A Multi-Sector Specific Factors Model of the U.S. Economy with Skilled and Unskilled Labor as Mobile Factors *

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Abstract

This paper appears to be the first application of the specific factors model to the study of the relative wages of skilled and unskilled workers by considering a multi-industry model with those two types of labor as the only mobile factors. By estimating the translog cost functions of 41 U.S. industries (covering 74% of the U.S. economy) the model is calibrated to calculate the impact of the change in any commodity price or factor supply on the skill premium. It is shown that for changes in the price of a single industry, the impact on the skill premium is usually quite modest and sometimes the sign is the reverse of expectations. The elasticity of substitution between skilled labor and capital is critical for single-sector price changes. To generate a Stolper-Samuelson magnification effect, it is necessary to have a large number of price changes across industries intensive in either skilled or unskilled labor.

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1 Introduction

Wage inequality between skilled and unskilled labor has been increasing since the late 1970s. For example, over the past 30 years, there has been a substantial widening in the difference between pay for workers with a bachelor's degree and pay for those with only a high school diploma. For men, this difference grew from 50 percent in 1975 to 87 percent in 2004.[1] Researchers have studied the skill premium in many different contexts to explore the main causes of the widening wage gap between the two types of labor. In this regard, changes in terms of trade along with the factor movements due to international trade are one of the mainstream explanations for the rise in the skill premium.[2]

Studies suggesting this explanation are mostly built on the Heckscher-Ohlin model. According to these studies, assuming perfectly competitive goods and labor markets, international trade affects the relative prices of products which in turn affect the factor prices through relative factor demands. In a model with two factors, say skilled and unskilled labor, in a skill-rich country, like the U.S., the famous Stolper-Samuelson Theorem predicts that relative price of skill-intensive goods will rise and hence skilled wages rise while unskilled wages fall.

On the empirical side, many researchers employing the H-O model have used variations of the factor intensity approach to evaluate the relationship between trade and wages.[3] Haskel and Slaughter (2000) demonstrate the effects of changes in the US trade barriers on wage inequality through sector-biased changes in prices. Haskel and Slaughter (2001) find that international trade has a negative effect on the wages of unskilled workers in the UK. On the other hand, Lawrence and Slaughter (1993) and Bhagwati (1991) do not find a clear trend in relative prices of goods in the U.S. during the 1980's. Revenga (1992) measures the impact of changes in imports on wages in the US and finds that the prices of imported goods have small effects on wages. Krugman

[1] See *2007 Economic Report of the President* for a detailed discussion.

[2] One other common explanation for the skill premium is the skill biased technical change. Technological advances that increase the productivity advantages associated with skill result in a higher increase in the productivity of more-skilled workers compared to less-skilled workers. Due to this change, referred as skill-biased technical change in the literature, demand for skilled labor increases and so does the skill premium.

[3] Most studies so far have examined factor intensity and the timing of price changes through so-called "consistency checks" (Krueger 1997, Lawrence and Slaughter 1993). In other empirical approaches, mandated wage equations have been used to predict changes in wages and price and to check the consistency of Stolper-Samuelson effects (Baldwin and Cain 2000, Haskel and Slaughter 2001, Leamer 1998).

(1995) shows that American trade with developing countries had only a small impact on prices and wages. Grossman (1987) observes only minor sensitivity of wages to tariff changes and prices of imports in the US, although he finds that the impact on employment levels is significant in a few industries.

The H-O model is convenient in the sense that it is analytically easy to explain how prices affect real wages and that it requires minimal data to test.[4] However as several studies have correctly emphasized, this approach is based on the very restrictive assumption of complete factor mobility between industries. This assumption may not be well-suited to answering questions involving the impact of trade policy on income distribution, at least in the short run.[5] It is likely that some factors are sector specific and thus immobile, and some researchers include immobility in their models. Moreover it is difficult to generalize the model to describe a multi-industry economy.

The specific factor model, introduced by Jones (1971) and Samuelson (1971), has since been interpreted by Mayer (1974), Mussa (1974), and Neary (1978) as an alternative to the H-O model. The specific factor model assumes that one factor is mobile between sectors with given supplies of specific factors. The advantage of the specific factors model is that any number of sectors of the economy can be studied and so it is not necessary to confine oneself to some generalized change in the terms of trade. In the real world, whether trade occurs or not, relative prices are going in different directions even in industries intensive in a given factor.

This paper appears to be the first application of the specific factors model to the study of the relative wages of skilled and unskilled workers by considering a multi-industry model with those two types of labor as the only mobile factors.[6] By estimating the translog cost functions of 41 U.S. industries (covering 74% of the U.S. economy) the model is calibrated to calculate the impact of the change in any commodity price or factor supply on the skill premium. It is shown that for changes in the price of a single industry, the impact on the skill premium is usually quite modest and sometimes the sign is the opposite of expectations. The elasticity of substitution between skilled labor and capital is critical for single-sector price changes. To generate a Stolper-Samuelson magnification effect, it is necessary to have a large number of price changes across industries intensive in either skilled or unskilled labor.

[4] See Leamer (1998).

[5] See Mayer (1974) and Mussa (1974) for analysis of the short-run specificity of capital.

[6] See Piermartini et. al (2005), and Shoven and Whalley (1984) for a survey of computational general equilibrium models.

This paper shows that the question of the impact of a change a single price on the skill premium depends very much on whether the skilled labor and capital are complements or substitutes in that industry. If skilled labor and capital are complements, as they are in almost half of the industries in the data, the impact of an increase in the value of the product has a small but negative impact on the skill premium, even in such a skill-intensive industry as chemicals.

The model may also be applied to suggest how a tariff or quota might effect factor prices throughout the economy. For example, what will be the ripple effect of a tariff or the removal of a tariff or quota on, say, textiles, on returns in other industries or the skill premium. Moreover, it offers a rich set of predictions for determining the effect of endowment changes on factor returns such as migration.

2 The Model

Jones (1971) developed the algebra of the two sector specific factors model with one mobile factor. When there is a single mobile factor, diminishing returns plus constant returns to scale imply that more of one factor in an industry must raise the marginal product of the other factor. Thus, as the price of a good rises, industry expands, attracting labor from other industries. But wages rise by less than the price due to diminishing marginal product in that industry. The return to the specific factor used in the expanding industry rises by a magnified amount, as with more labor in that industry increases the marginal product of that specific factor. But the return to the specific factors in all the other industries must fall because labor is leaving and moving into the expanding industry. Ruffin and Jones (1977) extended the discussion to many sectors, focusing on the impact of a change in one commodity price on the wage of a single mobile factor. Jones and Ruffin (2008) discuss the role of the elasticity of substitution in determining the impact of commodity prices on wage of the mobile factor. In the case of a single mobile factor, the elasticity of substitution between the mobile factor and the specific factor must indicate substitutability. This paper builds on Ruffin and Jones (1977) by considering a multi-industry model with two mobile factors and a specific factor for each industry. With three factors in each industry it is possible for any two factors to be complements. From a theoretical point of view, this extension allows for an analysis of different elasticities of substitution for skilled and unskilled labor to capital that is specific to an industry. This feature plays a crucial role on the effect of trade on the skill premium.

Let S be the total supply skilled labor, U be the total supply of unskilled labor, and K_j be the total amount of capital specific to industry j, $j = 1$ *to* N. Production in each industry involves constant returns to scale.

Define the following;

a_{ij} = The amount of type i factor used to produce 1 unit of good $j.i = s, u$.
X_j = The amount of good j produced.
w_i = wage of labor type i.
r_j = return of capital specific to industry j.

Given these denotations, full employment conditions are:

$$\sum_{j=1}^{N} a_{sj} X_j = S. \tag{1}$$

$$\sum_{j=1}^{N} a_{uj} X_j = U. \tag{2}$$

Techniques are sufficiently flexible so that specific capitals are also fully employed:

$$a_{kj} X_j = K_j. \tag{3}$$

Assuming perfectly competitive goods and labor markets, prices are driven to costs:

$$a_{sj} w_s + a_{uj} w_u + a_{kj} r_j = P_j. \tag{4}$$

Substituting equation (3) into (1) and (2) gives the link between the factors of production:

$$\sum_{j=1}^{N} \left(\frac{a_{sj}}{a_{kj}} \right) K_j = S. \tag{5}$$

$$\sum_{j=1}^{N} \left(\frac{a_{uj}}{a_{kj}} \right) K_j = U. \tag{6}$$

The elasticity of substitution between factors is one of the key elements in specific factors model that determines the degree the production process responds to a change in the terms of trade. The difference between the elasticity of substitution of capital and unskilled labor and that of capital and skilled labor affects the returns to both labor types and therefore has a direct effect on the skill premium. The partial elasticity of substitution between capital and labor is defined as;

$$\sigma_{uk}^{j} = \frac{(\widehat{a}_{kj} - \widehat{a}_{uj})}{(\widehat{w}_u - \widehat{r}_j)} \tag{7}$$

for unskilled labor and;

$$\sigma_{sk}^{j} = \frac{(\widehat{a}_{kj} - \widehat{a}_{sj})}{(\widehat{w}_s - \widehat{r}_j)} \tag{8}$$

for skilled labor where a "$\widehat{\ }$" over a variable represents a relative change in that variable.

Differentiating (5) and making use of (8) gives (see appendix for derivation):

$$\sum_{j=1}^{N} \left[\lambda_{sj}\sigma_{sk}^{j}\left(\widehat{r}_j - \widehat{w}_s\right)\right] = \widehat{S}, \tag{9}$$

where $\lambda_{ij} = \frac{\frac{a_{ij}}{a_{kj}}K_j}{\sum_{j=1}^{N}\left(\frac{a_{ij}}{a_{kj}}K_j\right)}$ is the fraction of labor type i used in industry j. The same applies to the unskilled labor:

$$\sum_{j=1}^{N} \left[\lambda_{uj}\sigma_{uk}^{j}\left(\widehat{r}_j - \widehat{w}_u\right)\right] = \widehat{U}. \tag{10}$$

These two equations relate changes in factor returns to changes in factor endowments. They imply that a change in factor endowment is equal to the difference in changes of factor returns weighted by the elasticity of substitution of labor and capital in that industry, and the fraction of labor used in that industry. Or, if labor is kept constant, an increase in return to capital in one industry has to be offset by a decrease in returns to specific capitals in other industries adjusted by the elasticity of substitution between labor and capital in each industry.

To be able to solve for an equilibrium, it is also necessary to identify the link between prices and the factor returns. Cost minimization requires the selection of the input-output coefficients along the unit-isoquant. This condition implies:

$$\theta_{sj}a_{sj} + \theta_{uj}a_{uj} + \theta_{kj}a_{kj} = 0, \tag{11}$$

where $\theta_{ij} = \frac{a_{ij}r_j}{P_j}$ is the distributive share of factor i in industry j.

Total differentiation of (4) and using (11) yield (see appendix for derivation):

$$\theta_{sj}\widehat{w}_s + \theta_{uj}\widehat{w}_u + \theta_{kj}\widehat{r}_j = \widehat{P}_j. \tag{12}$$

Equation (12) shows that a change in price is an average of changes in factor returns weighted by their distributive shares in that industry.

Equations (9), (10) and (12) characterize the full model and can be solved simultaneously for an equilibrium. Writing them in a matrix form:

$$\begin{bmatrix} -\sigma_{sk} & 0 & \sigma_{sk}^{1}\lambda_{s1} & \sigma_{sk}^{2}\lambda_{s2} & .. & \sigma_{sk}^{N}\lambda_{sN} \\ 0 & -\sigma_{uk} & \sigma_{uk}^{1}\lambda_{u1} & \sigma_{uk}^{2}\lambda_{u2} & .. & \sigma_{uk}^{N}\lambda_{uN} \\ \theta_{s1} & \theta_{u1} & \theta_{k1} & 0 & .. & 0 \\ \theta_{s2} & \theta_{u2} & 0 & \theta_{k2} & .. & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \theta_{sN} & \theta_{uN} & 0 & 0 & .. & \theta_{kN} \end{bmatrix} \begin{bmatrix} \widehat{w}_s \\ \widehat{w}_u \\ \widehat{r}_1 \\ \widehat{r}_2 \\ \vdots \\ \widehat{r}_N \end{bmatrix} = \begin{bmatrix} \widehat{S} \\ \widehat{U} \\ \widehat{P}_1 \\ \widehat{P}_2 \\ \vdots \\ \widehat{P}_N \end{bmatrix} \tag{13}$$

where $\sigma_{sk} = \sum_{j=1}^{N} \left(\sigma_{sk}^{j}\lambda_{sj}\right)$ and $\sigma_{uk} = \sum_{j=1}^{N} (\sigma_{uk}^{j}\lambda_{uj})$ can be considered as the average elasticities of substitution weighted by the labor shares in each industry. Analytically, solutions for $\widehat{w}_s$ and $\widehat{w}_u$ are too complicated to do comparative statics. Yet the skill premium, $\frac{(\widehat{w}_s - \widehat{w}_u)}{\widehat{P}_i}$, can be calculated and analyzed by calibrating the model with the estimates of the substitution elasticities. See Appendix for a system of equations constructed with just 4 factors of production to have a better intuition.

3 Estimation of Elasticity of Substitutions Between Capital and Two Types of Labor

Elasticity of substitution between capital and labor is one of the key elements in measuring factor returns and the skill premium in case of a change in the terms of trade. Intuitively, if capital and labor are substitutes, an increase in the rate of return on capital will cause the demand for labor to rise, whereas if they are complements, the demand for labor will fall, thus having an implication for the skill premium. In this regard, studies explaining the skill premium are concerned with the elasticity of substitution between skilled, unskilled labor and capital. Griliches (1969) showed that unskilled labor can be more easily substituted for capital than skilled labor. Theoretically, if the elasticity of substitution between capital and skilled labor is less than the elasticity of substitution between unskilled labor and capital, then the relative capital-skill complementarity holds. A large number of studies have analyzed the issue of capital-skill complementarity. However, the results are contradictory. Griliches (1969) and Hamermesh (1993) find support for the capital-skill complementarity hypotheses. Autor, Katz, and Krueger (1998) also find greater shifts toward college-educated workers in industries with a rapid growth in computer capital per worker. Fallon and Layard (1975) present evidence consistent with capital-skill complementarity using cross-country data at both the aggregate and sectoral levels. Bergstrom and Panas (1992) observe relative capital-skill complementarity, Berndt and Christensen (1974) find absolute complementarity, while Berndt and Morrison (1979) reject both relative and absolute complementarity between capital and skilled labor.

The variation in these empirical results is partially due to the empirical methodology employed. Early studies assumed some form of the constant elasticity of substitution function (CES) which can be used to directly estimate elasticities of substitution.[7] Even though CES is a general functional form of Cobb-Douglas (when elasticity of substitution, σ, is 1 and fixed shares are paid to each factor), Linear (when $\sigma = \infty$, and factors are perfect substitutes), and Leontief (when $\sigma = 0$, and factors are perfect complements) production functions, it still forces the elasticity of substitution to be the same for all pairs of factors. This is regarded as a highly restrictive assumption from an empirical point of view.

Rather than assuming such a restrictive functional form, most recent work has relied on a more flexible form that does not impose any restrictions on the elasticity of substitution and that goes well with any arbitrary unknown functional form. Suggested by Christensen et al. (1973), a transcendental logarithmic function (referred as *translog function*) has been extensively used in the literature to estimate the elasticity of substitution between factors of production. It can be interpreted as a second-order approximation to a generalized cost or production function. It does not place any a priori restrictions on substitution possibilities between the factors of production. This paper applies the approach of estimating elasticities based on translog cost function by using a diverse and disaggregated industry level data for the U.S. which covers the period 1979-2001.

[7] See Arrow, Chenerey, Minhas and Solow (1961), Uzawa (1962), Goldin and Katz(1998) for a more detailed discussion.

3.1 Empirical Methodology

The translog cost function is estimated for each industry. For a production function with three inputs of capital, skilled and unskilled labor, the translog cost function is given by:

$$
\begin{aligned}
\ln C \;=\; & \alpha_0 + \alpha_k \ln P_k + \alpha_s \ln P_s + \alpha_u \ln P_u \\
& + \frac{1}{2}\gamma_{kk}(\ln P_k)^2 + \frac{1}{2}\gamma_{ss}(\ln P_s)^2 + \frac{1}{2}\gamma_{uu}(\ln P_u)^2 \\
& + \frac{1}{2}\gamma_{ks}\ln P_k \ln P_s + \frac{1}{2}\gamma_{ku}\ln P_k \ln P_u + \frac{1}{2}\gamma_{su}\ln P_s \ln P_u \\
& + \frac{1}{2}\gamma_{sk}\ln P_k \ln P_s + \frac{1}{2}\gamma_{uk}\ln P_k \ln P_u + \frac{1}{2}\gamma_{us}\ln P_s \ln P_u \\
& + \alpha_y \ln Y
\end{aligned}
\tag{14}
$$

where C represents total cost, Y is output and P_j is the price of factor $j.(\ j = k, s, u)$

According to Shephard's Lemma, the cost minimizing demand for a factor can be derived through differentiation of the cost function with respect to its price. In case of the translog cost function this equals the cost share of factor j, S_j :

$$\frac{\partial \ln C}{\partial \ln P_j} = \frac{P_j}{C}\frac{\partial C}{\partial P_j} = \frac{P_j V_j}{C} = S_j. \tag{15}$$

V_j measures the quantity of factor j. Monotonicity of the partial derivatives require the LHS of (15) be positive. For the three factors, capital and two types of labor, differentiation of (14) with respect to $(\ln P_j)$ yields the following cost shares of factors:

$$S_k = \alpha_k + \gamma_{kk}\ln P_k + \gamma_{ks}\ln P_s + \gamma_{ku}\ln P_u \tag{16}$$

$$S_s = \alpha_s + \gamma_{ss}\ln P_s + \gamma_{sk}\ln P_k + \gamma_{su}\ln P_u \tag{17}$$

$$S_u = \alpha_u + \gamma_{us}\ln P_s + \gamma_{uk}\ln P_k + \gamma_{uu}\ln P_u \tag{18}$$

The cost shares, by definition, sum up to 1, ie. $S_k + S_s + S_u = 1$. The equality of cross derivatives is assured through the imposition of the following symmetry:

$$\gamma_{ks} = \gamma_{sk},\ \gamma_{ku} = \gamma_{uk},\ \gamma_{us} = \gamma_{su}. \tag{19}$$

As the cost shares sum up to 1, only two of the three equations are independent. Linear homogeneity is imposed through the following conditions:

$$\alpha_k + \alpha_s + \alpha_u = 1. \tag{20}$$

$$\gamma_{kk} + \gamma_{ks} + \gamma_{ku} = \gamma_{ss} + \gamma_{sk} + \gamma_{su} = \gamma_{uu} + \gamma_{uk} + \gamma_{us} = \gamma_{uy} + \gamma_{sy} + \gamma_{ky} = 0. \tag{21}$$

Stochastic specification of the function is done through adding a disturbance term to each cost-share equation. It is assumed that the vector $\{\varepsilon_k, \varepsilon_s, \varepsilon_u\}$ is multivariate-normally distributed, with a mean vector of zero and a constant covariance matrix. Since the sum of the cost shares is 1 and only two of them are linearly independent, random errors sum up to zero for each observation. These properties generate a singular and non-linear covariance matrix. To overcome the problem of singularity, one of the three cost-share equations from the system is dropped. Only two equations need to be directly estimated. The parameter estimates give the same result regardless of the choice of which equation is to be dropped. In the case where the cost-share equation of capital is dropped, after the imposition of symmetry, equality (19), and constant returns to scale, the two equations to be estimated are:

$$S_s = \alpha_s + \gamma_{ss} \ln \frac{P_s}{P_k} + \gamma_{su} \ln \frac{P_u}{P_k}. \tag{22}$$

$$S_u = \alpha_u + \gamma_{us} \ln \frac{P_s}{P_k} + \gamma_{uu} \ln \frac{P_u}{P_k}. \tag{23}$$

From the estimated coefficients of the system of equations (22) and (23), Allen-Elasticities of substitution can be obtained by:

$$\sigma_{ij} = \frac{\left(\gamma_{ij} + S_i S_j\right)}{(S_i S_j)}. \tag{24}$$

3.2 Data

To estimate the translog cost function, data on factor inputs; number of skilled workers, number of unskilled workers, amount of capital and their returns, and total output are required. Two different sources are used to compile the data set. BEA releases estimates on number of full time employees and compensation of employees in each industry. Compensation of employees is defined as the sum of employee wages and salaries and supplements to wages and salaries. Educational attainment and annual earnings by education are derived from the Current Population Survey. Workers are grouped as either skilled or unskilled according to their educational attainment. High school graduates, high school dropouts, and workers who have lower levels of education are classified as unskilled while workers with some college, associate, bachelors' or advanced degrees are classified as skilled labor. Since labor is assumed to be mobile, the earnings of a skill level is set to be the same across all industries. BEA's chain-type quantity indices for net stock of private fixed assets which include equipment, software and structures are used for capital stock in each industry. The estimates provide measures of the value of assets in the prices of the given period, which are end of year for net stocks and annual averages for depreciation.[8] The index uses 1996 as the base year. Rental rates are calculated by dividing property-type income by the net stock quantity index.[9] Property type income includes corporate profits, proprietor's income, rental income, net interest, private capital consumption allowances, business transfer payments, and government consumption of fixed capital. Gross product by industry is used as the measure of output.

The BEA dataset is compiled based on the 2002 NAICS code and merged with Current Population Survey data. It covers 9 two-digit and 32 3-digit non-overlapping industries from 1979 to 2001. Considering datasets exploited by the majority of the previous studies, data coverage is superior and sufficiently high to represent the economy as a whole. The industries in the data count for approximately 74% of total GDP and 72 % of the total labor force of the U.S. Economy. (Table-1) shows a summary of the data

[8]See Survey of Current Busines (2001) for detailed definitions and methodology to calculate indices.
[9]See. Balistreri et.al (2002)

3.3 Estimation and Calibration

The translog cost function and the system of cost share equations characterized by equations (14), (22), and (23) form a system of multiple equations with cross-equation parameter restrictions (Restrictions (19), (20), and (21)). This system is estimated for each industry using Zellner's seemingly unrelated regressions (SUR) method. Each equation in the system assumed to be stochastic and the stochastic error terms are assumed to be additive and jointly normally distributed. The problem of singularity is overcome by dropping the cost share equation of capital, equation (16), off the system. Constant returns to scale production function is assumed and thus the coefficient of output is constrained to be 1. A time trend is added in the estimation to capture for productivity growth in each industry. Because the SUR estimates are not invariant to the dropped equation, by using iterative Zellner efficient method (ISUR) neutral parameter estimates are obtained. Estimating just the two share equations or adding the cost equation in the system does not have any significant effect on the estimated coefficients. Additionally, all parameters of interest can be derived from the estimated coefficients from the share equations by making use of the symmetry and the linear homogeneity constraints. Yet the cost equation is included to see the effect of productivity growth.

Table-2 shows estimation results for the fabricated metal products industry as an example. Seemingly Unrelated Regression is run for a system of 3 equations. There are 23 observations for each regression. All coefficients are significant at the 1% level. All wages are scaled by the price of the specific capital in that industry to solve the problem of singularity of the disturbance covariance matrix of the cost share equations. In addition to the coefficients of interest, estimation results show that there is about 5% productivity increase in the fabricated metal products industry. The same regression is run for the remaining 40 industries.

According to underlying economic theory if the cost function is concave in factor prices, then the assumption of cost minimization in translog cost function holds. estimation can based on minimizing the cost function. Concavity requires that the own price elasticities for factor inputs be negative . This condition is satisfied in the estimation results as own price elasticity for skilled is -0.79 and for unskilled is -0.75.

The estimated coefficients are used to calibrate the generalized multi-industry specific factors model. The matrix (13) composed of 43 equations (41 specific factors for each industry and 2 mobile factors) is inverted to solve for the general equilibrium. All consistency checks to see if the calibrated model well behaves hold and support the calibration.[10]

4 Main Findings

The solution obtained is rich enough to do all comparative statics of interest. The effect of terms of trade changes in each industry on the wages of skilled and unskilled workers is reported in the appendix (Table-3). One of the main differences of these results compared to the ones in the literature is that table -3 shows the percentage change in skill and unskilled wage not just in one industry but in the entire economy when a price of good j increases by 1%. For example if prices in farm industry increase by 1 percent then the wage of skilled labor in all industries decreases by 0.016% and the wage of unskilled labor in all industries increases by 0.0041%. The effect of terms of trade on wages seems to be very small, contrary to what Stolper-Samuelson theorem argues. Stolper Samuelson Theorem implies an even higher effects on wages than 1%, when price changes by 1 % which is known as the magnification effect. This is due to aggregating all industries to 2 single industries and lumping all the effects together into a single parameter. The methodology used here allows one to evaluate this aggregation problem.

To test the validity of Stolper Samuelson's magnification effect, all prices in skill intensive industries are raised by 1% and as a result skilled wage rises by 2.39% and unskilled wage decreases by 0.23%. Similarly when all prices in unskill intensive industries increase by 1%, skilled wage decreases by 1.39 % and unskilled wage increases by 1.23%, which is consistent with the magnification effect.

These results have two important implications. First, to generate a Stolper-Samuelson magnification effect, it is necessary to have a large number of price changes across industries intensive in either skilled or unskilled labor. This may explain most of the debate in the literature on the validity of the Stolper Samuelson theorem. The second implication is that the Stolper-Samuelson theorem may be seriously plagued by an aggregation problem (Leontief, 1947; Fisher, 1993). Suppose a country is abundant in unskilled labor, and begins to liberalize its trade. All of the products that it exports will not necessarily face higher prices; some prices may go down. Moreover, prices of

[10] Theoretically, if all prices go up by 1 percent then both wages should rise by 1 percent. If labor endowments increase then returns of all specific factors should decrease.

some skill-intensive goods will be rising as well, not because of the liberalizing of trade but because of other factors going on at the same time. Therefore, it may be asking too much to expect that the liberalization of trade will raise the price of the abundant factor relative to the scarce factor in a multi-commodity environment. The studies that show that Stolper-Samuelson theorem fails in many instances therefore are not really critical tests of the theorem simply because the aggregation conditions may not be satisfied.

Moreover, the general equilibrium model stated here allows one to see the ripple effect of a price change on the return of each and every factor input even without assuming trade. For any reason, if a price of good i increases, what happens to the return of specific factor of good j and wages can be obtained by solving the system (13) for that variable. In the standard specific factors model the rate of return in other industries must fall as one industry expands because they have to pay more for the mobile factor. There are, however, many cases in which the rate of return in industries that compete for mobile factors may actually rise presumably because they intensively use the mobile factor whose price goes down. For example if price in textiles industry increases then the wages of unskilled labor and the return to the specific capital in textiles industry increase while the wages of skilled labor decreases. Consequently, industries that are highly skilled labor intensive such as legal, educational, scientific and technical services benefit from this decrease in skilled wages and the returns to the specific capitals in those industries increase. Similarly, when the price in management of companies and enterprises industry increases, return to specific capital in almost all industries that are unskilled intensive increase as well . Table-4 shows the effects of a 1 percent price increase in industry i on all factor returns in the economy, both specific and mobile. These estimated effects may also be highly useful in evaluating the tax and tariff policy effects on the industry outcomes. Say, if the government imposes a 1% tax on wood products, the return of the specific capital in water transportation industry decreases by 0.02%.

One interesting result that seems to contradict with the standard Heckscher-Ohlin Model is that when the price of a good rises, sometimes both factor prices rise, as in forestry, apparel and leather, machinery industries. In almost 25% of the industries both wages rise. This may be due to the fact that substitution elasticities in all industries play a role in determining the equilibrium wages.

Another important aspect of the model is that it is easy to see the effect of changes in factor endowments on factor returns. Fixed labor endowments can be seen as a sensible assumption since the entire labor force is being analyzed in the model. Yet in case of a migration or changing the composition of labor force from unskilled to skilled, the effect on factor returns can be found. The effect of such changes are also reported in table-4.

5 Conclusion

The skill premium has been studied in many different contexts and researchers have drawn different conclusions in regards to what the underlying reasons are. Theoretically, majority of the studies use the Heckscher-Ohlin Model, which uses two industries only and has additional restrictive assumptions. Alternatively, this paper employs the specific factors model to exploit substitution elasticities in determining the general equilibrium. This paper appears to be the first application of the specific factors model to the study of the relative wages of skilled and unskilled workers by considering a multi-industry model with those two types of labor as the only mobile factors. To make the model operational, substitution elasticities between capital and two types of mobile labor, skilled and unskilled labor, are estimated using a translog cost function for 41 U.S. industries. Then the model is calibrated by those estimates and solved for a general equilibrium.

It is shown that for changes in price of a single industry, the impact on the skill premium is usually quite modest and sometimes the sign is the reverse of expectations. It is necessary to have a large number of price changes across industries to generate a Stolper-Samuelson magnification effect. This indicates how much valuable information is lost when industries are aggregated. In contrast to what the standard Heckscher-Ohlin Model predicts, in a large number of industries, both skilled and unskilled wages rise in response to an increase in commodity prices. With all substitution elasticities and labor shares playing a role, it is not straightforward, as in the two industry case, to predict changes in factor prices without solving for the general equilibrium.

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A Proofs

Derivation of Equation 9 and 10. Keeping K_j constant, total differentiation of (5) yields:

$$\sum_{j=1}^{N}\left[\frac{\partial a_{sj}a_{kj}-a_{sj}\partial a_{kj}}{\left(a_{kj}\right)^{2}}K_j\right]=\partial S. \tag{25}$$

Using the definition of relative change, $\frac{\partial a_{sj}}{a_{sj}}=\widehat{a}_{sj}$, equation (25) can be written as:

$$\sum_{j=1}^{N}\left[\frac{a_{sj}}{a_{kj}}K_j\left(\widehat{a}_{sj}-\widehat{a}_{kj}\right)\right]=\widehat{S}S. \tag{26}$$

After dividing both sides by S, and letting $\lambda_{sj}=\frac{\frac{a_{sj}}{a_{kj}}K_j}{\sum_{j=1}^{N}\left(\frac{a_{sj}}{a_{kj}}K_j\right)}$, equation (26) becomes:

$$\sum_{j=1}^{N}\left[\lambda_{sj}\left(\widehat{a}_{sj}-\widehat{a}_{kj}\right)\right]=\widehat{S}.$$

And finally, using equation (8) one obtains:

$$\sum_{j=1}^{N}\left[\lambda_{sj}\sigma_{sk}^{j}\left(\widehat{r}_j-\widehat{w}_s\right)\right]=\widehat{S}.$$

The same procedure applies to equation (6) to derive equation (10). ■

Matrix Form of The Model with 2 Industries. In the literature, most studies assume 2 goods with 3 or more factors. This greatly simplifies the analysis. The matrix (13) that is constructed for N industries boils down to the matrix below when 2 industries and 4 factors of production are assumed.

$$\begin{bmatrix} -\sigma_{sk} & 0 & \sigma_{sk}^{1}\lambda_{s1} & \sigma_{sk}^{2}\lambda_{s2} \\ 0 & -\sigma_{uk} & \sigma_{uk}^{1}\lambda_{u1} & \sigma_{uk}^{2}\lambda_{u2} \\ \theta_{s1} & \theta_{u1} & \theta_{k1} & 0 \\ \theta_{s2} & \theta_{u2} & 0 & \theta_{k2} \end{bmatrix}\begin{bmatrix} \widehat{w}_s \\ \widehat{w}_u \\ \widehat{r}_1 \\ \widehat{r}_2 \end{bmatrix}=\begin{bmatrix} \widehat{S} \\ \widehat{U} \\ \widehat{P}_1 \\ \widehat{P}_2 \end{bmatrix} \tag{27}$$

■

TABLE-1 Summary Statistics

INDUSTRY	λ_{si}	λ_{ui}	θ_{si}	θ_{u_i}	θ_{ki}
Farms	.003	.008	.034	.157	.807
Forestry, fishing, and related activities	.005	.008	.172	.422	.404
Mining, except oil and gas	.001	.001	.179	.454	.365
Oil and gas extraction	.012	.008	.108	.164	.726
Construction	.038	.098	.112	.576	.310
Food and beverage and tobacco products	.013	.030	.112	.500	.386
Textile mills and textile product mills	.003	.010	.112	.666	.221
Apparel and leather and allied products	.003	.012	.105	.673	.220
Paper products	.008	.014	.147	.511	.341
Printing and related support activities	.023	.020	.262	.451	.286
Chemical products	.032	.019	.245	.288	.466
Petroleum and coal products	.005	.004	.159	.230	.609
Plastics and rubber products	.007	.015	.153	.630	.215
Wood products	.003	.012	.081	.555	.362
Furniture and related products	.002	.007	.114	.686	.198
Primary metals	.009	.020	.154	.635	.209
Fabricated metal products	.013	.029	.132	.581	.285
Machinery	.039	.040	.257	.525	.216
Electrical equipment, appliances	.034	.031	.240	.436	.323
Motor vehicles, bodies and trailers, parts	.018	.022	.204	.516	.279
Miscellaneous manufacturing	.003	.006	.143	.467	.388
Railroad transportation	.004	.001	.127	.617	.254
Transit and ground passenger transportation	.001	.003	.139	.592	.267
Warehousing and storage	.010	.027	.104	.563	.332
Water transportation	.002	.003	.215	.541	.243
Air transportation	.016	.013	.302	.505	.192
Other transportation and support activities	.005	.003	.236	.344	.418
Broadcasting and telecommunications	.009	.003	.269	.216	.514
Wholesale trade	.104	.098	.242	.470	.287
Retail trade	.081	.174	.135	.582	.281
Federal Reserve banks	.032	.023	.153	.241	.605

TABLE-1 (Contn'd)

INDUSTRY	λ_{si}	λ_{ui}	θ_{si}	θ_{u_i}	θ_{ki}
Federal Reserve banks	.032	.023	.153	.241	.605
Securities, commodity contracts, investments	.036	.007	.546	.230	.222
Real estate	.018	.013	.026	.037	.936
Accommodation and food services	.007	.015	.136	.532	.330
Management of companies and enterprises	.081	.053	.291	.369	.339
Motion picture, sound recording industries	.006	.004	.292	.371	.335
Arts, entertainment, and recreation	.008	.011	.181	.499	.318
Health care and social assistance	.133	.081	.365	.420	.213
Legal services	.033	.006	.422	.139	.437
Educational services	.033	.006	.698	.246	.054
Professional, scientific, technical services	.085	.015	.542	.197	.259

TABLE-2 Fabricated Metal Products Industry

	Total Cost	Share of Unskilled	Share of Skilled
unskilled wage	-0.790*	0.586*	-0.231*
	(0.199)	(0.071)	(0.044)
skilled wage	-0.230*	-0.231*	0.274*
	(0.085)	(0.044)	(0.041)
$(unskilled\ wage)^2$	0.293*		
	(0.035)		
$skilled * unskilled\ wage$	-0.231*		
	(0.044)		
$(skilled\ wage)^2$	0.137*		
	(0.020)		
year	-0.050*		
	(0.001)		
output	1		
R^2	0.68	0.60	0.51

Notes: Seemingly Unrelated Regression is run for a system of 3 equations. There are 23 observations for each regression. All wages are scaled by the price of the specific capital in that industry. Constant terms are included but not reported. The standard errors are reported in parenthesis. The coefficient of output is set to be 1 in the total cost equation due to the assumption of constant returns to scale production function. The coefficient of skilled wage in "Share of Unskilled" equation is set to be equal to the coefficient of unskilled wage in "Share of Skilled" equation" and that is set to be equal to the coefficient of the cross term, skilled * unskilled wage, in "Total Cost" equation. All coefficients are significant at 1% level. The year variable shows that there is about 5% productivity increase in the fabricated metal products industry. The same regression is run for other 40 industries.

Table-3 The Skill Premium

INDUSTRY	$\widehat{w}_s/\widehat{P}_i$	$\widehat{w}_u/\widehat{P}_i$	$\frac{(\widehat{w}_s-\widehat{w}_u)}{\widehat{P}_i}$	λ_s/λ_u
Farms	-0.017	0.004	-0.021	0.39
Forestry, fishing, and related activities	0.009	0.011	-0.002	0.71
Mining, except oil and gas	-0.006	0.002	-0.008	0.82
Oil and gas extraction	0.008	0.005	0.003	1.38
Construction*	-0.144	0.199	-0.343	0.39
Food and beverage and tobacco products	-0.199	0.051	-0.250	0.44
Textile mills and textile product mills	-0.022	0.024	-0.046	0.32
Apparel and leather	0.158	0.008	0.150	0.27
Paper products	-0.108	0.031	-0.139	0.58
Printing, related support activities	0.099	0.004	0.096	1.16
Chemical products	-0.083	0.017	-0.100	1.71
Petroleum and coal products	-0.005	0.002	-0.007	1.46
Plastics and rubber products	-0.171	0.045	-0.216	0.48
Wood products	-0.039	0.019	-0.058	0.29
Furniture and related products	-0.059	0.026	-0.085	0.32
Primary metals	-0.122	0.056	-0.177	0.48
Fabricated metal products	-0.298	0.068	-0.366	0.46
Machinery	0.097	0.072	0.025	0.97
Electrical equipment, appliances and components	-0.273	0.033	-0.306	1.10
Motor vehicles, bodies and trailers	0.014	0.047	-0.033	0.79
Miscellaneous manufacturing	-0.046	0.012	-0.057	0.60
Railroad transportation	-0.005	0.013	-0.018	0.42

Table-3 The Skill Premium(Contn'd)

INDUSTRY	$\widehat{w}_s/\widehat{P}_i$	$\widehat{w}_u/\widehat{P}_i$	$\frac{(\widehat{w}_s-\widehat{w}_u)}{\widehat{P}_i}$	λ_s/λ_u
Transit and ground passenger transportation	-0.030	0.010	-0.040	0.47
Warehousing and storage	-0.263	0.087	-0.350	0.38
Water transportation	-0.034	0.010	-0.044	0.80
Air transportation	0.007	0.030	-0.023	1.29
Other transportation and support activites	0.016	0.006	0.009	1.43
Broadcasting and telecommunications	0.005	-0.002	0.006	2.64
Wholesale trade*	0.496	0.073	0.424	1.07
Retail trade*	0.009	0.393	-0.384	0.47
Federal Reserve banks	0.083	0.027	0.056	1.38
Securities, commodity contracts, investments	0.129	-0.015	0.144	5.05
Real estate	0.010	0.007	0.003	1.42
Accommodation and food services*	-0.116	0.025	-0.141	0.50
Management of companies and enterprises*	0.027	-0.055	0.081	1.53
Motion picture, sound recording industries	-0.011	0.004	-0.015	1.52
Arts, entertainment, and recreation*	-0.005	0.021	-0.026	0.70
Health care and social assistance*	1.034	-0.137	1.171	1.64
Legal services	0.085	-0.024	0.109	5.18
Educational services*	0.397	-0.123	0.520	5.27
Professional, scientific, technical services*	0.373	-0.085	0.458	5.45

Table-3 The Skill Premium (Contn'd)

INDUSTRY	$\widehat{w}_s/\widehat{P}_i$	$\widehat{w}_u/\widehat{P}_i$	$\frac{(\widehat{w}_s-\widehat{w}_u)}{\widehat{P}_i}$	λ_s/λ_u
Transit and ground passenger transportation	-0.030	0.010	-0.040	0.47
Warehousing and storage	-0.263	0.087	-0.350	0.38
Water transportation	-0.034	0.010	-0.044	0.80
Air transportation	0.007	0.030	-0.023	1.29
Other transportation and support activites	0.016	0.006	0.009	1.43
Broadcasting and telecommunications	0.005	-0.002	0.006	2.64
Wholesale trade*	0.496	0.073	0.424	1.07
Retail trade*	0.009	0.393	-0.384	0.47
Federal Reserve banks	0.083	0.027	0.056	1.38
Securities, commodity contracts, investments	0.129	-0.015	0.144	5.05
Real estate	0.010	0.007	0.003	1.42
Accommodation and food services*	-0.116	0.025	-0.141	0.50
Management of companies and enterprises*	0.027	-0.055	0.081	1.53
Motion picture, sound recording industries	-0.011	0.004	-0.015	1.52
Arts, entertainment, and recreation*	-0.005	0.021	-0.026	0.70
Health care and social assistance*	1.034	-0.137	1.171	1.64
Legal services	0.085	-0.024	0.109	5.18
Educational services*	0.397	-0.123	0.520	5.27
Professional, scientific, technical services*	0.373	-0.085	0.458	5.45

Table-4 The Substitution Elasticities

INDUSTRY	λ_s	λ_u	σ_{sk}	σ_{uk}	σ_{us}
Farms	.003	.008	-4.45	0.58	-1.88
Forestry, fishing, and related activities	.005	.008	0.77	0.90	-1.10
Mining, except oil and gas	.001	.001	-1.99	0.89	0.24
Oil and gas extraction	.012	.008	0.56	0.62	2.54
Construction*	.038	.098	-1.05	1.00	-1.02
Food and beverage and tobacco products	.013	.030	-6.04	0.94	-1.54
Textile mills and textile product mills	.003	.010	-1.30	0.78	-0.81
Apparel and leather	.003	.012	11.04	0.34	-3.11
Paper products	.008	.014	-4.50	1.06	-1.87
Printing, related support activities	.023	.020	1.30	0.14	-4.14
Chemical products	.032	.019	-1.25	0.58	-2.64
Petroleum and coal products	.005	.004	-0.56	0.33	-2.46
Plastics and rubber products	.007	.015	-5.30	0.93	-1.47
Wood products	.003	.012	-4.02	0.84	-0.70
Furniture and related products	.002	.007	-4.80	0.98	-3.41
Primary metals	.009	.020	-2.64	0.87	-2.34
Fabricated metal products	.013	.029	-6.67	0.95	-1.86
Machinery	.039	.040	0.63	0.64	-2.28
Electrical equipment, appliances and components	.034	.031	-2.70	0.43	-3.19
Motor vehicles, bodies and trailers	.018	.022	0.33	0.93	-2.43
Miscellaneous manufacturing	.003	.006	-5.10	1.10	-1.04
Railroad transportation	.004	.001	-0.21	0.54	2.48

Table-4 The Substitution Elasticities (Contn'd)

INDUSTRY	λ_s	λ_u	σ_{sk}	σ_{uk}	σ_{us}
Transit and ground passenger transportation	.001	.003	-4.50	0.96	-5.53
Warehousing and storage	.010	.027	-8.60	1.55	-0.21
Water transportation	.002	.003	-2.91	0.95	-2.14
Air transportation	.016	.013	0.13	0.72	-2.39
Other transportation and support activites	.005	.003	1.37	1.21	-3.13
Broadcasting and telecommunications	.009	.003	0.27	-0.33	-1.75
Wholesale trade*	.104	.098	1.50	0.40	-0.20
Retail trade*	.081	.174	0.21	1.02	-2.02
Federal Reserve banks	.032	.023	1.74	1.21	-9.95
Securities, commodity contracts, investments	.036	.007	0.83	-0.59	-4.06
Real estate	.018	.013	0.58	0.86	-39.00
Accommodation and food services*	.007	.015	-5.21	0.74	-3.28
Management of companies and enterprises*	.081	.053	0.09	-0.55	-3.13
Motion picture, sound recording industries	.006	.004	-0.62	0.53	-4.95
Arts, entertainment, and recreation*	.008	.011	-0.11	0.90	-2.38
Health care and social assistance*	.133	.081	1.76	-0.47	-1.41
Legal services	.033	.006	1.16	-2.39	0.86
Educational services*	.033	.006	0.67	-1.55	-1.01
Professional, scientific, technical services*	.085	.015	1.19	-2.02	-0.48

Table-5 The Ripple Effects of a 1% Price Change on Factor Returns

		$\widehat{S}$	$\widehat{U}$	$\widehat{P}_1$	$\widehat{P}_2$	$\widehat{P}_3$
	$\widehat{w}_s$	-0.928	0.075	-0.017	0.009	-0.006
	$\widehat{w}_u$	0.023	-0.624	0.004	0.011	0.002
1	Farms	0.035	0.118	1.238	-0.003	0.000
2	Forestry, fishing, and related	0.371	0.619	0.003	2.455	0.000
3	Mining, except oil and gas	0.428	0.740	0.003	-0.018	2.738
4	Oil and gas extraction	0.133	0.130	0.002	-0.004	0.000
5	Construction	0.292	1.131	-0.002	-0.024	-0.002
6	Food and tobacco products	0.240	0.785	0.000	-0.017	-0.001
7	Textile mills	0.399	1.839	-0.004	-0.037	-0.004
8	Apparel and leather products	0.373	1.864	-0.004	-0.038	-0.004
9	Paper products	0.365	0.901	0.001	-0.020	-0.001
10	Printing and related activities	0.813	0.914	0.009	-0.025	0.002
11	Chemical products	0.474	0.346	0.006	-0.011	0.002
12	Petroleum and coal products	0.234	0.217	0.003	-0.006	0.001
13	Plastics and rubber products	0.594	1.774	0.000	-0.038	-0.002
14	Wood products	0.173	0.939	-0.002	-0.019	-0.002
15	Furniture and related products	0.455	2.111	-0.004	-0.043	-0.004
16	Primary metals	0.615	1.838	0.000	-0.040	-0.002
17	Fabricated metal products	0.384	1.234	-0.001	-0.026	-0.002
18	Machinery	1.046	1.423	0.010	-0.037	0.002
19	Electrical equipment	0.659	0.785	0.007	-0.021	0.001
20	Motor vehicles, and bodies	0.636	1.097	0.005	-0.027	0.000

Table-5 The Ripple Effects of a 1% Price Change on Factor Returns (Contn'd)

		$\widehat{S}$	$\widehat{U}$	$\widehat{P}_1$	$\widehat{P}_2$	$\widehat{P}_3$
21	Miscellaneous manufacturing	0.315	0.723	0.001	-0.016	-0.001
22	Railroad transportation	0.408	1.472	-0.001	-0.031	-0.002
23	Transit, passenger transportation	0.433	1.339	0.000	-0.029	-0.002
24	Warehousing and storage	0.253	1.033	-0.002	-0.021	-0.002
25	Water transportation	0.766	1.318	0.006	-0.032	0.000
26	Air transportation	1.398	1.521	0.016	-0.043	0.004
27	Other transportation and activites	0.506	0.470	0.006	-0.014	0.002
28	Broadcasting, telecommunications	0.475	0.223	0.007	-0.009	0.002
29	Wholesale trade	0.745	0.958	0.007	-0.025	0.001
30	Retail trade	0.400	1.256	0.000	-0.027	-0.002
31	Federal Reserve banks	0.225	0.229	0.003	-0.007	0.001
32	Securities, commodity contracts	2.252	0.459	0.037	-0.033	0.013
33	Real estate	0.025	0.023	0.000	-0.001	0.000
34	Accommodation & food services	0.347	0.975	0.000	-0.021	-0.001
35	Management of companies	0.770	0.615	0.010	-0.020	0.003
36	Motion picture, sound recording	0.783	0.625	0.010	-0.020	0.003
37	Arts, entertainment, and recreation	0.492	0.934	0.003	-0.022	0.000
38	Health care and social assistance	1.542	1.098	0.021	-0.037	0.006
39	Legal services	0.890	0.126	0.015	-0.012	0.005
40	Educational services	11.682	1.842	0.194	-0.161	0.067
41	Professional, scientific services	1.921	0.317	0.032	-0.027	0.011

Table-5 The Ripple Effects of a 1% Price Change on Factor Returns (Contn'd)

		$\widehat{P}_4$	$\widehat{P}_5$	$\widehat{P}_6$	$\widehat{P}_7$	$\widehat{P}_8$	$\widehat{P}_9$
	$\widehat{w}_s$	0.008	-0.144	-0.199	-0.022	0.158	-0.108
	$\widehat{w}_u$	0.005	0.200	0.051	0.024	0.008	0.031
1	Farms	-0.001	-0.033	-0.001	-0.004	-0.008	-0.001
2	Forestry, fishing, and related	-0.008	-0.147	0.031	-0.016	-0.076	0.013
3	Mining, except oil and gas	-0.010	-0.178	0.034	-0.019	-0.088	0.014
4	Oil and gas extraction	1.373	-0.024	0.018	-0.002	-0.025	0.009
5	Construction	-0.011	2.899	-0.023	-0.037	-0.072	-0.019
6	Food and tobacco products	-0.008	-0.217	2.577	-0.025	-0.057	-0.009
7	Textile mills	-0.018	-0.529	-0.053	4.455	-0.105	-0.039
8	Apparel and leather products	-0.018	-0.540	-0.061	-0.063	4.426	-0.043
9	Paper products	-0.010	-0.237	0.009	-0.027	-0.080	2.928
10	Printing and related activities	-0.015	-0.183	0.102	-0.018	-0.158	0.050
11	Chemical products	-0.007	-0.048	0.073	-0.003	-0.088	0.037
12	Petroleum and coal products	-0.004	-0.038	0.033	-0.003	-0.044	0.016
13	Plastics and rubber products	-0.019	-0.483	-0.008	-0.055	-0.137	-0.014
14	Wood products	-0.009	-0.274	-0.034	-0.032	-0.048	-0.023
15	Furniture and related products	-0.020	-0.608	-0.062	-0.070	-0.119	-0.045
16	Primary metals	-0.020	-0.501	-0.008	-0.057	-0.142	-0.015
17	Fabricated metal products	-0.013	-0.340	-0.012	-0.039	-0.090	-0.013
18	Machinery	-0.021	-0.314	0.112	-0.032	-0.207	0.053
19	Electrical equipment	-0.012	-0.163	0.079	-0.016	-0.129	0.038
20	Motor vehicles, and bodies	-0.014	-0.264	0.051	-0.028	-0.131	0.022

Table-5 The Ripple Effects of a 1% Price Change on Factor Returns (Contn'd)

		$\widehat{P}_4$	$\widehat{P}_5$	$\widehat{P}_6$	$\widehat{P}_7$	$\widehat{P}_8$	$\widehat{P}_9$
21	Miscellaneous manufacturing	-0.008	-0.188	0.012	-0.021	-0.068	0.002
22	Railroad transportation	-0.015	-0.412	-0.024	-0.047	-0.099	-0.021
23	Transit, passenger transportation	-0.014	-0.367	-0.009	-0.042	-0.101	-0.012
24	Warehousing and storage	-0.010	-0.293	-0.024	-0.034	-0.064	-0.019
25	Water transportation	-0.017	-0.317	0.062	-0.034	-0.157	0.026
26	Air transportation	-0.025	-0.300	0.179	-0.029	-0.270	0.088
27	Other transportation and activites	-0.008	-0.083	0.071	-0.007	-0.096	0.035
28	Broadcasting, telecommunications	-0.006	-0.009	0.083	0.001	-0.086	0.043
29	Wholesale trade	-0.014	-0.206	0.084	-0.021	-0.147	0.040
30	Retail trade	-0.013	-0.345	-0.010	-0.039	-0.093	-0.012
31	Federal Reserve banks	-0.004	-0.043	0.030	-0.004	-0.043	0.015
32	Securities, commodity contracts	-0.025	0.146	0.436	0.028	-0.396	0.232
33	Real estate	0.000	-0.004	0.004	0.000	-0.005	0.002
34	Accommodation & food services	-0.011	-0.263	0.000	-0.030	-0.079	-0.005
35	Management of companies	-0.012	-0.094	0.115	-0.008	-0.144	0.058
36	Motion picture, sound recording	-0.012	-0.096	0.117	-0.008	-0.147	0.059
37	Arts, entertainment, and recreation	-0.012	-0.231	0.033	-0.025	-0.103	0.013
38	Health care and social assistance	-0.023	-0.147	0.240	-0.010	-0.286	0.123
39	Legal services	-0.009	0.075	0.176	0.013	-0.155	0.094
40	Educational services	-0.124	0.929	2.299	0.166	-2.042	1.227
41	Professional, scientific services	-0.021	0.148	0.377	0.027	-0.336	0.201