and on any trade barriers that wedge between international and domestic prices. If the country is small, then international prices are independent of domestic trade barriers and other parameters. Otherwise, domestic trade barriers and other domestic parameters do affect international prices. Given this setup, statements 1 through 3 address how domestic prices depend on the wedge—and, if the country is large, how they depend on international prices as well. Statement 4 addresses how domestic prices depend on developments abroad communicated to the domestic economy through changes in international prices.

Overall, to meaningfully analyze whether "international trade changes product prices," one must have sufficient data to restate the issue into something like one of these four statements. Without some data on trade barriers, tastes, technology, and endowments, actual price changes cannot be empirically linked to some exogenous aspect of international trade.

A second key point about Deardorff's six SS versions is that the best guide for empirical work depends on the world's dimensionality. The first three versions hold only in worlds with two factors and two products. The Strong Version holds only for worlds with the same number of factors and products (more than two allowed) and only under certain technology restrictions. Only the last two versions hold for any arbitrary number of factors and products. If one thinks that the world cannot be reasonably approximated as two by two, then one should focus on the last three versions. If one is uncomfortable assuming the world is even, then one should focus on the last two versions.

The third key point is that only the Correlation Version directly addresses something other than real-wage changes. This matters because all nine product-price studies surveyed here focus on rising inequality, not the absolute losses of the less skilled.[3] In light of the discussion regarding dimensionality, this point suggests that the Correlation Version might be the best guide for empirical work on relative wages. The Friends and Enemies Version focuses on the price change of only a single product, and it claims only that this single price change will raise the real return to one unidentifiable factor and lower the real return of some other unidentifiable

3. It is also true that most less-skilled workers have suffered real-wage declines in recent decades. For many less-skilled workers the declines have been staggering; for example, the real hourly earnings of male high school dropouts fell by 20 percent from 1979 to 1993.

factor. In contrast, the Correlation Version relates any vector of relative product-price changes and allows these changes to be systematically related to relative factor-price changes to relative factor prices. Granted, one cannot predict for certain what will happen to any particular relative factor price. But one can say that, on average, factors employed intensively in rising- (falling-) price industries will experience relative price increases (declines). This result seems closest in spirit to the empirical issue of rising wage inequality.

The fourth key point is that all six SS versions do not consider intermediate inputs. In reality, intermediate inputs matter a lot; for nearly 40 years, in U.S. manufacturing input purchases have accounted for well over 50 percent of the value of final shipments. Accordingly, any empirical work must account for the fact that firms hire both primary factors and intermediate inputs. Rewriting equation (1) to account for intermediate inputs suggests alternative ways of doing this. Define matrix B as the $(N \times N)$ matrix of intermediate input requirements whose b_{ij} element tells the number of units of intermediate input i required to produce one unit of product j. Then the set of zero-profit conditions in (1) can be rewritten as follows:

$$P = B \times P + A \times W. \tag{3}$$

Equivalently, these zero-profit conditions can be rewritten two other ways:

$$P = [(I - B)^{-1} \times A] \times W, \tag{3'}$$

$$(P - BP) = A \times W, \tag{3''}$$

where I is an $(N \times N)$ identity matrix.

This suggests two alternative ways to account for intermediate inputs when linking product prices to factor prices. Following equation (3′), one can measure factor use not in direct terms, but rather in total terms, accounting both for direct factor use and indirect factor use through intermediate inputs. That is, one can relate factor prices to $[(I - B)^{-1} \times A]$ rather than just to A. Alternatively, following equation (3″), one can continue using just direct factor use as regressors, but construct the regressand to be gross output prices less input prices weighted by the B matrix.

To summarize this theoretical preview of the empirical work, these alternative versions of the SS theorem provide some helpful guideposts. Assume, as most researchers have, that the U.S. economy has less-than-free trade with countries abroad, more than two products and two factors, and intermediate inputs. Given these assumptions, the most appropriate version of the SS theorem for guiding empirical work is probably the Correlation Version. That is, for any given change in product prices and factor prices consistent with equation (2), in the data one should try to demonstrate the following:

(4) $$\mathrm{Cor}(P^*, \theta \times W^*) > 0.$$

All this requires a substantial amount of data. In terms of the explanatory variable, one needs some systematic way to identify the effect of one or more exogenous characteristics of international trade on domestic product prices while controlling for nontrade influences on these prices. To identify how this exogenous force of international trade affects relative wages, one also needs industry-level data on domestic product prices, and on the prices and quantities of inputs and factors employed.

4.3 A Survey of Nine Product-Price Studies

In this section I cover the following product-price studies: Bhagwati (1991), Lawrence and Slaughter (1993), Sachs and Shatz (1994), Feenstra and Hanson (1995), Leamer (1998), Baldwin and Cain (1997), Krueger (1997), Feenstra and Hanson (1999), and Harrigan and Balaban (1997). Together, these papers demonstrate how the methodology of product-price studies has evolved. Where appropriate, other related papers will be mentioned. By surveying these nine papers in this order I can relate each to the relevant work preceding it. For each paper, I refer the interested reader to exact pages with the key results. Table 4.1 summarizes key aspects of each of the nine studies (with some details and terminology to be clarified in the rest of this section).

Bhagwati (1991) is the first researcher I am aware of to link rising U.S. wage inequality to international trade working through product prices. He plots (51, fig. 7) quarterly observations from 1982 through 1989 of the U.S. price indexes for exports and imports of all manufactures aggregated together. Observing that import prices rose more quickly than the export prices after 1986, Bhagwati concludes that "the trade-focused explanation [of rising wage inequality thanks to declining relative prices of imported products which presumably employ less-skilled labor relatively intensively] . . . therefore carries little plausibility, at least at first blush" (51).

Lawrence and Slaughter (1993) (LS) are the first researchers to use price data disaggregated by industry and also to use direct measures of industry factor use. They use three sets of U.S. manufacturing prices: imports, exports, and domestic production. The export and import prices cover all industries at the two-digit and three-digit Standard Industrial Classification (SIC) levels for which the Bureau of Labor Statistics (BLS) assembles the data. These data do not cover all manufacturing industries; for example, the import prices cover 18 of the 20 two-digit SIC industries, but only about 50 of the 143 three-digit SIC industries. LS assume (195, n. 55) "that the price movements in these industries are reasonably representative" of all industries. The domestic prices cover all three-digit SIC industries. LS refer to the traded prices as "international prices" whose "changes . . . [are]

Table 4.1 **Summary of the Nine Product-Price Studies**

Study	Time Period	Methodology	Skills Measure	Key Results
Bhagwati (1991)	1980s	Description of time series of U.S. terms of trade	Assumes exports more skill-intensive than imports	No clear trend in terms of trade
Lawrence and Slaughter (1993)	1980s	Consistency-check regressions using U.S. manufacturing prices (export, import, and domestic)	Job classification	No clear trend in relative prices
Sachs and Shatz (1994)	1980s	Consistency-check regressions using U.S. manufacturing prices plus dummy for computer industry	Job classification; educational attainment	Relative-price declines in unskilled-intensive sectors
Feenstra and Hanson (1995)	1980s	Description of domestic prices vs. import prices for three countries	Assumes domestic activity skill-intensive relative to outsourced imports	Domestic prices rose by more than import prices did in all three countries

Leamer (1998)	1960s–80s	Mandated-wage regressions using U.S. domestic manufacturing prices and TFP data, too	Job classification; earnings per worker	Relative-price declines in unskilled-intensive sectors during 1970s only
Baldwin and Cain (1997)	1960s–80s	Mandated-wage regressions using U.S. manufacturing prices (export, import, and domestic)	Job classification; educational attainment	Relative-price declines in unskilled-intensive sectors during 1970s for some specifications
Krueger (1997)	1990s	Consistency-check regressions and mandated-wage regressions	Job classification; educational attainment; earnings per worker	Relative-price declines in unskilled-intensive sectors
Feenstra and Hanson (1999)	1980s	Mandated-wage regressions extended to a two-stage procedure with structural forces like outsourcing	Job classification	Outsourcing mandated rising inequality during 1980s
Harrigan and Balaban (1997)	1960s–80s	Regression analysis of cost-share equations from U.S. GDP function	Educational attainment	Relative-price declines of tradables relative to nontradables

prompted by international trade" (198–99). Thus, they model the United States as a small price-taking economy facing product prices determined exogenously abroad. For domestic prices, LS assume (202, n. 63) that "changes in these domestic price deflators tracked changes in international prices. This is a weaker assumption than the law of one price: it allows prices to differ across countries by some fixed constant," presumably due to U.S. trade barriers. Because LS assume that all product-price changes come from foreign developments, when analyzing industry differences in total factor productivity (TFP) growth, they assume that U.S. technology changes do not influence product prices (199).

For each price sample, LS test whether in the 1980s—defined as 1980–89—the prices of skilled-labor-intensive products rose relative to the prices of unskilled-labor-intensive products. Each industry's skill intensity is measured as the industry's direct employment ratio of nonproduction to production workers (*NPW/PW*). LS identify the pattern of price changes two ways. First, (196–97, figs. 8 and 9) they pool all industries in each price sample and regress the industries' percentage change in product prices over the 1980s against the industries' skill intensity in 1980. That is, they estimate via ordinary least squares (OLS) the following regression:

$$\text{(LS)} \qquad P_j^{*1980s} = \alpha + \beta(NPW/PW)_j^{1980} + e_j.$$

Second, to complement these regressions for each price sample they construct a weighted average of all decadal price changes using nonproduction-employment weights and then production-employment weights (199, table 3, and 203, table 4). For the domestic prices, LS construct these weighted averages for the 1970s and 1960s as well.

The basic finding by LS is that they estimate β to be 0 or negative, not positive, for their various series of traded prices: Industries with higher relative direct employment of nonproduction to production workers did not have larger price increases during the 1980s. These estimates are corroborated by the weighted averages. LS interpret these results as evidence against the hypothesis that international trade contributed to rising U.S. wage inequality by raising the relative price of skilled-labor-intensive products.

Sachs and Shatz (1994) (SSh) follow the LS methodology with two minor changes and one major change. First, they define the decade of the 1980s as 1978–89. Second, they use a slightly different dependent variable, the share of production employment in total industry employment. Their major difference from LS is the treatment of the computer industry (SIC 357 at the three-digit level, SIC 3573 at the four-digit level). They argue (37) that LS "should have separated the effects of computer prices from the other sectors." The reason is that the computer-industry price data are exceptionally mismeasured: "The relative prices of computers fell sharply during the decade, matching extraordinary productivity increases. The exact measurement of these price and productivity changes is highly problematic, so that it is important that these changes do not overwhelm the message in the rest of the data." Thus, using both import prices and the full sample of three-digit SIC domestic prices, SSh run the following regression using OLS:

$$\text{(SSh)} \quad P_j^{*1980s} = \alpha + \beta(PW/(PW + NPW))_j^{1980} + \beta_c(D_{\text{computers}}) + e_j.$$

The main results from these regressions (38, table 16) are that β is estimated to be negative (insignificantly so for import prices and significantly [with a *t*-statistic of −1.98] for domestic prices) while β_c is also estimated to be negative (very significantly so [*t*-statistic of −13.40] for domestic prices). Thus, SSh find among the noncomputer sample that industries employing a larger share of production workers had lower relative price increases over the 1980s. SSh conclude this supports the hypothesis that international trade contributed to rising U.S. wage inequality by raising the relative price of skilled-labor-intensive products.

Unlike the previous three papers, Feenstra and Hanson (1995) (FH95) analyze the data from a Ricardian perspective rather than a Heckscher-Ohlin perspective. In their framework countries make completely different sets of products, unlike the Heckscher-Ohlin framework where all countries are (usually) assumed to be in the same cone of diversification. Importantly, FH95 are the first researchers to move away from the assumption that U.S. prices merely reflect international prices for the same products. They highlight the fact that during the 1980s (defined as 1980 through 1989) in the United States, Germany, and Japan, domestic prices rose by more than import prices did (17–18, and 105, table 1). This fact is consistent with their model of international outsourcing, which raises wage inequality both in the United States and abroad (16, prop. 3). As marginal production activities relocate from the United States to countries abroad, the relative demand for skills rises in both countries. A corollary of this shift is that U.S. prices rise by more than foreign prices. Thus if one interprets U.S. import prices as representative of the basket of foreign production, the fact about domestic versus import prices is consistent with outsourcing raising U.S. (and foreign) wage inequality.

Leamer (1998) uses a Heckscher-Ohlin perspective to analyze the wage implications of product-price shifts during the 1960s (defined as 1961–71), 1970s (1971–81), and 1980s (1981–91). The data analysis has a descriptive component where "the empirical facts are presented with only a 'light' touch of the HO framework" followed by a "formal data analysis . . . which is based explicitly on the one-cone HO model" (15).

Leamer's descriptive analysis tracks domestic product prices for two-digit-level industries relative to the overall producer price index (PPI) (162, fig. 10, and 169, fig. 14). The key sectors are textiles and apparel, two very labor intensive industries. Leamer reports that the 3 decades behaved very differently. During the 1960s the prices of textiles and apparel fell relative to the overall PPI by a relatively modest 8 percent and 4 percent, respectively. During the 1970s their relative prices plunged by 30 percent. Finally, during the 1980s their relative prices were quite stable. The key message from these descriptive facts are that the 1970s, not the 1960s or 1980s, appear to be the decade where U.S. relative prices of unskilled-labor-intensive products fell markedly.

For his more structural analysis, Leamer uses the zero-profit conditions written in equation (1). In differentiating these equations to express them in terms of changes, however, Leamer does not assume away changes in technology and their possible feedback to prices—he explicitly allows these changes in his framework. Thus, along with Baldwin and Cain, Leamer is one of the first researchers to consider causes of product-price changes other than some aspect of international trade. Differentiating equation (1) for (sufficiently small) changes while allowing technological progress yields the following equation:

$$P^* = \theta \times W^* - TFP^*, \tag{2'}$$

where P^* is defined, as earlier, as an $(N \times 1)$ vector of product prices; θ and W^* now include both primary factors and intermediate inputs; and TFP^* is an $(N \times 1)$ vector of TFP growth in all industries.

As equation (2′) indicates, technological progress can affect equilibrium prices for products and/or factors. The key question is how much does technological progress feed into product-price declines? Consistent with their assumption that the United States is a small price-taking economy, LS assumed zero pass-through from TFP growth to product prices. Leamer explicitly relaxes this assumption by considering pass-through rates (identical across all industries) of both 0 and 1 from technological progress to value-added product prices (i.e., P less the cost-share-weighted prices of intermediate inputs). Having controlled for some effect of TFP on product prices, Leamer then assumes that the amount of actual product-price changes not accounted for by technological progress can be attributed to what he terms "globalization." He does not attribute these globalization price changes to anything more specific, such as trade barriers or foreign developments communicated to U.S. product prices through the U.S. terms of trade.

Leamer thus distinguishes two forces affecting U.S. factor prices: technological progress and globalization price changes. The relative magnitude of these forces depends on how large a pass-through coefficient from technology to product prices is assumed. Leamer uses regressions to estimate a link from these forces to factor prices. For technology changes, Leamer pools all industries to estimate the following:

(L-T) $$[(1 - \lambda) \times TFP_j^*] = (\theta_{ij})\beta_{it} + e_j,$$

where λ is the pass-through coefficient from technology to value-added product prices. Similarly, for globalization price changes Leamer pools all industries to estimate the following:

(L-G) $$[P_j^* + (\lambda \times TFP_j^*)] = (\theta_{ij})\beta_{ig} + e_j,$$

where $P_j^* + (\lambda \times \mathrm{TFP}_j^*)$ is the vector of globalization price changes.

In both equations (L-T) and (L-G) Leamer interprets the parameter estimates as "mandated" factor-price changes. "These are the changes in factor costs that are needed to keep the zero profits condition operative in the face of changes in technology [i.e., β_{it}] and product prices [i.e., β_{ig}]" (23). Stated differently, the regressions estimate the factor-price changes mandated by changes in technology and/or product prices to maintain zero profits in all sectors. The error term in each equation allows the zero-profit conditions not to bind exactly (for whatever unspecified reasons). Because the econometric fit is not perfect, the mandated factor-price changes can be interpreted as the changes "consistent with the least change in profits in the economy" (29). These mandated factor-price estimates β_{it} and β_{ig} can then be compared with actual factor-price changes. "If the two conform adequately, we will argue that we have provided an accurate explanation of the trends in wages" (23). Thus the parameter estimates are tested by directly comparing them with actual data. Overall, these regressions can be interpreted as an accounting exercise. What changes in factor prices are mandated from the observed changes in technology and/or product prices—and what share of actual changes do these mandated changes explain?

In Leamer's regressions, intermediate inputs are measured as materials purchased. For primary factors, he uses capital and either labor or labor disaggregated between more-skilled and less-skilled workers. Leamer measures skills in two distinct ways. One is the classification between nonproduction and production workers. Concerned that this measure excessively misclassifies actual skills, Leamer constructs an alternative skill ranking of industries based on their average earnings per worker (higher average earnings are translated into a higher mix of more-skilled workers). Changes in product prices and technology are the annualized changes over the decades as he defines them and cost shares are measured for the first year of each decade. In equation (L-T) Leamer assumes that technological progress affects the prices of primary factors only. In equation (L-G) Leamer constrains the parameter estimate on intermediate inputs to equal the actual observed price change for intermediate inputs; thus, he accounts for inputs by following equation (3″). Finally, Leamer weights industries by either employment or value added.

For the various combinations of dependent variable and decade, Leamer reports three sets of results. One uses just capital and labor as factors, the second uses capital plus labor disaggregated by Leamer's skills definition, and the third uses capital plus labor disaggregated into non-production and production workers (190, table 6, 192, table 7, and 194, table 8). The results for wage inequality related to globalization changes in product prices are as follows. For each decade there are four combinations of skill measure (Leamer's or *NP* vs. *P*) and pass-through rate (0 or 1) to consider. The 1960s results are somewhat mixed; in two of the cases the estimates warrant rising inequality while the other cases warrant falling inequality. The 1970s cases are more clear; in three of the four cases (all except the *NP/P* measure combined with zero pass-through) the estimates warrant strongly rising inequality. And for the 1980s the results generally split across skill measures. With Leamer's measure and both pass-through assumptions, the estimates warrant essentially unchanged or falling inequality, while, with the *NP/P* measure and both pass-through assumptions, the estimates warrant rising inequality (although given the reported standard errors, this rise does not appear to be statistically significant). From the results of these 3 decades, Leamer concludes "that the 1970s was the Stolper-Samuelson decade with product-price changes causing increases in inequality" (31).

The methodology of Leamer closely parallels that of Baldwin and Cain (1997) (BC).[4] Their empirical analysis consists of a comprehensive set of descriptive facts (57–58, table 1) followed by a more structural approach. Like Leamer, BC also regress a set of cross-industry zero-profit conditions expressed as changes to estimate mandated factor-price changes that can be compared with actual factor-price changes. Unlike Leamer, however, because of concerns that technology data are poorly measured (15), BC do not incorporate TFP measures in their econometric analysis. Their alternative "is to infer from the general equilibrium trade model the biases in the regression coefficients" (15) that are introduced by omitting technological change. Beyond technology, BC account for the influence of national factor supplies as well. Rather than somehow incorporating these influences in the zero-profit regression analysis, BC evaluate their importance in separate analyses of industry outputs, factor/employment ratios, and net exports.

The econometric component of their product-price analysis basically follows equation (2) with the inclusion of an additive error term plus a

4. The work of Baldwin and Cain—and indeed, all the studies in this paper—is in turn related to Baldwin and Hilton (1984), who model cross-country differences in factor prices as being accounted for by cross-country differences in unit production costs. The key difference between this early study and those surveyed in this paper is that Baldwin and Hilton explored cross-country differences factor by factor whereas the other studies explore within-U.S. differences over time in more-skilled and less-skilled wages.

constant to allow for "possible trends in price variables due to 'outside' forces" (22),

$$P_j^* = \alpha + (\theta_{ij})\beta_i + e_j. \qquad \text{(BC)}$$

In estimating this equation, BC expand the scope of previous work in several ways. First, like Leamer, they cover three time periods defined as 1968–73, 1973–79, and 1979–91. Second, they include all industries in the economy, not just manufacturing industries. Altogether they have 79 two-digit SIC industries used in input-output (I-O) tables constructed by the Bureau of Economic Analysis (BEA). To ease comparability with previous research, their main results are reported two ways, for all industries together and for just manufacturing industries. Third, they obtain employment from the Current Population Surveys (CPS), which report skills by educational attainment. Educational data are probably a better measure of skills than the commonly used nonproduction-production job classification (which is only meaningful for manufacturing industries). Moreover, these data allow more flexible definitions of skill groups. BC work with three groupings: 1–12 years and 13 or more years; 1–11 years and 12 or more years; and 1–11 years, 12 years, and 13 or more years. In addition to labor, BC also include physical capital. To control for intermediate inputs BC use I-O tables to construct total factor cost shares (i.e., they construct cost shares as given by equation (3′)). These I-O tables are available only for the years covered by the Census of Manufacturing, so BC use cost shares from 1967 for their first time period, 1972 for their second period, and 1977 for their final period. In their main analysis, BC use annualized changes in domestic product prices (with the end points for each period taken as 3-year averages to prevent outlier years from influencing the results). In addition, for manufacturing BC replicate their analysis for the 1980s using export and import prices from 1982 through 1992 (total price changes, not annualized). Finally, BC use both unweighted and weighted least squares with either employment or output weights.

BC describe aggregate price movements between more-skilled and less-skilled categories in their table (57–58). For each of the Census of Manufactures years plus the year 1980, BC calculate the domestic price ratio of industries intensively using more-skilled workers to industries intensively using less-skilled workers. They construct this price ratio for two industry samples, all sectors and just manufacturing. Within each sample, each industry is placed in a skill category based on whether its total employment ratio (i.e., ratio of direct employment plus indirect calculated from I-O tables) of workers with 13 or more years of education to workers with 12 or fewer years is above or below the median industry's ratio. From 1967 to 1972 both price ratios fell. From 1972 to 1980 the price ratio for all sectors continued to fall, but the manufacturing price ratio rose. Finally, from

1980 to 1992 the price ratio for all sectors rose sharply, while the manufacturing price ratio declined. Note that these descriptive price movements within manufacturing generally match those found by Leamer: During the 1970s the relative price of unskilled-labor-intensive products fell, but during the 1980s this relative price did not fall further.

BC report their main OLS estimation results in their tables 3–7 (60–64); their appendix 1 (66–67) reports analogous results for the weighted regressions. Again, their overall methodology is first to estimate equation (BC) for each time period/factor set combination and then to discuss what combinations of changes in trade, technology, and endowments most plausibly explain the observed price patterns and implied mandated factor-price changes indicated by β_i.

For the period 1968–73, OLS price regressions for both all industries and just manufacturing industries and for all three factor sets mandate a decline in wage inequality. BC argue that this implied decline in the relative price of skilled-labor-intensive products was caused primarily by an expanding relative endowment of skilled labor, which in turn expanded the relative output of skilled-labor-intensive products. The weighted regressions yield the same qualitative result.

For the middle period 1973–79, the OLS price regressions again mandate a decline in wage inequality for both all industries and for just manufacturing industries. Analyzing the supporting data on outputs, endowments, and net exports, BC conclude that endowment changes were not as strong an influence in this period. The three-labor-type regressions for manufacturing only suggest that trade might have helped lower the warranted wage of high school dropouts relative to high school graduates. The weighted regressions for this period look qualitatively similar for all industries together, but qualitatively different for just manufacturing. The manufacturing weighted estimates tend to indicate a mandated rise, not fall, in wage inequality—particularly when outputs are the weights.

Finally, for the period 1979–91 BC estimate different mandated-wage patterns across the two industry groups. For all industries together, BC find a mandated rise in wage inequality. For just manufacturing they find a mandated decline in wage inequality (particularly so for the two cases with only two labor types). These manufacturing results are matched by the regressions using the BLS export and import prices. In light of the fact that the manufacturing results suggest that international trade was generating mandated declines in wage inequality rather than the actual rises in inequality (40), BC argue that the most likely explanation for the observed price patterns is a combination of skill-biased technological change and demand shifts toward skilled-labor-intensive products. The results from the weighted price regressions look qualitatively similar, although the manufacturing results are weaker when weighted for the cases with only two labor types.

Krueger (1997) is the only study in this survey to focus on the 1990s, defined in his data as 1989–94. He follows the methodology of both LS and SSh by regressing industry product-price changes on direct factor employment. Specifically, he follows SSh by using the fraction of production workers by industry, measured as the average over the years 1989, 1990, and 1991. He also runs this regression both with and without a dummy variable for the computer industry:

$$\text{(K-1)} \quad P_j^{*1990s} = \alpha + \beta(PW/(PW + NPW))_j + \beta_c(D_{\text{computers}}) + e_j.$$

In addition, Krueger also follows Leamer and BC by regressing a set of cross-industry zero-profit conditions expressed as changes to estimate mandated factor-price changes that can then be compared with actual factor-price changes. Unlike Leamer and BC, Krueger does not attempt in any way to distribute observed product-price changes between trade and nontrade causes. Thus, his mandated-wage specification is

$$\text{(K-2)} \qquad P_j^* = \alpha + (\theta_{ij})\beta_i + e_j.$$

Krueger's data cover the 150 four-digit SIC manufacturing industries, which have at least 75 percent of their output going to final consumer demand (i.e., "finished processor" industries). The product prices are the domestic producer prices such as those used in many of the earlier studies. In his cost-share matrix Krueger includes more-skilled labor, less-skilled labor, capital, and materials. Thus, like Leamer he accounts for intermediate inputs as suggested by equation (3″). For equation (K-1), Krueger uses the nonproduction-production classification; for robustness he also incorporates average worker educational attainment by industry from the CPS. To calculate industry cost shares of less-skilled labor in equation (K-2), Krueger multiplies industry total employment by the average annual earnings of a high school dropout and then divides this product by industry value of shipments. More-skilled cost shares are calculated as total payroll less this product, all divided by the industry value of shipments. All regressions are estimated with weighted least squares using 1988 values of shipments as weights.

Krueger's results from equation (K-1) are reported in his figures 1 (22) and 2 (23), table 4 (28; col. 1 and 2), and table 5 (29; col. 2). His main finding is that β is estimated to be statistically significantly less than 0 with virtually the same point estimate either with or without the computer dummy variable. That is, the data indicate a positive correlation between product-price increases and skill intensity. Measuring skill intensity by educational attainment yields the same result.

The result from equation (K-2) is reported in his table 5 (29; col. 1). The main finding here is an estimated mandated rise in wage inequality: The difference between the estimated β_i for skilled and unskilled labor is 0.52

and is statistically significant at the .0001 level. In an unreported robustness check, Krueger obtains qualitatively similar results from OLS and median regressions, although the estimated rise in warranted inequality is smaller (17). Thus Krueger draws the same conclusion from the results of both equation (K-1) and (K-2): "fairly robust evidence that price growth was relatively lower in less-skill intensive industries between 1989 and 1995. . . . The magnitude of the price changes is roughly compatible with observed wage changes for skilled and unskilled workers" (19–20).

Feenstra and Hanson (1999) (FH99) also use the mandated-wage framework used by Leamer, BC, and Krueger. However, FH99 differ from these earlier studies in two important ways. First, they do not consider product-price changes alone to contain any direct evidence of the role of international trade on factor prices. Rather, building on their earlier model of outsourcing, FH95, they argue that outsourcing manifests itself in industry-level data as TFP growth. Because outsourcing changes the mix of activities done within industries, "this will shift the entire production function for activities done at home, and therefore show up in the industry aggregate production function as a change in total factor productivity" (10). Second, they allow for technological change to affect product prices rather than assuming some quantity for it—either 0, under the small-economy assumption, or some nonzero value as in Leamer (1998).[5]

Their empirical approach thus involves two steps. First, they regress the sum of observed value-added product-price changes and observed TFP on measures of outsourcing and investment in high-technology equipment. This first-stage regression decomposes observed price and TFP changes into components attributable to various structural forces, among them outsourcing. Second, they regress each decomposed component on factor-cost shares to estimate mandated factor-price changes attributable to each structural force. The coefficient estimates from this second regression are interpreted as the economywide wage changes mandated by that structural force that, ceteris paribus, would have appeared in the actual economy. Their crucial second-stage mandated-wage regression of FH99 is

$$\text{(FH)} \qquad \text{“Outsourcing”}\ (P_j^* + TFP_j^*) = (\theta_{ij})\beta_i + e_j.$$

FH99 use two measures of outsourcing. One "narrow" measure tracks imports of intermediate inputs only from the same two-digit industry as the good being produced. A second "broad" measure tracks all imported intermediate inputs regardless of industry. In their analysis, FH99 actually use the narrow measure and then the difference between the broad and narrow measures. FH99 also try two stage 1 specifications: one with the

5. With regard to mandated-wage regressions, FH99 also point out that mandated-wage regressions like equation (2′) fit the data perfectly (i.e., have $R^2 = 1$) if one includes as a regressor differences between industry-specific and economywide changes in factor prices. They account for industry-specific wage changes in their measure of TFP.

structural variables entering linearly and another with these structural variables interacting with the quantities of primary factors. Thus, for their period of analysis, 1979–90, FH99 actually estimate four total versions of the (FH) equation. For all regressions, FH99 use 447 of the 450 four-digit SIC manufacturing industries; three are excluded because of inadequate data on materials. The nonproduction-production classification is used to separate more-skilled from less-skilled workers, and capital is included as a third primary factor. Also, FH99 test the robustness of their results by using alternative measures of computerization, and they adjust their standard errors on β_i because the second-stage regressand is constructed with parameter estimates from the first-stage regression. All regressions use weighted least squares with average value of shipments during the relevant period as weights.

The key stage 1 results are reported in their tables 4 (932) and 7 (936), and stage 2 results in tables 5, 6 (933–34), and 8 (937). In the stage 1 regressions, both outsourcing and computer use are estimated to be positively correlated with price-plus-TFP changes. In the stage 2 regressions, narrow outsourcing generally mandates a significant rise in wage inequality, while broad outsourcing generally mandates smaller and insignificant rises in wage inequality. In their baseline specifications, FH99 report that narrow outsourcing accounts for about 15 percent of the observed rise in inequality. In most specifications, high-technology capital mandated somewhat larger rises in inequality than outsourcing.

Finally, Harrigan and Balaban (1997) (HB) analyze product-price changes using a methodology different from the mandated-wage regressions. Their goal is to model economywide wages as determined jointly by technology, endowments, and product prices—which can be influenced by, among other things, international trade. Thus, like Leamer and BC, HB consider wage determinants other than international trade. HB start with a national revenue function with the standard properties implied by perfect competition, profit maximization, and nonjointness of production. HB then assume that this revenue function can be written as a general translog function with parameter restrictions implied by the standard properties. From this functional form, a set of equations can be derived that relate each factor's share in total national income to technology, factor supplies, and product prices. With appropriate data these cost-share equations can be estimated, and the parameter estimates linking factor cost shares with technology, endowments, and product prices can be combined with observed changes in these regressors to decompose actual wage changes into components due to technology, endowments, and prices.

HB apply this model to U.S. data from 1963 through 1991 by decomposing the economy into four primary factors and four products. The primary factors are high school dropouts, high school graduates plus some college, college graduates, and physical capital. There are two tradable and two nontradable industries, one each intensive in more-skilled labor and the other two intensive in less-skilled labor. Total industry factor intensities are determined using both direct and indirect factor employments from 1977 I-O tables. Thus like BC, HB focus on the entire U.S. economy and not just tradables.

HB consider U.S. product prices to be endogenous and thus require instruments for consistent estimation. For domestic prices their instrument set includes a set of domestic variables such as factor supplies, TFP, and government demand. For tradables prices HB use a set of international variables meant to capture the effect of developments abroad communicated to the United States through changes in our product prices. More specifically, they construct variables aimed at measuring "the presence of each country's labor supply in the international market" (9). To do this, for each year HB separate all countries into four income quartiles and then sum across all countries in each quartile the product of each country's labor force multiplied by its ratio of gross trade to GDP. Thus, HB are the first researchers to try to model the effect on U.S. prices of international trade in terms of foreign changes in productive capacity communicated to the United States through changes in our product prices.

The main results from their wage decomposition are reported in their table 5 (23). HB find that the most important relative-price change contributing to rising wage inequality was the large increase in the price of nontraded skill-intensive products relative to tradables and to the other nontraded sector. The effects of changes in tradables' relative prices are less clear: parameter estimates for these variables are relatively imprecise. This suggests that the international instruments might be weak.

4.4 Synthesis of Existing Findings and Methodological Progress

Having surveyed each of the nine product-price studies individually, I now try to synthesize their similarities and differences. I do this in three steps. First, I discuss how research has refined a set of empirical strategies for applying the SS theorem to the data. Second, I comment on some important methodological issues regarding the robustness of results. The "facts" about product prices and their warranted wage changes are relatively sensitive to the selection and weighting of industries sampled and to the decade considered. On the other hand, the "facts" are relatively insensitive to the extent of data aggregation and the measurement of skills. Third, in light of these methodological issues I summarize what the "facts" seem to be about product-price changes and their mandated wage changes.

4.4.1 A Methodological Progression

A summary of the empirical methodologies surveyed in section 4.3 is provided here (recall these studies were also summarized, without the regression equations, in table 4.1).

1. Bhagwati (1991). Discussion of U.S. terms of trade.
2. Lawrence and Slaughter (1993). Regression analysis:

(LS) $$P_j^{*1980s} = \alpha + \beta(NPW/PW)_j^{1980} + e_j.$$

3. Sachs and Shatz (1994). Regression analysis:

(SSh) $$P_j^{*1980s} = \alpha + \beta(PW/(PW + NPW))_j^{1980} + \beta_c(D_{\text{computers}}) + e_j.$$

4. Feenstra and Hanson (1995). Descriptive comparison of domestic and import prices.

5. Leamer (1998). Discussion of industry relative prices plus regression analysis:

(L-T) $$[(1 - \lambda) \times TFP_j^*] = (\theta_{ij})\beta_{it} + e_j,$$

(L-G) $$[P_j^* + (\lambda \times TFP_j^*)] = (\theta_{ij})\beta_{ig} + e_j,$$

6. Baldwin and Cain (1997). Discussion of industry relative prices plus regression analysis:

(BC) $$P_j^* = \alpha + (\theta_{ij})\beta_i + e_j.$$

7. Krueger (1997). Regression analysis:

(K-1) $$P_j^{*1990s} = \alpha + \beta(PW/(PW + NPW))_j + \beta_c(D_{\text{computers}}) + e_j.$$

(K-2) $$P_j^* = \alpha + (\theta_{ij})\beta_i + e_j.$$

8. Feenstra and Hanson (1999). Regression analysis:

(FH) $$\text{“Outsourcing”}\ (P_j^* + TFP_j^*) = (\theta_{ij})\beta_i + e_j.$$

9. Harrigan and Balaban (1997). Regression analysis of cost-share equations from translog representation of U.S. revenue function.

How do these different approaches relate to each other? By listing them in this order, I think one can identify a progressive refinement in the application of the SS theorem to the data.

First, the studies of Bhagwati, LS, and SSh I call “consistency checks.” That is, these studies analyze whether observed product-price changes were consistent with rising wage inequality in the sense that the relative price of skilled-labor-intensive products rose relative to those of unskilled-labor-intensive products. Bhagwati simply assumes that exports (imports) employ more-skilled (less-skilled) labor relatively intensively. LS, and SSh following LS, refine this assumption by using disaggregated data to identify the pattern of relative factor use.

These first three studies have some important limitations in terms of the distance between the SS theorem and the empirical analysis and in terms of appropriately accounting for data complexities. One important limitation is that a consistency check on product prices cannot make the important link to factor prices. It cannot answer the important question of how much product-price changes might have contributed to actual factor-price changes. Another major limitation is that these regressions of product-price changes on factor-employment levels is not a tight implication of the SS theorem's zero-profit logic as summarized in equations (1) and (2). Equation (1) relates price levels to factor-employment levels (i.e., to the A matrix), while equation (2) relates price changes to factor cost shares (i.e., to the θ matrix). Regressing price changes on employment levels seems to capture the broad intuition of the SS theorem, but it uncomfortably mixes the levels and changes versions of the zero-profit conditions central to the SS theorem.

There are some data limitations as well. One is that these studies assume that the United States does not affect world prices; changes in domestic (or export or import) prices reflect changes in world prices triggered abroad that are communicated to the price-taking U.S. economy. Another limitation is that these studies ignore capital and any other primary factors of production. Given this, their results are best interpreted as a test of the General, Restrictive, or Essential Versions of the SS theorem under the maintained assumption that other primary factors do not matter. A third limitation is that they measure only direct factor intensities; they do not account for factor use embodied in intermediate inputs.

The later studies improve on the consistency check methodology in several ways. Most importantly, they have less distance between the SS theorem and their empirical analysis. The mandated-wage regressions of Leamer, BC, Krueger, and FH99 come closer than the consistency checks to testing the Correlation Version of the SS theorem that, as discussed in section 4.2, is probably the version most applicable to the issue of rising wage inequality. And these regressions follow directly from the zero-profit conditions expressed in terms of changes in equation (2), rather than mixing changes with levels. Product-price changes (or some other trade-related exogenous force such as outsourcing working through prices and TFP for FH99) are the dependent variable, factor-cost shares are the independent variable, and factor-price changes are the parameter estimates. These estimates have a clear interpretation in light of equation (2) as the "best guess" factor-prices changes mandated by changes in the dependent variable to maintain zero-profits in all producing sectors. In terms of the SS Correlation Version in equation (4), these mandated "best guesses" estimate the correlation between changes in the dependent variable and changes in the cost-share-weighted factor prices. Comparing actual with mandated factor-price changes indicates how much of the actual factor-price changes can be accounted for by the dependent variable. The ability to do this accounting within the mandated-wage framework solves one of the major limitations of the consistency check framework. (This is not to say that descriptive consistency checks are abandoned altogether: Leamer and BC complement their regressions with stylized facts, and Krueger also estimates LS-style regressions.) And as Leamer and FH99 demonstrate, this mandated-wage framework can be used not just for product-price changes, but for technology changes as well.[6]

The mandated-wage studies also have the advantage of allowing better treatment of some data complexities. Several of them try to relax the assumption of a small price-taking U.S. economy, as will be discussed later in greater detail. In addition, these studies also account for intermediate inputs as well as primary factors.

Mandated-wage regressions might appear odd because the exogenous variable is the regressand rather than the regressor, while the dependent variable of interest (factor-price changes) is estimated rather than the regressand. The most important reason a standard regression cannot be used is that the dimensionality of the data prevents inversion of the θ matrix. For example, the NBER Productivity Database used by LS, Leamer, and FH99 contains 450 four-digit SIC manufacturing industries, but only three primary factors plus two intermediate inputs. With more products than factors, in equation (2) the θ matrix is not square and thus cannot be inverted to obtain a set of equations equating wage changes with product-price changes multiplied by an inverted θ matrix.

This lack of invertibility suggests that the warranted-wage regressions can be interpreted as an accounting exercise, rather than as identifying causation in the way regressions are usually presumed to. Warranted-wage regressions estimate what changes in factor prices are mandated from the observed changes in technology and/or product prices. With these mandated changes one can determine what share of actual wage changes is accounted for by the driving exogenous change. Note that because the exogenous change enters the regression as the dependent variable, the mandated-wage methodology cannot analyze two or more exogenous forces in the same regression—it can process only one exogenous force at a time.

Overall, the product-price methodology has advanced from consistency checks to warranted-wage regressions. I argue that this progression has moved empirical work closer to the motivating SS theorem in a number of important ways.

4.4.2 How Robust Are the "Facts"?—Methodological Issues

The variety of empirical methods used in this research area raises the issue of how robust the results are in relation to various methodological

6. Building on these examples, Haskel and Slaughter (1998) use the mandated-wage framework to document that the sector bias of skill-biased technological change appears to account for much of the fall and subsequent rise in wage inequality during the 1970s and 1980s in both the United Kingdom and United States.

choices. In this section I discuss how sensitive the results are to four robustness issues: the selection and weighting of industries sampled, the decade considered, the extent of data aggregation, and the measurement of skills.

Robustness to Industry Selection and Weighting

The SS theorem's zero-profit conditions apply to all domestic industries currently producing positive output. In the matrix equations (1) and (2), there are N rows corresponding to all N industries currently producing. Any domestic industry not currently producing is assumed to have average costs exceeding the industry's price; thus that industry has no zero-profit equality. This suggests that empirical work on the SS theorem requires data on all operating domestic industries.

This raises two separate issues. One is whether to limit the sample to just all operating domestic industries that are tradable. As discussed in section 4.2, four of the versions of the SS theorem do not explicitly involve international trade. The link between product prices and factor prices holds even in autarky. Given this, focusing on just tradable industries seems appropriate when trying to understand product-price changes attributable to international trade.[7] The other issue is conditional on a selected sample: Are all available industries included in the data analysis? Theory suggests that all data should be included. Missing industries introduces the risk of the analysis not being representative of the appropriate full sample.

How robust are empirical results to sample selection? First, results definitely depend on whether all sectors or just tradables are analyzed. Looking at all sectors together, BC and HB find an increase in the price of skill-intensive nontradables during the 1980s. In light of SS versions that do not directly involve international trade, this suggests that one cause of rising inequality was rising relative prices for skill-intensive nontraded products. For the subset of just the tradable manufactures, LS, Leamer, and BC all find no strong trend in relative prices during the 1980s. This finding suggests that trade did not contribute to rising inequality. Clearly, in comparing studies one must be careful to identify differences driven by sample selection of tradables versus nontradables.

Conditional on the selection of the overall set of industries to analyze, the empirical results also depend on whether data on all available industries is included. In some cases results have been somewhat robust to sample selection. For example, both LS and BC use import and export prices for manufacturing industries despite the fact that these data do not exist for every single manufacturing industry. Import prices exist for only

7. Another reason to focus on just tradable industries is that if external competitiveness conditions are sufficient to determine an economy's factor prices, then that economy's nontraded product prices are determined automatically by these factor prices and the state of nontraded production technology. In this case, with fixed nontraded technology, nontraded product prices mechanically follow national factor prices.

18 of the 20 two-digit SIC industries and only about 50 of the 143 three-digit SIC industries. Despite this, both LS and BC find no strong trend in relative prices during the 1980s for these smaller samples, matching the results of Leamer and BC using the full set of 450 four-digit manufacturing industries. But in other cases the issue of inadequate sample selection appears to be very crucial. For example, Krueger's analysis of the 1990s uses only 150 of the 450 four-digit SIC manufacturing industries. He acknowledges that his sample of finished-processor industries is incomplete and comments that in "a later draft of this paper, I hope to obtain data for non-finished goods industries" (1997, 8, n. 8). It seems reasonable to wonder whether his analysis is representative of manufacturing overall during this period.

Because the NBER Productivity Database covering all four-digit manufacturing industries now extends through 1994, this can be checked. I have used these data to replicate Krueger's findings for the sample of finished-processor industries and then to see what results obtain when the sample is expanded to include all industries. Because I do not have all of Krueger's data to replicate his construction of factor-cost shares, I follow Leamer's approach for constructing cost shares for nonproduction labor, production labor, capital, energy, and materials. These alternative measures seem reasonable in that they replicate Krueger's results. The cost-share regressors are for 1989 and the dependent variable is the annualized rate of change in industry price. For all sets of industries I regress product-price changes on the cost shares to estimate the mandated factor-price changes.

Table 4.2 reports the results. The first three rows replicate Krueger's finding that for the sample of finished-processor industries the mandated wage increase for nonproduction labor exceeds that for production labor. The next three rows expand the sample to all manufacturing industries. Qualitatively, the parameter estimates between the two labor types have flipped. Now production labor has a larger mandated wage increase than nonproduction labor—this implies a mandated decline, not increase, in wage inequality. The final three rows show that the nonfinished-processor industries are driving the different results for overall manufacturing. For this sample of industries, the annualized mandated decline in inequality is larger than that of manufacturing overall. Notice that the results are robust to alternative weighting schemes for industries.[8]

On balance, then, it seems that Krueger's results for the 1990s are particular to his sample of industries. Table 4.2 suggests that for the full sample of all manufacturing industries the product-price changes during the early 1990s were not mandating increased wage inequality.

The issue of sample selection can even hinge on the presence or absence

8. Results are also robust to using 1988 or 1990 cost shares and to using the total-period price change. A similar difference between the full manufacturing sample and just the finished-processor industries shows up for regressions of price changes on the share of production workers in total employment.

Table 4.2 Mandated Factor-Price Changes (1989–94)

Industry Sample	Estimation Method	Nonproduction Labor	Production Labor
Finished-processor industries	OLS	0.073	0.029
		(3.503)	(1.609)
	WLS (value of shipments)	0.055	0.036
		(2.091)	(1.793)
	WLS (employment)	0.071	0.006
		(3.278)	(0.308)
All industries	OLS	0.057	0.058
		(2.391)	(3.714)
	WLS (value of shipments)	0.005	0.104
		(0.082)	(2.002)
	WLS (employment)	0.036	0.081
		(0.818)	(1.988)
All non-finished processor industries	OLS	0.040	0.071
		(1.259)	(3.436)
	WLS (value of shipments)	0.007	0.125
		(0.098)	(1.970)
	WLS (employment)	0.041	0.115
		(0.837)	(1.999)

Source: NBER Productivity Database.

Notes: Mandated factor-price changes are the coefficients from a mandated-wage regression pooling all industries in the indicated sample to estimate product-price changes on input cost shares. Numbers in parentheses are t-statistics. OLS, ordinary least squares; WLS, weighted least squares.

of a single industry, with computers being the trickiest case. SSh do not literally drop computers from the sample, but they effectively do so with a dummy variable for this industry. As discussed earlier, SSh treat computers differently because of concerns that reported computer prices do not adequately reflect the extent of this industry's quality upgrading. They argue that accounting for computers this way improves on specifications such as LS.

How much do computers really matter for the SSh results? They do not report results for equation (SSh) excluding the computer dummy, but this can easily be done using the NBER's Productivity Database. SSh use three-digit data; I use the four-digit data assuming that more-disaggregated data are better. SSh report unweighted regressions; for robustness I also use value of shipments and employment to weight industries. Table 4.3 reports the results. The key message is that "computers matter." Without a computer-industry dummy, no strong relationship appears between product-price changes and the share of production workers in total industry employment. But, as was reported for SSh earlier, with a computer-industry

Table 4.3 **Consistency Check of Product-Price Changes against Skill Intensity (1978–89)**

Industry Sample	Estimation Method	Coefficient on Production Share	Coefficient on Computer Dummy
All industries, without computer dummy	OLS	−0.007	NA
		(−0.594)	
	WLS	0.008	NA
	(value of shipments)	(0.813)	
	WLS	0.003	NA
	(employment)	(0.931)	
All industries, with computer dummy	OLS	−0.017	−0.168
		(−2.449)	(−69.658)
	WLS	−0.025	−1.70
	(value of shipments)	(−2.518)	(−52.504)
	WLS	−0.031	−0.173
	(employment)	(−3.036)	(−47.639)

Source: NBER Productivity Database.

Notes: Coefficient estimates are from the regression (SSh), $P_j^*1980s = \alpha + \beta\,(PW/(PW+NPW))_j^{1980} + \beta_c\,(D_{computers}) + e_j$, estimated both with and without a dummy variable for the computer industry (SIC 3573 revision 2 industry). Numbers in parentheses are t-statistics. OLS, ordinary least squares; WLS, weighted least squared; NA, not applicable.

dummy effectively removing this industry a strong negative relationship appears among the noncomputer industries.

Given that computers (and perhaps other single industries?) can play such an important role, when can industries be excluded from an analysis? Lack of data seems to be one justifiable reason. Examples include LS and BC's using all tradables' price data that exist and FH99's excluding three industries that did not have materials prices. LS explicitly state their assumption that their smaller samples are representative of overall manufacturing (Lawrence and Slaughter 1993, 195, n. 55 and 202, n. 63).

The issue of selectively excluding data that do exist seems to be a trickier issue. SSh invoke the criterion of bad data quality. They do not elaborate on this point, however, either in terms of why computer price data are so bad in absolute terms or, more importantly, relative to other industries. Presumably other industries also had quality improvements that need to be accounted for in constructing "true" price changes.

At the very least, when possible, the direction of bias introduced by "bad" data should be considered before excluding data. For example, SSh claim that reported computer prices do not adequately control for quality improvements. Stated another way, they argue that the reported price decline for computers, in absolute value, understates the true quality-adjusted price decline for computers. This suggests that the reported price decline in computers is biased upward toward 0. The solution that SS use of dummying out the computer industry actually reinforces this bias rather than mitigating it. Rather than using information about the direction of bias, the dummy variable effectively sets the price change for the computers to 0 when estimating the cross-industry relationship between price changes and relative employment. To control for the bias introduced by computers, therefore, the results without the computer dummy are arguably better than the results with the computer dummy.

Related to the issue of industry selection is the issue of industry weighting. The logic of the SS theorem suggests that empirically all industries should be weighted equally. The link from product prices to factor prices relies on the existence of industries, not their sizes. Thanks to the assumption of perfect interindustry factor mobility, as long as an industry has positive output its product price affects factor prices in every industry. That is, as long as an industry has some positive output it accounts for one of the rows in matrix equations (1) and (2), regardless of how large the industry is. A product-price change in even the smallest industry is qualitatively just as important as a product price in the largest industry. This suggests that any data analysis should weight all industries equally.

Given the theoretical preference for equally weighted industries, weighting data differently probably requires empirical justification. For example, as BC suggest (Baldwin and Cain 1997, 22, n. 29) one might weight larger industries more heavily if smaller industries had poorer quality data. Another reason to weight might be that many smaller sectors are residual categories of a wide range of products.

Does weighting industries differently matter? In finite samples, ordinary and weighted least squares yield different parameter estimates. On balance, the answer appears to be maybe. Instances where weighting does not change the qualitative results include Krueger's work on the 1990s (and the extensions thereof in table 4.2). BC offer the most insight on this issue with their very thorough reporting of both unweighted and weighted results using both employment and output as weights. For the 1960s and 1980s results look very similar across the weighted and unweighted specifications. But for manufacturing industries during the 1970s, weighting seems to matter much more. Their unweighted results suggest a mandated fall in inequality, but their weighted results—particularly with output weights—suggest a mandated rise in inequality. This difference seems particularly important when compared with Leamer's conclusion that the 1970s was the Stolper-Samuelson decade, with a large rise in mandated inequality. Leamer reports this finding only for weighted specifications, not unweighted ones. Employment and value-added weights give similar results, but "unweighted regressions are entirely different" (Leamer 1998, 29, n. 5).

Robustness to Different Decades

Different decades appear to have different product-price trends. Assuming for the moment that the evidence presented in the previous studies is correct, on balance it appears that the U.S. prices of unskilled-labor-intensive products relative to skilled-labor-intensive products held relatively constant during the 1960s and 1980s, but declined during the 1970s and 1990s. Thus it is important not to generalize about the pattern in U.S. product prices without specifying the particular time period. For example, Krueger concludes that his evidence of declining relative prices during the 1990s "is consistent with Sachs and Shatz (1994), but inconsistent with Lawrence and Slaughter (1993)" (1997, 19). Because SSh and LS analyze the 1980s, not the 1990s, it is not clear that there should be any necessary relationship among results across different decades.

Importantly, the results for each given decade appear to be fairly robust to the end points chosen. For example, LS, Leamer, and BC all find no strong trend in manufacturing relative prices during the 1980s, even though each study defines the decade slightly differently.[9]

Robustness to Data Aggregation

The SS theorem is largely silent on this point. In theory, different industries are distinguished by their different relative employment of factors as dictated by their different production technologies. Empirically, it is generally assumed that more-disaggregated data is better.

The results appear to be quite robust to data aggregation. Many studies of the manufacturing sector use four-digit SIC industries (Leamer, Krueger, and FH99). Studies using three-digit data (LS, SSh, and BC) and/or two-digit data (LS and BC) obtain qualitatively similar results to the more-disaggregated studies. For example, the finding of constant relative manufacturing prices during the 1980s is obtained at the four-digit level (Leamer), the three-digit level (LS and BC), and the two-digit level (LS and BC).

Robustness to Measurement of Skills

Trade theory is largely silent on this point of how to measure skills. It is generally accepted that the nonproduction-production classification for manufacturing workers suffers more misclassification of skills than a categorization based on education. However, this claim is a statement about noisiness of data, not necessarily bias.

In fact, the nonproduction-production classification does not appear to be a biased measure of skills. Studies using this measure tend to obtain results similar to other measures such as educational attainment. Again, for the 1980s the conclusion of relatively stable relative product prices and thus little mandated change in wage inequality is obtained from studies using the nonproduction-production classification (LS and Leamer, for

9. Obviously there were other differences among these three studies, so the role of time period alone cannot be determined with certainty. Unfortunately, none of the studies reports a robustness check of its own methodology to the way the decades are defined.

the case of zero pass-through), using educational attainment to identify two labor groups (BC with two different cut-off points between the two groups), and using skills inferred form actual wages paid (Leamer). Similarly, for the 1990s for the sample of finished-processor industries Krueger obtains the same result for equation (K-1) using both the nonproduction-production classification and average years of education. The results for equation (K-2) are qualitatively the same for the nonproduction-production classification (reported in table 4.1) as for Krueger's skill measure using minimum wages.

A Summary of the "Facts" Regarding Product Prices and Mandated Wages

In light of the previous discussion about methodological robustness, here is a summary of the "facts" regarding product-price changes and the mandated-wage changes. To organize the summary I use decades. HB do not break their analysis by time period, so I report one of their important findings in the 1980s.

The 1960s have been analyzed by BC and Leamer. The consensus finding seems to be a slight decline in the relative price of skill-intensive industries, both in manufacturing and in all sectors overall. These price changes suggest a mandated decline in wage inequality during this period.

The 1970s have been analyzed by BC and Leamer. The consensus finding between BC and Leamer seems to be a moderate to substantial decline in the relative price of non-skill-intensive industries both in manufacturing and in all sectors overall. These price changes suggest a mandated rise in wage inequality during this period.

The 1980s have been analyzed by Bhagwati, LS, SSh, FH95, Leamer, BC, FH99, and HB. The consistency checks of Bhagwati and LS and the descriptive facts of Leamer and BC all find no clear pattern of price changes across tradable industries during this period. The consistency check of SSh does find evidence of a relative-price decline for non-skill-intensive industries, but only after dummying out the computer industry. The mandated-wage regressions of Leamer and BC on manufacturing industries both find no clear pattern of mandated changes in wage inequality during this period. The structural estimates of HB corroborate this. FH95 find that the greater rise in domestic prices relative to import prices is consistent with their model of outsourcing, and FH99 find that changes in their narrow measure of outsourcing working through observed TFP and product prices led to mandated rises in wage inequality. Both BC and HB find a rise in the relative price of skill-intensive nontradable industries during this period, which mandated a rise in wage inequality.

The 1990s have been analyzed by Krueger. Based on a sample of one-third of manufacturing industries, both his consistency check and his mandated-wage regressions find a mandated rise in wage inequality from

1989 through 1994. However, the evidence in table 4.2 for all manufacturing suggests, if anything, a mandated decline in wage inequality.

4.5 Limitations of Current Research and Directions for Future Research

Despite the methodological progress that has been made, research to date still has fundamental limitations regarding the key question of how much international trade has contributed to rising wage inequality. In this section, I highlight three important limitations: the need for a clearer understanding of how product-price changes are related to exogenous forces attributable to international trade, the need to explore how slowly the Heckscher-Ohlin clock ticks, and the need to complement product-price data with other data to overcome potential limits of product-price data.

4.5.1 Decomposing Product-Price Changes

Most importantly, more work needs to link exogenous forces attributable to international trade to actual product-price changes. Stated alternatively, the literature to date has made substantial progress in understanding how to relate a given change in relative product prices to changes in relative factor prices. But it has made relatively less progress in understanding whether these product-price changes have anything to do with international trade.

This criticism of product-price studies is not new. Indeed, in a comprehensive survey of rising inequality Freeman (1995, 29) made the very same point 3 years ago: "Perhaps the biggest problem with these studies is that they ignore potential determinants of changes in sectoral prices and potential reasons for the proportion of unskilled workers in a sector to be correlated with changes in prices, save for trade." But what is important is that 3 years later, despite some progress, the criticism still applies.

The studies of Bhagwati, LS, SSh, and Krueger assume (explicitly or implicitly) that U.S. product prices are determined in the rest of the world without any influence from U.S. variables. This assumption is a reasonable first pass at the data, but it is almost certainly not correct. The other studies in this survey move away from this assumption in various ways. Leamer decomposes observed product-price changes into two components, technological progress and globalization price changes. However, he does not attribute these globalization price changes to anything more specific, such as trade barriers or foreign developments communicated through the U.S. terms of trade. BC consider three forces acting on product prices, international trade, technology, and endowments. Like Leamer, however, they do not specify anything more specific regarding what trade's force consists of. FH99 use regression analysis to explain observed price-plus-TFP changes with outsourcing and computerization. In estimating the mandated wage changes driven by each of these forces they allow an endogenous response of product prices. Finally, instead of using direct measures of domestic product prices in tradable industries, HB instrument for these prices using data on foreign labor endowments and trade quantities.

These latter studies, which attempt to decompose product-price changes among various causes, are an improvement on the earlier first-pass studies. Nevertheless, it seems that much more work is needed here. As discussed in section 4.2, in theory the question of how international trade causes product-price changes can be refined with reference to at least four distinct trade-related forces that are plausibly exogenous to domestic firms at a point in time: U.S. political trade barriers, foreign trade barriers, worldwide natural trade barriers, and developments abroad in parameters such as tastes, technology, and endowments that are communicated to the United States via the international prices constituting our terms of trade. None of the nine studies in this survey uses data on political or natural trade barriers. And only HB use data on foreign parameters to help explain U.S. domestic product prices.

Granted, decomposing product-price changes requires more data. But, as HB demonstrate, at least some progress could be made here. For example, perhaps sensible use could be made of net export patterns among countries. Ideally there would be sufficient data on all forces affecting product prices—both trade-related and otherwise—to account for price movements similar to how FH99 account for price-plus-TFP movements in terms of outsourcing and computerization.

Having a clearer decomposition of product-price changes could contribute greatly to understanding both what has caused past price changes and what might cause future price changes. As an illustration, consider the relative prices of textiles and apparel, two of the most unskilled-labor-intensive industries in U.S. manufacturing. In his descriptive facts, Leamer documents that the relative producer prices of these unskilled-labor-intensive sectors declined dramatically during the 1970s, but stabilized during the 1980s. There are at least two alternative trade-related explanations for why the decline halted. One is that these sectors enjoyed more protection in the 1980s thanks to the more-binding Multi-Fiber Arrangement (MFA). Another is that the price declines of the 1970s forced domestic producers to eliminate the very unskilled-labor-intensive sectors within textiles and apparel and to focus on the relatively skilled-labor-intensive sectors. With the rest of the world continuing to produce the very unskilled-labor-intensive sectors, this second story implies the United States moved to a different cone of diversification.

These two stories carry very different implications for future U.S. product prices and thus factor prices. In the first case, the 1980s price stabilization is a temporary lull that will disappear as the MFA is phased out and/or as countries like China with comparative advantages in unskilled-labor-intensive products continue to integrate into the world economy. Thus, this first case foreshadows further trade-induced rises in U.S. inequality. The second case, however, has much rosier implications. It suggests that the United States has already incurred the pain of losing some of its unskilled-labor-intensive industries. As countries like China continue to expand production and thus lower the relative prices of these products, no downward pressure is put on U.S. unskilled wages. Instead, all U.S. factors enjoy a consumption real-wage increase. Clearly, a better understanding of the relative causes of U.S. domestic price changes would help distinguish which of these very different futures seems more likely.

4.5.2 How Slowly Does the Heckscher-Ohlin Clock Tick?

The Heckscher-Ohlin (HO) framework of the SS theorem assumes that within a country each factor of production can move costlessly from one industry to another. In this sense, HO theory is a long-run theory: It focuses on how the economy operates once factors have had sufficient time to locate in whatever industries they choose. In contrast, the Ricardo-Viner (RV) framework assumes that within a country some factors cannot move across industries—perhaps because these factors incur prohibitively high moving costs. In this sense, RV theory is a short-run theory: It focuses on the economy when some factors cannot relocate from their current industry.

When a shock hits the economy (e.g., a change in international product prices), most trade economists presume that RV theory describes how the economy reacts in the short run, while HO theory describes how the economy reacts in the long run. It is well known that the reactions usually look very different depending on the time horizon. For example, after a price rise in some industry a country's relatively scarce factor can enjoy short-run wage increases for those employed in that industry—but in the long run these increases reverse and the factor suffers wage declines.

Despite these clean theoretical results, there is very little empirical evidence on what this transition from short run to long run looks like in reality. This lack of evidence poses a potentially very serious problem for almost all the empirical work to date on the effect of international trade on wage inequality. Every study surveyed in this paper tries to explain inequality changes with contemporaneous product-price changes. Thus, for example, researchers exploring rising inequality during the 1980s analyze trends in product prices during the 1980s. The implicit assumption in all these studies is that the U.S. economy is sufficiently HO in nature that price shocks over some time period affect the economy as predicted by HO theory in that same period.

But what if that assumption is incorrect? What if the U.S. economy has sufficiently important short-run frictions—such as imperfect information, high costs of reallocating capital across sectors, and people reluctant to relocate geographically—that price shocks over some time period do not generate HO factor-price effects in that same period? A lot of research indicates that these frictions can matter for several years. For example, Blanchard and Katz (1992) find that in states hit by aggregate demand drops, people can take between 5 and 10 years before deciding to move away to recover economically. The more important these frictions are for any given shock, the longer it takes the economy to adjust in an RV manner before switching over to an HO manner.

If price shocks do not generate HO wage effects over the same time horizon, then the basic methodology of linking prices and wages contemporaneously is incorrect such that the common conclusion that trade has contributed very little to rising income inequality needs further exploration. To see this, again consider the finding in Leamer (1998) that during the 1970s the U.S. experienced a sharp decline in the relative price of unskilled-labor-intensive products. By most measures (e.g., college–high school premium) inequality did not rise until the 1980s. If price shocks and wage effects occur contemporaneously, then these two facts do not support the idea that trade mattered. But if the U.S. economy contains extensive frictions that prevent interindustry factor mobility for several years, then this 1970s price shock might not have generated wage effects until the 1980s. In this case, trade-induced price changes might have mattered a lot.

This discussion indicates that a full understanding of trade's effect on income inequality must address the issue of timing: How slowly does the HO clock tick? If it ticks decade by decade rather than year by year, the literature's current thinking might need revising.

4.5.3 Potential Limitations of Price Index Data: What About Cones?

One final issue to consider is the inability of price index data to identify the crucial issue of how relative factor prices depend on a country's product mix.

As discussed earlier, the SS theorem involves the prices of only those industries with current domestic production. Price changes for industries not domestically produced simply entail consumption-deflated real-wage changes for all domestic factors. Cheaper foreign T-shirts are a good thing for even less-skilled U.S. workers if no U.S. firms produce T-shirts. Whether or not the United States makes T-shirts depends on forces such as the national endowment mix and level of technology. Thus changes over time in product mixes can matter greatly for the economy's links between product prices and factor prices.

There is a potential problem with the domestic, export, and import price data used by the studies in this paper. All these data are price indexes designed to measure the prices of unchanging baskets of goods. All three series are produced by the BLS, and the *Handbook of Methods* (U.S. Department of Labor 1992) details the various methods for eliminating product changes from the indexes. This is done both by selecting a fixed basket of goods to price and by systematically eliminating from transaction prices any changes due to quality changes (except in instances of "drastic" introductions and/or eliminations of products).

The price index methodology suggests that the BLS price data tend not to reflect changes in product mixes either by domestic producers or foreign producers. Price increases that are due to quality upgrading get reduced, while price decreases that are due to quality reductions get increased. Thus, there is an important tension between the theory of cones of diversification and the empirical reality of price index construction.

How might this price problem be addressed? Alterman (1991) points out that the import and export unit values that can be constructed from Census Bureau trade-flow data do not adjust for quality changes. In principle, one might be able to compare BLS traded-price indexes with traded-goods unit values to look for evidence of changing product quality. For example, if domestic producers are moving toward higher-quality products, then export unit values should rise faster than export price indexes. Indeed, Alterman does a direct comparison like this and reports the "puzzling" result that during the 1970s and 1980s BLS import price indexes tend to rise faster than the Census unit values. Alterman suggests that one might expect quality-adjusted price indexes to rise more slowly if import quality is rising over time. But thinking about different countries moving into different cones suggests an alternative view. Perhaps the average quality of U.S. imports is declining, not rising as is usually presumed, as foreign producers increasingly concentrate on unskilled-labor-intensive products. In this case, quality-adjusted price indexes should rise faster than unit values, as the data actually show. Another possible solution to changing product mixes and price indexes is suggested by Feenstra (1994), who develops a methodology for adjusting import-price data to account for new product varieties.

4.6 Conclusion

This paper has attempted to provide a comprehensive survey and synthesis of research on how product-price changes have contributed to rising U.S. wage inequality. It has surveyed nine product-price studies, which together demonstrate how the methodology of product-price studies has evolved. After surveying each paper individually I synthesized the findings and drew two main conclusions. The first conclusion is that this literature has refined a set of empirical strategies for applying the SS theorem to the data from which important methodological lessons can be learned. The second main conclusion is that, despite the methodological progress that has been made, research to date still has fundamental limitations regarding the key question of how much international trade has contributed to rising wage inequality.

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Comment Robert E. Baldwin

Matthew Slaughter has written an extremely valuable paper for economists interested in the impact of international trade on U.S. wages. Focusing on papers based on the product-price/factor-price relationships embedded in the Stolper-Samuelson theorem, he begins by discussing the empirical feasibility of implementing alternative theoretical versions of this theorem. He then thoroughly reviews nine such studies, carefully pointing out and synthesizing the similarities and differences among the authors in assumptions and statistical methodology that do and do not seem to matter for differences in the authors' findings. In his concluding remarks on the limitations of current research and suggestions for future research, Slaughter emphasizes the failure of the studies thus far to determine clearly the relative importance of international versus domestic factors in influencing changes in relative wages or the ranking in importance of the various international forces that operate on relative wages. He also stresses our lack of understanding of the time framework within which various domestic or international forces affect relative wages. I am in general agreement with Slaughter's appraisals of the strengths and drawbacks of the various studies, but will suggest a somewhat different ordering in importance of these, as well as providing additional examples of his general themes.

By applying the small-country assumption to the United States, four of

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the nine studies reviewed (Bhagwati, Lawrence and Slaughter, Sachs and Shatz, and Krueger) assume that U.S. product prices are not influenced by any U.S. real variables such as changes in relative factor endowments, changes in technology, or changes in tastes. Leamer (1996) also makes this assumption in his paper, except with regard to the effect of domestic technological progress (as measured by total factor productivity growth) on domestic prices. In his empirical analysis, Leamer regresses changes in domestic prices and total factor productivity growth on factor shares, allowing alternatively for a 0 and 100 percent pass-through effect of total factor productivity growth on domestic prices. The results yield mandated growth rates in the wages of high- and low-skilled labor, as well as in the earnings of capital that he attributes to "globalization." In view of the intense policy debate about the effects of globalization on American workers, I think this is a somewhat unfortunate use of the term. As Leamer points out himself, if domestic as well as international economic conditions affect domestic prices, he may be attributing to "globalization" relative price effects that are due to important economic changes (other than domestic technological changes) strictly internal to the United States. One such change is the increase in the endowment of more-educated labor relative to the endowment of less-educated labor that has taken place in the United States over the last few decades. For example, the proportion of U.S. workers with only 1–11 years of education fell from 36 percent to 10 percent between 1967 and 1992, while the proportion of workers with 13 years or more of education rose from 25 percent to 53 percent between these years.

We should drop the small-country assumption when applying the Stolper-Samuelson framework to large developed countries, such as the United States. Estimations of import- and export-demand elasticities, as well as studies of the pass-through effects of exchange rate changes, provide ample evidence that this assumption is not valid for the United States. Dropping the assumption makes it much more difficult to estimate the relative wage effects stemming from international factors, but avoiding a difficult decomposition problem by an unrealistic assumption may misinform the policy debate on trade issues. The 1997 paper by Feenstra and Hanson demonstrates how progress still can be made in assessing the relative importance of trade and technical change on relative wages even when industry prices are not assumed to be exogenous.

Unlike the Leamer and Feenstra and Hanson papers, my colleague Glen Cain and I do not include a measure of total factor productivity growth in our regression analysis in order to control for the effect of technology. Unfortunately, these efforts are hampered by the lack of a suitable measure of exogenous technological change for an industry. The measure used, total factor productivity (TFP) from Bartelsman and Gray (1996), includes several variables that are endogenous with respect to current-period product prices for an industry, namely, current labor and capital quantities, current wages and returns to capital, and the current price and quantity of industry output. The simultaneity problem is especially severe because TFP includes the current product price, which is the model's dependent variable. Our alternative is to infer from the general equilibrium trade model and from the standard properties of regression analysis the biases in the regression coefficients of the factor shares that would exist with varying types of technological change. However, for comparative purposes and to illustrate further some of the points Slaughter makes, I report regression results using our data set when the standard TFP measure is included.

Table 4C.1 presents estimates of what Leamer terms "total mandated annualized earnings growth" for two types of labor and a capital proxy,

Table 4C.1 A Comparison of Leamer's "Total Mandated Annualized Earnings Growth" under Various Assumptions Using BC Data Set

	0 Percent Pass-Through (%)			100 Percent Pass-Through (%)		
	1968–73	1973–79	1979–91	1968–73	1973–79	1979–91
	Weighted Regressions (by employment); No Constant Term					
Labor (years of education)						
1–12	−0.10	−6.39	−1.38	1.15	−6.64	−1.46
(1–12 minus 13+)	(11.18)	(−14.65)	(−5.95)	(13.93)	(−14.57)	(−5.85)
13+	−11.28	8.26	3.97	−12.78	7.93	3.89
Capital	−0.82	−5.42	−2.72	0.20	−5.76	−2.80
	Unweighted Regressions; No Constant Term					
Labor (years of education)						
1–12	3.10	−6.06	−0.85	4.14	−6.40	−0.92
(1–12 minus 13+)	(19.56)	(−14.90)	(3.40)	(20.21)	(−14.91)	(−5.52)
13+	−16.46	8.84	−4.25	−16.07	8.51	4.60
Capital	−1.57	−5.46	−3.00	−0.54	−5.79	−3.08
	Unweighted Regressions; with Constant Term					
Labor (years of education)						
1–12	0.07	−10.61	−6.20	0.91	−10.65	−6.83
(1–12 minus 13+)	(20.06)	(−14.90)	(−3.40)	(20.06)	(−13.82)	(−3.70)
13+	−19.99	3.21	−3.18	−19.15	3.17	−3.13
Capital	−1.92	−6.35	−2.14	−1.09	−6.40	−3.87

	Actual Average Annual Growth of Real Wages (%)		
Years of Education	1967–72	1972–79	1979–92
1–12	2.97	−0.37	−0.60
13+	2.40	−1.00	−0.00

assuming alternatively a 0 percent pass-through of productivity changes into price changes and a 100 percent pass-through. Results from three econometric specifications are given. The first follows Leamer in reporting a weighted regression (where the weights are industry employment) without a constant term. The second set of results is based on an unweighted regression without a constant term, while the third set of regressions is unweighted but includes a constant term.

As is apparent from the table, even with TFP data included in the regressions, the product-price approach performs badly with our data in predicting the magnitude of the actual rates of change of the real wages of less-educated and more-educated labor over the periods covered. At best, it only seems possible to use the approach to analyze the differences between the growth rates of wages for the two groups, and then not in absolute terms but in terms of whether inequality increases or decreases. For example, all three sets of regressions both with 0 and 100 percent pass-through correctly predict the trend toward greater wage equality in the period 1968–73. In contrast, none of the three variations correctly predicts the continued increase in wage equality between 1973 and 1979. However, two of the three regressions under the assumption of a 0 percent pass-through and all of the regressions under the assumption of a 100 percent pass-through correctly predict the increase in wage inequality in the 1979–91 period. In terms of a change toward greater or less wage equality, in only one case (the unweighted regression without a constant term for 1979–91) do the differences between weighting and not weighting and between including a constant term or not matter for the results.

To elaborate further on Slaughter's analysis of what differences in assumptions and statistical methodology seem to matter most for differences in results, I used our data set to investigate how the labor-share coefficients in the price regressions differ when the regressions are modified in the following manner: (1) the computer sector is excluded from the data set, (2) direct rather than direct and indirect input-output coefficients are used, (3) labor shares by industry are calculated using actual industry wages by education level rather than the nationwide wage for a particular education group, and (4) primary products and services are included in the regression analysis in addition to manufacturing industries. For the period 1968–73, our basic regression for manufacturing industries and the regressions for all four of these variations correctly predict a rise in the wages of unskilled (1–12 years of education) workers relative to skilled (13+ years of education) workers. All the regressions except the one omitting the computer sector also correctly predict the continued reduction in wage inequality during the period 1973–79. However, for the period 1979–91, only the regression omitting the computer sector and the regression including primary products and services correctly predict the increase in wage inequality during these years.

These results reinforce Slaughter's point that the extent of industry coverage seems to matter greatly. This suggests that technology shocks move across industries in a very uneven manner in terms of their impact on the relative wages of broad groups with similar levels of education. This may bring about not only the significant differences in relative wage changes among different groups of industries such as services and manufacturing, but also the large differences in the coefficients on labor shares within the manufacturing group. The forces tending to eliminate excess profits and rents and change the relative wages of a particular skill group across all industries clearly seem to be operating, but in an imperfect manner that apparently makes relative price and productivity changes a poor short-run predictor of relative wage changes.

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