Treating the Stolper-Samuelson Theorem Seriously:

Is there a Long-run Relationship between Relative Commodity Prices and Relative Factor Prices?

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Abstract:

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This paper argues that an appropriate test of the Stolper-Samuelson theorem must take account of the fact that the theorem refers to a *long-run* relationship between relative commodity-prices and relative factor-prices. Thus, this paper applies the unit root/cointegration methodology developed by Johansen to evaluate the Stolper-Samuelson relationship. The results are weak but, in some series, consistent with the presence of a long-run Stolper-Samuelson relationship between the relative prices of capital intensive and labour intensive goods and the capital rental relative to the wage.

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The Stolper-Samuelson theorem is an essential tool for thinking about the relationship between international trade and the distribution of income. The 2-good × 2-factor general equilibrium model, from which the Stolper-Samuelson theorem is derived, provides the minimally complex microfoundations for a well-specified macroeconomic model with international trade that might generate income distribution effects. It was the extraordinary accomplishment of Wolfgang Stolper and Paul Samuelson that, using this model, they were able to cut through what had previously seemed to be intractable analytical problems to derive a clear result on this important question[1]

> *Theorem*: Under the assumptions of the Heckscher-Ohlin-Samuelson Model, an increase in the relative price of a good raises the return to the factor used intensively in the production of that good relative to all other prices and lowers the return to the other factor relative to all other prices.

If we are interested in broad labour aggregates, such as skilled and unskilled labour, a highly aggregated model such as the HOS model would seem to be a particularly appropriate vehicle as an intuition generator and as a framework for a rough pass at the data. With the emergence of a widening skill-premium in the 1980s, associated with accelerating globalisation, a number of commentators were quick to suggest a causal relationship, often with the implication that the US

[1]Stolper and Samuelson's (1941) original paper still bears reading, both for the way the paper is motivated as well as for the clarity with which the then counterintuitive result is exposited. Deardorff and Stern (1994) contains the original paper, a number of the most important extensions, and a collection or reminiscences by the original authors as well as by trade economists from every post-Stolper-Samuelson generation to date.

should reconsider its commitment to international liberalism. Concern with this implication led a number of trade economists to recoil from the Stolper-Samuelson theorem and its recognition that changed trading conditions creates losers and winners as well as aggregate gains, and considerable effort and ingenuity has been invested in demonstrating the empirical irrelevance of the Stolper-Samuelson theorem, at least to the current situation.[2] While this conclusion might well prove correct, we argue that tests to this point are far from dispositive because they may be seriously misspecified. The primary goal of this paper is to take some initial steps toward a more properly specified test of the Stolper-Samuelson theorem.

Specifically, we will argue that the Stolper-Samuelson theorem is best seen as a long-run comparative static result that cannot be effectively estimated in a cross-section framework, but rather must be implemented in a time series framework. Given the centrality of this claim to our research, the next section motivates our analysis by placing it in the context of the existing research on trade and wages. The second section argues for a presumption in favor of Stolper-Samuelson effects. The third section presents our data and methodology, the fourth section our results, and fifth section concludes.

I. Some Motivation

Edward Leamer (1994) begins his recent survey of trade theory with three useful meta-

[2]See Gaston and Nelson (forthcoming) for a survey of this research and a discussion of its motivations. This paper is not the place to discuss the link between trade, technology, and trade policy, but it is worth noting that the logic, common on both sides of this debate, that trade induced income distribution effects call for trade intervention while technological change does not is not sustainable as a matter of logic. This absolutely essential point is very well made in a recent paper by Alan Deardorff (1999).

methodological recommendations. The first two relate to the relationship between theory and empirical implementation; the third expands on the first two by suggesting a framework of implementing the first two suggestions. "*Estimate, don't test*" is essentially a reminder that as applied economists we should not take our theory too seriously. That is, given the heroic simplifications necessary to deriving any results, we cannot expect the world to do anything but falsify our theory. However, to the extent that we believe our theory to capture some important aspect of reality, for whatever reason, the empirical question is whether we can find some evidence supporting this belief in a well-constructed empirical implementation of the theory. A loosely Bayesian way of putting this is that we are really interested in how our priors are affected by the results of the estimation. The emphasis on a well-constructed empirical implementation leads us to the second recommendation: "*theory before estimation*". That is, if we are going to estimate, we should be guided by the theory in constructing our empirical framework. Thus, in evaluating our results, we should recognize that our theories are not sufficiently robust to support testing; if we hope to have any effect on our priors, we need to treat the theory very seriously indeed in constructing our empirical model.

To implement these recommendations, Leamer suggests that a well-constructed research programme should have three layers: a set of issues that motivates the research; a theoretical framework appropriate to the issues; and an empirical framework for estimation (which Leamer calls the "data layer"). The search for elements of an explanation for the emergence of sustained relative (and possibly absolute) deterioration in the income of unskilled workers scarcely requires justification as a research question of first-rate importance. The boom in research on this question since the early-1990s stands as eloquent testimony to this importance. Thus, the first layer is

unproblematic. The greatest dispute within the research community interested in these issues has been less with respect to results and far more with the second layer: the appropriate theoretical framework. Trade economists have argued for a general equilibrium theory that emphasizes intersectoral interdependencies rooted in resource constraints, while labour economists have argued for a partial equilibrium framework that can accommodate the kind of intersectoral heterogeneity that would seem to be essential to thinking about the variety of ways increased globalisation is translated into returns to participation in the labour market (Gaston and Nelson, forthcoming). While this issue is far from resolved, we take it that general equilibrium effects must play an essential, if not the entire, role in any compelling account of the effects of trade on wages. If this claim is accepted, then, as we suggested in the introduction, a low-dimensional model is the appropriate place to start and, because policy should be based on long-run considerations, the 2-good × 2-factor neoclassical (HOS) model, and the Stolper-Samuelson theorem, would seem to be the place to start.

This brings us to Leamer's third layer: empirical implementation of the theoretical framework. Empirical work within the HOS framework has taken two broad forms: factor-content studies; and Jones-Baldwin (mandated wage) regressions.[3] Leamer (2000) has argued forcefully that the former fail the theory-before-estimation rule. That is, in a model of the HOS sort, the Stolper-Samuelson theorem reminds us that income distribution effects (i.e. changes in relative factor returns) are driven by changes in commodity prices, not by quantity changes (i.e. trade volumes or endowments) (Leamer 1995, pg. 42). Leamer's claim is controversial on practical grounds. Krugman (2000), for example, argues that, under plausible auxiliary

[3]This characterization abstracts from work based on computational modeling.

assumptions, factor contents can be informative with respect to the wage effects of international trade.[4] However, since our goal in this paper is to evaluate the Stolper-Samuelson theorem itself, Leamer's arguments would seem to have considerable force. The other main line of empirical work on the Stolper-Samuelson theorem is explicitly based on Jones' (1965) classic decomposition:

$$\hat{p}_j = \sum_{i \in M} \theta_{ij} \hat{w}_i \,, \; \forall j \in N \,, \qquad \textbf{(1)}$$

where "hats" denote proportional changes, θ_{ij} are the shares of factor *i* in the returns to sale of product *j*, and, in the 2 × 2 case with skilled and unskilled labour considered here, $M = \{S, U\}$ and $N = \{1,2\}$. Using data on price changes and factor-shares, a number of analyses have sought to estimate the changes in wages implied ("mandated") by the price changes. These mandated wage changes can then be compared to actual wage changes as an indirect evaluation of the operation of Stolper-Samuelson type forces.[5] This approach has solid theoretical foundations for studying the general relationship between commodity-prices and factor-prices, however, in the high-dimensional world implied by 50-70 industries and 3-4 factors, there are well-known problems in stating the exact empirical prediction of the $M \times N$ HO model as implemented in a regression based on equation (1) (Ethier, 1984).

Our approach adopts an even more extreme implementation: we aggregate the data up to

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[4]See Deardorff (2000) and Smith (1998) for additional discussion of this important issue.

[5]The standard reference here is Baldwin and Cain (1997). Since that paper a number of papers have appeared applying more or less this methodology. Given the interest in mediating between trade and technology as forces in determining relative factor-returns, one of the main extensions has been the introduction of measures of technological change directly in this framework (e.g. Leamer, 1998).

two sectors and two factors of production. If the other assumptions of the HOS model are reasonably well approximated by the data, the 2 ×2 structure would ensure that the Stolper-Samuelson theorem holds exactly.[6] Although Samuelson (1947), appropriately, makes the existence of testable propositions the hallmark of scientific economics, the actual empirical implementation of such propositions is a tricky business.[7] Other papers have focused on problems related to dimensionality, market structure, and data. In this paper, we consider problems related to time. Specifically, we argue that the Stolper-Samuelson theorem is a long-run result in two important senses. First, it is a theorem of comparative statics. That is, it is a statement comparing the equilibrium values of endogenous variables of identical economies facing different commodity prices. Thus, if the theorem is to be applied to a given economy at different times, and abstracting from *ceteris paribus* considerations, the economy must be permitted sufficient time for the endogenous variables to adjust to the change in exogenous variables. Perhaps more importantly, the Stolper-Samuelson theorem is generally considered to be a long-run theorem in the sense that the initial response of the market to price changes appear to be more consistent with short-run equilibrium models of the Cairnes-Haberler and Ricardo-Viner sort. Thus, to give the Stolper-Samuelson theorem a fighting chance, we are virtually required to use a time series framework in its implementation. That is the goal of this paper.

Our point is not that a 2 × 2 aggregate model is obviously superior to more disaggregated approaches, we don't, and hope to extend our time series methodology to more disaggregated

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[6]The appendix to this paper lists the standard assumptions and provides one of the canonical graphical demonstrations of the Stolper-Samuelson theorem.

[7]Also see Silberberg (1990) for a textbook development of this programme.

data in future work. Rather, we are interested in the empirical content of a very simple model that lies at the foundation of our intuition and teaching as trade economists. The central concern of this paper is to treat the theory seriously by explicitly recognizing the temporal nature of comparative static propositions like the Stolper-Samuelson and Rybczynski theorems, at least as they are generally interpreted.[8] Considerable empirical effort in the last few years has gone into arguing against a presumption in favor of observable Stolper-Samuelson effects. Thus, in the next section, we develop an argument in favor of such a presumption.

II. For a Stolper-Samuelson Presumption

In this section we offer three sorts of motivation for treating the Stolper-Samuelson theorem empirically as a time-series proposition: eyeball econometrics; direct evidence of valuation effects induced by price changes; and indirect (political economy) evidence of such effects. We hope that the sum of these will underwrite a presumption in favor of Stolper-Samuelson effects that will then underwrite the empirical work we present below.

–Charts 1 - 3 about here--

The first exhibit in the case for a presumption of a relationship between relative commodity-prices and relative factor-prices is shown in charts 1, 2 and 3. Here we show plots of relative commodity-price, relative factor-price, and relative output series for our six definitions of

[8]As comparative static propositions, there is no formal difference between the Stolper-Samuelson and Rybczynski theorems on the one hand, and the Heckscher-Ohlin and Factor-Price equalization theorems on the other. It is nonetheless the case that, in empirical implementation, the Heckscher-Ohlin and FPE theorems are usually understood as static propositions, while the Stolper-Samuelson and Rybczynski theorems are understood as dynamic propositions.

factors.[9] Looking at these plots suggests quite close relationships between relative commodity-price and relative factor-price of the predicted sort, at least for the skilled-unskilled case. In addition, the relationship between relative commodity price and relative output seems to be loosely of the correct type, especially in the latter part of the series. These series seem sufficiently closely related, and related in the theoretically expected ways, to underwrite a basic presumption in favor of Stolper-Samuelson effects.

The direct and indirect evidence for factor-price effects of commodity-price change also underwrite our claim that the period to the long-run may actually be rather long. The indirect evidence is derived from the political behaviour of economic agents, the direct from market response to trade-related shocks.

Twenty years ago, Steve Magee (1978) had an exceptionally clever notion for "Three Simple Tests of the Stolper-Samuelson Theorem". The basic idea was to use the political behaviour of rational agents to determine the adjustments induced by changes in trading conditions. After tabulating the public lobbying behaviour of economic agents (i.e. representatives of firms and unions), Magee found that firms and unions (i.e. capital and labour) tend to lobby together–a result consistent with the Cairnes non-competing groups model and inconsistent with the apparent predictions of the Stolper-Samuelson theorem. Where Magee framed the analysis as a test of competing models (based on the assumption that agents are fully

[9]Charts 1 show series generated from a skilled-unskilled labour definition based on skilled labour as high school or more education and unskilled labour as less than high school and industries defined in terms of the median and mean skilled/unskilled ratio in 1977. Chart 2 gives skilled labour as more than high school. Charts 3 is a capital-labour breakdown, again using mean 1977 capital/labour ratio to define the two industries. The data are described in more detail below. The other series are similar.

intertemporally rational), we think it is fair to say that most political-economy analysts now take this result to say not that the economy is in fact characterized by non-competing groups of factors defined in terms of industry location, but that agents condition their political behaviour on short-run calculation.[10]

For our purposes, there are two important lessons from Magee's work: economic agents believe that there are income distribution effects from trade policy (and thus trade) that are non-trivial in magnitude; and over some significant time period, these effects are seen in terms of quite imperfect factor mobility. The first point is virtually self-explanatory: if economic agents are economically rational, and if political action is costly, then such agents will only pursue attempts to affect trade policy if they expect significant income distribution effects. At least for an economist, the best evidence in the world that something exists is that a lot of people are willing to pay money to pursue it. Thus, the extensive history of political action on trade policy provides strong, *prima facie* evidence in favor of the presence of trade-induced income distribution effects.

We might move some way toward unpacking this paradox by focusing on the second point, and Magee's central result: the political behaviour of economic agents suggests that any long-run adjustment to trade shocks only occurs after a considerable period–we might not be dead in this long run, but we'll all be a lot older. Suppose we start with a framework whose long-run equilibrium is HOS, and denote as the short-run a period in which no factors are mobile (the Cairnes model) and as the medium-run a period characterized by imperfect and asymmetric factor-

[10]This result has been directly replicated in Nelson and Wasley (1989) and provided with more compelling support by Grossman and Levinsohn (1989). That is, the fact that agents condition even market behaviour on short-run calculation would seem to provide strong support for the notion that political behaviour is also taken in response to short-run effects.

mobility.[11] If we assume sufficient sectoral factor-price flexibility to ensure full-employment, the short-run analysis is quite straightforward. Again, consider a trade-induced decrease in the price of *L*-intensive good 2, with no change in the price of the other good. Since factors are intersectorally immobile and fully employed, their marginal products are unchanged so relative returns are unchanged. Thus, both factor-prices fall in the same proportion as the commodity-price. If household income is generated from a single factor invested in a single sector, and households consume strictly positive quantities of each commodity, real incomes of all factors in sector 1 increase while those in sector 2 fall.

$$\hat{p}_1 = \hat{w}_1 = \hat{r}_1 = 0 > \hat{p}_2 = \hat{w}_2 = \hat{r}_2. \qquad \textbf{(2)}$$

This is certainly sufficient to induce the pattern of lobbying on trade legislation observed by Magee.[12]

The direct evidence uses capital market event studies to determine the presence and extent of valuation effects from well-specified trade events. Although there are a substantial number of these studies that focus on the response of industry portfolios to such events as anti-dumping procedures (steel has been particularly extensively studied), the key paper here is Grossman and Levinsohn (1989), who not only find that there are significant valuation effects in response to trade shocks, but that the market responds in a way more consistent with short-run than long-run

[11]See Caves (1960, Chapter 3, section I) for a brief survey and useful discussion of the earlier literature on specific-factors and non-competing groups.

[12]Also see Baldwin (1984a) for a model with sector-specific capital in which sector-specific labour skills generates Cairnes-type non-competing group political behaviour.

trade models.[13] The presence of any valuation effect suggests that globalization has economically significant effects, the fact that these are short-run effects in the first instance suggests that the use of synchronic methods may be picking up these short-run effects and not the long-run effects that the Stolper-Samuelson theorem relies on.

The implication of empirical results like those of Magee and Grossman-Levinsohn on the relationship between trade and wages is that if we are looking for Stolper-Samuelson effects with contemporaneous data on relative commodity-prices and relative factor-prices, we have probably misspecified the empirical model. That is, the short-run relationships between commodity-price shocks and factor-price adjustments are systematically different from the long-run relationships. The story of U.S. trade policy in the 1960s and 1970s is a story about sizable liberalization. The Kennedy Round and the Tokyo Round involved large reductions in total protection. Since these reductions were accomplished via reciprocal reductions in protection, protection fell both at home and in our trading partners. To whatever extent trade is endowment-based, both of these should have resulted in price reductions for, presumably labour intensive, import-competing goods. Furthermore, at least as far as these import-competing producers were concerned, the 1960s and 1970s were a period in which the administered protection mechanism was not working.[14]

The relevant empirical research relates to the *structure* of protection. Here the results are fairly clear:

> "[T]he various empirical tests indicate that industries receiving the greatest protection (and the lowest duty cuts during multilateral trade negotiations) are ones in which the

[13]Nelson and Wasley (1989) found similar valuation effects in response to the adoption of omnibus trade legislation.

[14]See Destler (1986) or Nivola (1993).

> workers tend to be unskilled, low-paid, older, and live in rural areas. These industries are also characterized by a large number of workers, a high labour-output coefficient, a small number of firms, slow growth, a high import penetration ratio, and historically high levels of protection." (Baldwin, 1984b, pg. 581)[15]

Following the empirical arguments of, for example, Hufbauer and Chilas (1974) and standard political-economy reasoning, and painting with a broad brush, we might interpret this as saying that the largest reductions in protection occurred in sectors characterized by intra-industry trade, i.e. sectors in which adjustment costs would be lowest. There were lower, but still positive, cuts in high adjustment cost sectors, but the cuts were such that the structure of protection has remained more-or-less the same (at lower levels across all sectors). If we suppose that price changes in the low-adjustment cost sectors are small (since there are increasing imports and exports) and that price changes are larger (even for lower reductions in protection) in the high-adjustment cost sector, and that exportables prices rise, we have the basis for long-run Stolper-Samuelson effects.[16] If we also suppose, consistent with the implication of political-economy research that adjustment to the long-run equilibrium takes a long time, it is entirely possible that the liberalizations of the 1960s and especially the 1970s played a substantial role in the deterioration of unskilled wages in the 1980s. Furthermore, we can only begin to determine now if the increased protection of the 1980s has produced reduced rates of relative unskilled wage decline in the late-1990s.

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[15]Rodrik (1995) provides essentially the same conclusion.

[16]It is provocative, though far from dispositive, that low average wages were positively associated with the (then Treasury's) less than fair value determination, but insignificantly (though negatively) in the ITC's injury determination. Since two positives are necessary for a final affirmative determination, this suggests that low-wage labour was not particularly well served by administered protection prior to the 1980s.

All of this suggests that any reasonable test of the Stolper-Samuelson theorem must focus on the long-run relationship between relative commodity-prices and relative factor-prices. In the next section, we present a natural framework for such an evaluation. Specifically, we develop the Johansen, VAR-based methodology to draw conclusions about the impact of lagged relative price on the U.S. wage gap. The following section describes our data and methodology, and section IV reports our results.

III. Data and Methodology

Because many time series are non-stationary, testing for unit-root and cointegration is needed as a first stage. Augmented Dickey-Fuller test (Dickey and Fuller, 1979) tests are employed to test the null hypothesis of non-stationarity for each series. The cointegration analysis is based on the Johansen Procedure (Johansen, 1988, 1995; Johansen and Juselius, 1990). Since it is based on a VAR, no particular variable needs to be designated as the dependent variable. Because we only have 20 years of data, we need to use critical values that are corrected for sample size (Reinsel and Ahn, 1988, 1992). If cointegration is not rejected, depending on the sign in the cointegrating vector, Stolper-Samuelson effects could be supported. However, we are not very optimistic. The evidence, from previous studies, rarely finds a strong contemporaneous relationship between wages and prices.

To evaluate the presence of Stolper-Samuelson effects in the U.S. data, we employ annual time series of relative factor-prices, relative-commodity prices, and relative output from 1967 to 1987. We construct a measure of relative wage following the approach of Baldwin and Cain in using the wages of workers with less than high school, high school, and college plus

education from the March CPS. The relative price and relative output series were computed as in Baldwin and Cain.[17] This involved identifying sectors with greater than average skill-intensity and less than average skill intensity (using the US input-output tables to account for direct and indirect factor use); then creating price indices for each of these aggregates.

Our hypothesis is that the relationship between lagged values of relative commodity prices and current relative wage is stronger. This lagged structure should be a consequence of sticky wages in the short-run, therefore they do not adjust immediately to changes in commodity prices. If the variables are cointegrated, Granger causality is tested using the error correction representation (Johansen, 1992) in which the lagged residual of the cointegration relationship is included in the VAR in differences. The system is represented as follows:

$$\Delta Z_t = \gamma_0 + \sum_{i=1}^{q} \gamma_i \Delta Z_{t-i} + \alpha\beta' Z_{t-1} + \varepsilon_t . \qquad \textbf{(3)}$$

where: $\mathbf{Z}_t$ is a 3x1 vector, includes the relative wage relative price, and relative output measures,
$_i$, i = 0,...,q, are 3x1 vectors of coefficients,
is the cointegrating vector (3x1),
is a 3x1 matrix of coefficients, and
$_t$ is a 3x1 vector of residuals.

q is the optimal lag chosen according to AIC and Schwarz criterion, if the optimal lag differs

[17]That is, industries were classified according to the 79 two-digit sectors in the Bureau of Economic Analysis' input-output table. This information was used to construct aggregate sectors based on factor intensity. For each of our measures of two factors (two skilled-unskilled measures, and capital-labour), we used 1977 as a base year and created one set of aggregates based on the median factor-intensity and another based on the mean. For these we calculated aggregate output and an aggregate price index for each sector. From these basic data we constructed ratios for relative commodity- and factor-price, and relative output. For relative commodity price and output we take the skilled to unskilled and capital to labour ratios, for relative factor-prices, because were wanted to illustrate the effect on unskilled workers we took the unskilled to skilled ratio, while for the capital-labour case we took wage to rental ratio.

between series we estimate systems under alternative lag-length specifications.

If all the coefficients of lagged values of relative prices and the error correction term ($'\mathbf{Z}_{t-1}$) do belong in the relative wage equation, and the impact of relative price on relative wage is positive, we can conclude that Stolper-Samuelson effects are present in the U.S. data. Also, if the system is cointegrated, the VAR in levels can be estimated. So, we can analyze the impulse response function and the variance decomposition in the system.

IV. Results

Our analysis of the individual series suggests, strongly by the standards of this sort of analysis, that the variables are not stationary. As can be seen in Tables 1 to 3, relative wage, price and output are I(1) for each data set at the 5 or 1% level.

Table 1: Unit Root Test Results. ADF (1967-1987)[1]

	SU12MD77		SU12MN77	
Variable	**Level**	**1st Difference**	**Level**	**1st Difference**
RELW	-1.509 (1,C,T)	-6.5 (0) ***	-2.577 (0,C,T)	-6.516 (0) ***
RELP	-0.710 (2,C,T)	-3.668 (1) ***	-1.902 (1,C,T)	-4.124 (1,C) ***
RELY	-2.115 (1,C,T)	-3.095 (0) ***	-2.344 (1,C,T)	-3.257 (0) ***

(1) Number of lags, constant (C), and trend (T) are indicated in parenthesis. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level.

Table 2: Unit Root Test Results. ADF (1967-1987)[1]

	SU13MD77		SU13MN77	
Variable	**Level**	**1st Difference**	**Level**	**1st Difference**
RELW	-1.605 (0,C)	-4.187 (0) ***	-1.605 (0,C)	-4.187 (0) ***
RELP	-1.576 (1,C)	-3.664 (1) ***	-0.401 (2,C,T)	-3.527 (1) ***
RELY	-2.208 (1,C,T)	-3.230 (0) ***	-1.818 (0,C,T)	-3.258 (0) ***

(1) Number of lags, constant (C), and trend (T) are indicated in parenthesis. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level.

Table 3: Unit Root Test Results. ADF (1967-1987)[1]

	KLMD77		KLMN77	
Variable	**Level**	**1st Difference**	**Level**	**1st Difference**
RELW	-2.337 (3,C)	-3.549 (1,C) **	-2.337 (3,C)	-3.549 (1,C) **
RELP	-2.971* (1,C)	-3.434 (1) ***	-2.439 (1,C)	-3.510 (0) ***
RELY	-1.311 (0,C)	-3.728 (0) ***	-2.383 (1,C,T)	-3.400 (0) ***

(1) Number of lags, constant (C), and trend (T) are indicated in parenthesis. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level.

The results of our cointegration analysis are not strong. The Johansen Procedure used to

test for cointegration suggests the existence of one cointegrating vector among the variables in two of the six cases. As can be seen in table 4 the null hypothesis no-cointegration is rejected at the 5 and 10% level, in those two cases. The SU13MD77 case is not considered, because the result is inconsistent. I f we have three variables, at most we will have two cointegrating vectors, while the test for this data set shows that there are more than two cointegrating vectors.

Table 4: Cointegration Test Result.
Likelihood ratio test

Lags = 2	**SU12MD77**	**SU12MN77**	**SU13MD77**	**SU13MD77**	**KLMD77**	**KLMN77**
r = 0	39.018	37.267	63.861***	56.893**	50.347	59.153*
r = 1	12.715	12.250	24.772*	20.965	19.744	12.792
r = 2	3.270	1.632	6.017*	4.841	4.036	3.528

*** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level.

Therefore, there is weak evidence of long run relationship among relative wage, relative price, and relative output in the U.S. in these two series. Normalizing the cointegrating vector, we could tell something about the contemporaneous relationship between the variables. The estimated cointegrating vectors are (t-statistic in parenthesis):

SU13MN77: RELW = 1.345 – 0.558 RELP + 0.147 RELY

(-10.35) (9.01)

KLMN77: RELW = -0.252 + 4.644 RELP – 61.432 RELY

(16.18) (34.60)

Now, to evaluate the Granger-causality in this VEC, we run a ^{2} test in which the null hypothesis is that the variable is weak exogenous. That is, that the variable is not Granger-caused by the other two variables. The results are in table 5. In the case of SU13MN77 all the variables are weak exogenous,

therefore Granger causality is rejected. On the second case, KLMN77, relative price and relative output are weak exogenous in the long run, but relative wage is found to be Granger-caused by the other two variables (a test for exclusion shows that all three variables are needed in the cointegrating vector). Thus, at least for the case of the (where sectors are defined by mean values of factor-intensity in 1977), we actually have a full Stolper-Samuelson result.

Table 5: Granger-Causality Test.

^{2}(1)	RELW	RELP	RELY
SU13MN77	2.39	2.33	1.98
KLMN77	27.11***	0.29	0.36

*** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level.

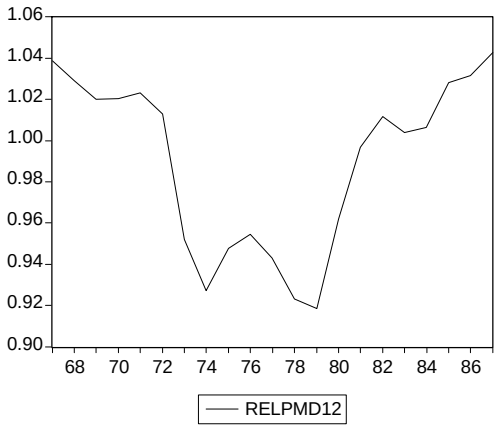
V. Directions for Future Research

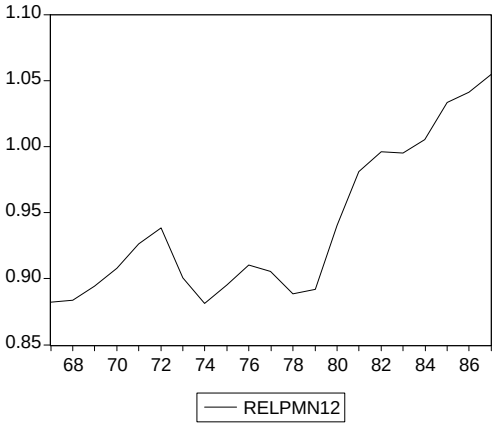
In this paper we have presented weak, but we think promising, evidence of Stolper-Samuelson effects in a highly aggregated empirical framework focusing on the long-run relationship implied by the theory. It is important to recognize, however, that we have provided evidence relative to what Deardorff (1994) calls the "essential version" of the Stolper-Samuelson theorem. That is, we have examined the relationship between relative *domestic* commodity-prices and relative factor-prices, where much of the current heat relative to research on Stolper-Samuelson effects is driven by concerns about the link between international trade and the deterioration of the return to labour force participation by unskilled workers. As Bhagwati (1959) makes perfectly clear, the essential version of the Stolper-Samuelson theorem is uninformative on this question. Thus, the next step in developing the research

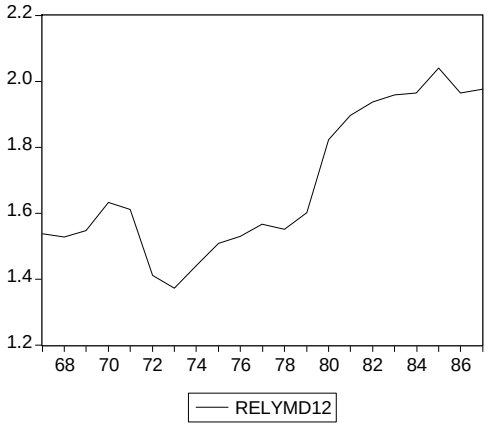
programme started in this paper is to introduce an international relative price variable into the analysis. In addition, our results are weak. There are many reasons why the results are weak: the model is hopelessly simple; the sectoral and factoral aggregations are heroic; we have relatively short series; and, from the perspective of this paper, the temporal aggregations are unattractively large. In future work, we plan to examine the effects of this sort in a more disaggregated panel and we hope to find data collected on a smaller unit of temporal aggregation (say, quarters).

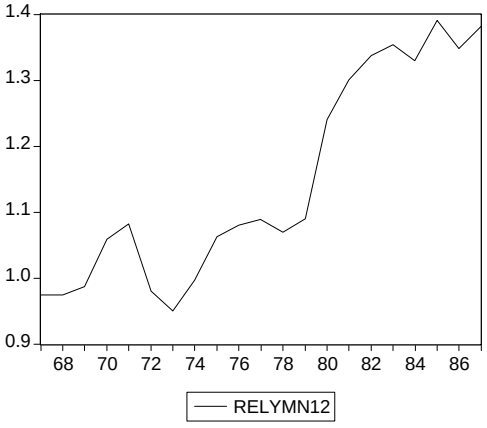
In terms of our direct research question: how are our priors affected by these results. Weak though they are, there is nothing in our results that suggest rejection of Stolper-Samuelson effects. If we take the priors of the profession to be accurately reflected in the discussions surrounding the current work by trade economists on trade and wages, our results would seem to suggest a posterior evaluation of the empirical content of the Stolper-Samuelson theorem toward a more positive evaluation. We, in any event, will continue to teach the theorem to our students as a genuinely useful result.

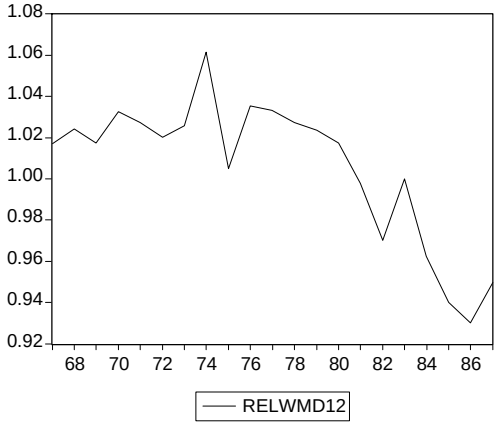
Charts 1: Skilled-Unskilled, Skilled = High School Plus

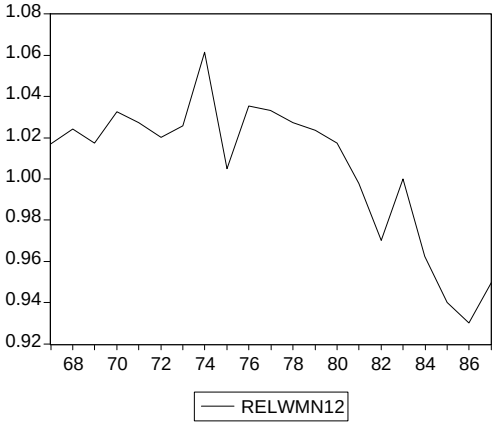




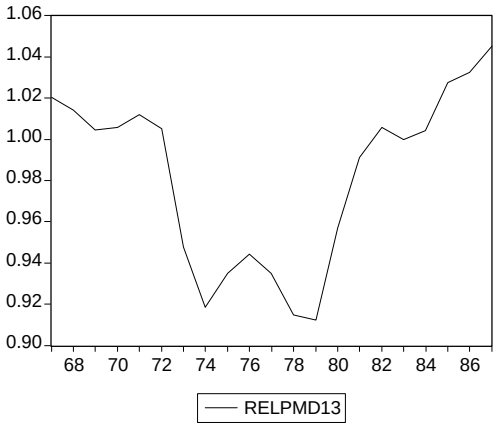


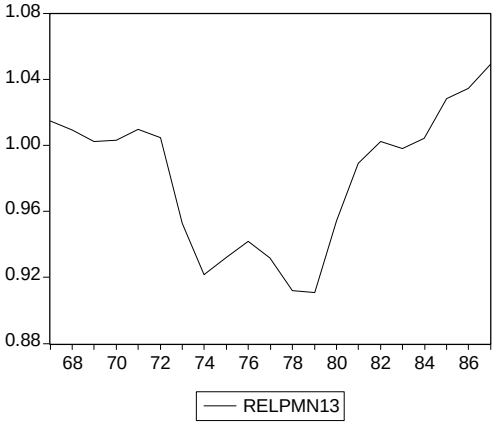


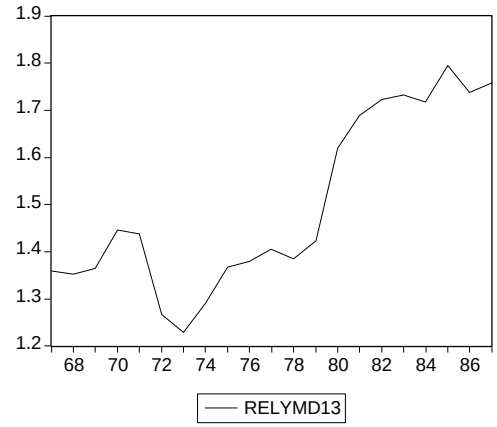


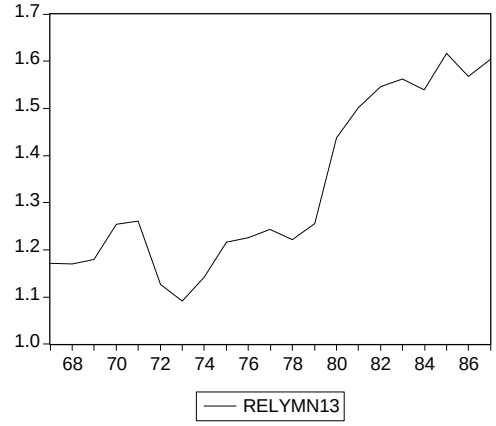


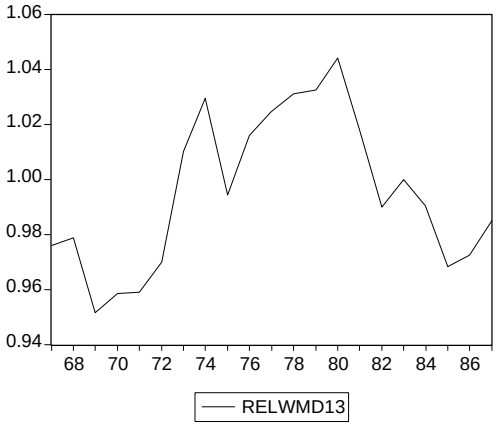
Charts 2: Skilled-Unskilled, Skilled = > High School

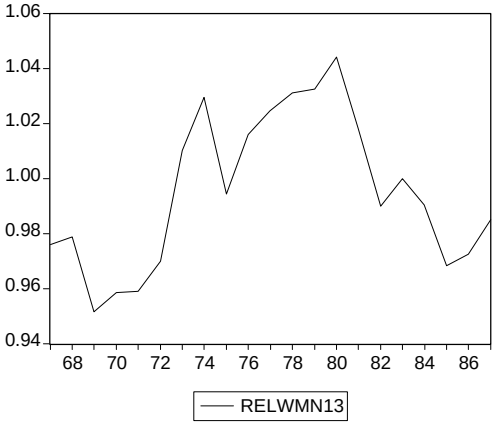




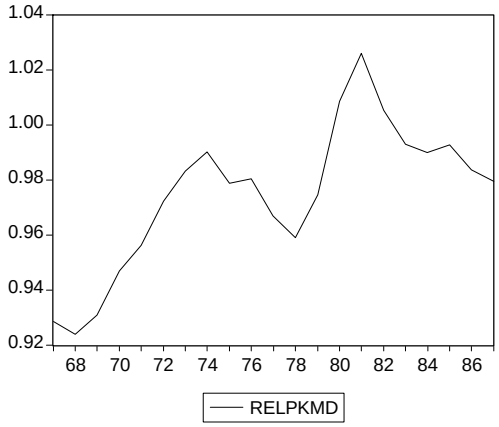


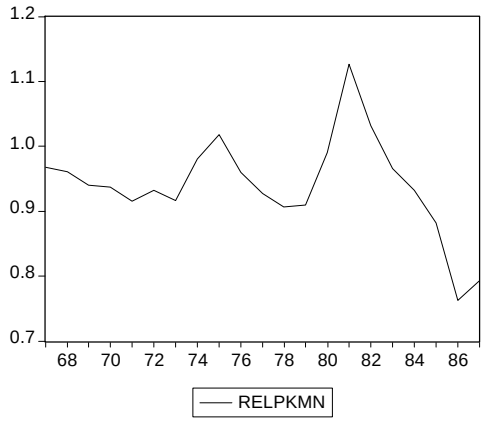


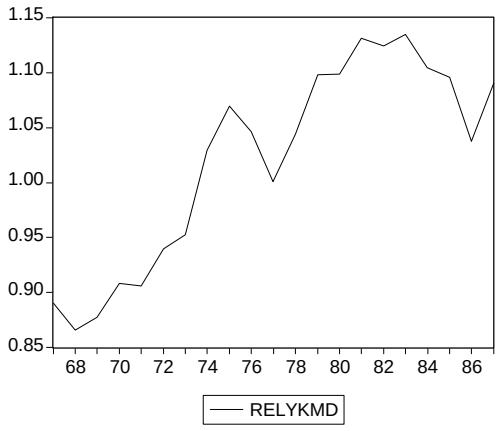


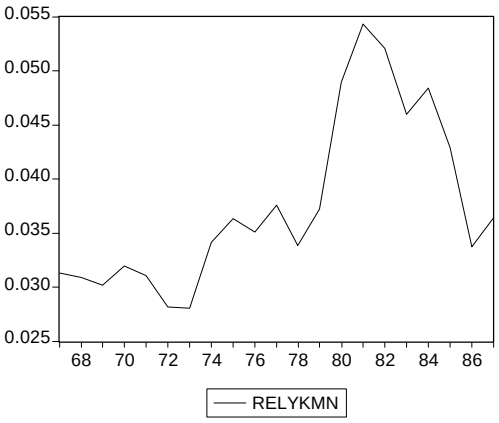


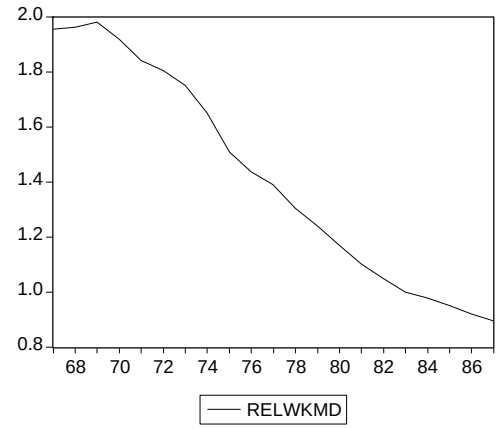
Charts 3: Capital-Labour

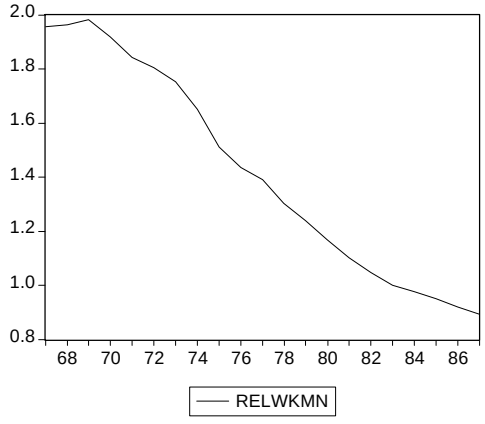












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Appendix

The standard assumptions of the HOS model are:

1. Behavioural/Institutional assumptions

    a. Rational behaviour by households and firms
    b. Complete, perfectly competitive markets
    c. Two countries
    d. Balanced trade

2. Both countries possess *identical tastes* that can be represented by identical systems of (homothetic) community indifference curves.

3. Each country is endowed with fixed quantities of *two factors of production* (usually called labour (L) and human capital (H)).[18]

    a. Factors are assumed to be of *uniform quality*.
    b. Factors are assumed to be *perfectly mobile between sectors*.
    c. Factors are assumed to be *perfectly immobile between countries*.

4. There are *two goods*

    a. Both countries share the same technological opportunities.
    b. Each good requires strictly positive inputs of both L and H to be produced in positive quantities
    c. These production functions are linear homogeneous, twice differentiable, and strictly concave.

5. *Factor-intensity*: At all relevant factor prices, it will be assumed that one of the goods is always human capital intensive relative to the other. Letting a_{ij} be the input of factor i needed to produce one unit of good j:[19]

[18]Actually, they are usually called labour and capital in pedagogical treatments, but in the literature on trade and wages, the convention is to focus on labour and human capital because of concerns for the deterioration in unskilled wages relative to skilled wages.

[19]Throughout this paper the set of factors is denoted M, a characteristic element is i; the set of commodities is denoted N, a characteristic element is denoted j. Where there are more than two elements in these sets, i can range from 1 to m and j can range from 1 to n.

$$\frac{a_{H1}}{a_{L1}} > \frac{a_{H2}}{a_{L2}}.$$

6. *Factor-Abundance*: One of the countries is taken to be relatively more richly endowed with human capital than the other. Letting a "bar" denote a fixed endowment and a "star" denote the Foreign country, this is:

$$\frac{\overline{H}}{\overline{L}} > \frac{\overline{H}^*}{\overline{L}^*}.$$

7. International trade in goods is costless.

Under these assumptions we are able to derive:

Stolper-Samuelson Theorem: An increase in the relative price of one of the goods will raise the return to the factor used intensively in the production of that good, relative to all other prices, and lower the return to the other factor, relative to all other prices.

As many others before us have done, we illustrate this result with the Lerner-Pearce diagram: into *H-L* space we project the unit-value isoquants for each of the two goods. Since the unit isoquant gives all combinations of *H* and *L* that can produce one physical unit of output, and since that unit sells for a price P_j, then we divide by P_j to scale the quantity back to \$1 worth of output at the given price. With price equal to cost under constant returns and competitive markets, each isoquant must be tangent to the \$1 isocost line.[20] Thus the equilibrium is illustrated in figure 1. Note, in particular the representation of the assumption that production of good 1 is human capital intensive relative to good 2.

–figure 1 about here–

Suppose we consider an archetypal OECD economy, taken to be relatively abundant in *H* (and thus an exporter of good 1). Now consider a reduction in protection, and assume for now that the

[20]The isocost line gives all combinations of *H* and *L* that can be purchased for \$1 at relative factor prices given by the slope: $1 = rH + wL$ or $H = 1/r - w/r\ L$. Note that *w* is the payment per unit labour ("wage") and *r* the payment per unit human capital ("rental").

country is economically small. Since the *L*-intensive good 2 is importable, the result is a fall in the price of good 2, represented by an outward shift in the unit value isoquant for good 2. As illustrated, if good 2 is to be produced in the new equilibrium, the *w/r* ratio must fall to permit a tangency for both unit isoquants. This is the friends and enemies part of the Stolper-Samuelson theorem: each factor has a good that is a friend and a good that is an enemy.[21] In this case, good 1 is a friend to *H* and an enemy to *L*; good 2 is a friend to *L* and an enemy to *H*. The other part of the theorem asserts a magnification effect: that the factor-price changes are magnified relative to the commodity-price changes.[22] We can see the magnification effect by recognizing that the intercepts of the isocost line give 1/*r* and 1/*w*. Thus, the fact that the new *H*-intercept is below the initial intercept implies that *r* has risen and, since the price of good 1 is unchanged and that of good 2 has fallen, this implies an increase in the real wage (i.e. a magnification). Similarly, since the new *L*-intercept is to the right of the old one implies that *w* has fallen. Furthermore, since the distance B'-B'' is equal to the proportional increase in price, and the wage has actually fallen by A'-B', the reduction in the wage is a magnification of the fall in the price of good 2. Using hats to denote proportional changes, we have:

$$\hat{r} > \hat{p}_1 (= 0) > \hat{p}_2 > \hat{w}. \qquad \textbf{(1)}$$

---

[21] A good is a friend to a factor if an increase in its price causes an increase in the factor's price, and an enemy if an increase in its price causes a decrease in the factor's price. This terminology is essentially that of Jones and Schienkman (1977).

[22] As Jones (1965) makes clear, this is a function of the fact, derived from zero profits and cost minimization, that the proportional change in a commodity price must be a distributive share weighted average of the proportional changes in factor prices: $\hat{p}_j = q_{Lj}\hat{w} + q_{Kj}\hat{r}$ –where θ_{ij} is the distributive share of factor *i* in sector *j*, and "hat" denote proportional changes. As a result, commodity-price changes must be bound between factor-price changes. So, given perfect factor mobility and the factor-intensity assumption, a change in relative commodity prices must result in one factor-price increasing by more than the largest price change and the other by less than the smallest commodity price change.

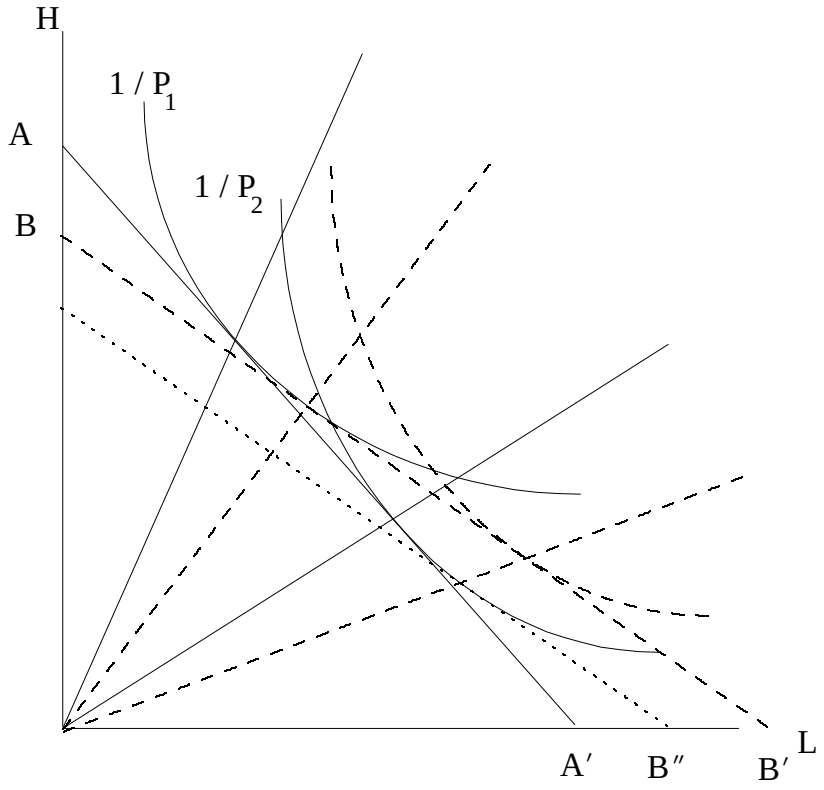

Figure 7: The Stolper-Samuelson Theorem in the Lerner-Pearce Diagram
Reducing protection in the unskilled labour (L)-intensive sector (2) causes a fall in P_2 and, thus, an outward shift in the unit-value isoquant. For production of both goods to be feasible, both unit value isoquants must be tangent to the unit isocost, so the wage must fall relative to the rental (the w/r ratio, given by the slope of the equilibrium unit isocost, falls from AA′ to BB′). As a result, both sectors become more L-intensive.