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Factor proportions trade theory focuses on wage adjustments to product prices and factor endowments estimated directly for the first time in the present paper with a structural vector auto regression. Yearly data cover the US wage, labor force, fixed capital assets, and relative prices of services and manufactures from 1949 to 2006. This model with only capital and labor inputs is inconsistent with the evidence leading to the addition of energy input. Energy has a stronger wage impact than capital, labor is revealed as the middle factor in the intensity ranking, and results suggest a high degree of substitution.

Keywords: wage, factor proportions, structural vector autoregression, impulse response functions

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Factor Proportions Wages in a Structural Vector Autoregression

A good deal is known about the theoretical wage effects of changing factor endowments and prices in factor proportions trade theory. This literature has grown from the writings of Heckscher (1919) and Ohlin (1933) and the algebraic models of Stolper and Samuelson (1941), Jones (1965), and Chipman (1979) to include a variety of assumptions. Potential wage adjustments have been simulated as reviewed by Thompson (2005) and analyzed in an array of applied general equilibrium models as reviewed by Shoven and Whalley (1992), Bhattacharyya (1996), Hertel (2002), and Kehoe, Srinivasan, and Whalley (2005).

Based on the unrealistic assumptions leading to the Stolper-Samuelson theorem, Davis and Mishra (2007) declare it dead empirical evidence is more relevant. Evidence of expected wage convergence across trading partners reviewed by Rassekh and Thompson (1993) is found by Tovias (1982), Gremmen (1985), Dollar and Wolff (1988), Mokhtari and Rassekh (1989), O'Rourke and Williamson (1992), and Rassekh (1993). Indirect support for labor scarce developed countries is uncovered by Leamer and Levinshon (1995) and Leamer (1996). Support in cross section OECD manufacturing data controlling for model assumptions is found by Rassekh and Thompson (1997). Time series evidence that declining US tariffs between 1964 and 1997 slightly lowered the wage but increased its purchasing power is found by Copeland and Thompson (2008). Time series wage elasticities consistent with factor proportions theory are reported by Thompson (2009).

The present paper is the first to estimate factor proportions wage adjustments with structural vector auto-regression and impulse response functions. Data cover the wage, labor force, stock of fixed capital assets, and prices of manufactures and services in the US from 1949 to 2006. Manufactures and services are the two major sectors and their prices would capture movement of the economy along the contract curve. Changes in capital and labor affect the wage contrary to implications of the two factor model. Adding energy as a third input creates a model consistent with the empirical results, and energy has a stronger wage effect than capital.

The following section presents the factor proportions model, followed by a section on structural vector autoregression and impulse response functions, and sections on the data and estimation results.

1. The Factor Proportions Model

The algebraic factor proportions model is clearly presented by Takayama (1982). Assumptions include full employment, competitive pricing, neoclassical production, constant returns to scale, and perfectly mobile factors of production between industries. The present specification includes manufactures M and services S outputs.

Changing factor endowments do not impact the wage w in the model with capital K and labor L inputs as shown by Lerner (1952) and Samuelson (1948) but the present empirical analysis uncovers strong wage impacts and energy input E is added as a third input to create a model consistent with the evidence. There is ample motivation to include energy on its own merit. The three factor model is analyzed by Ruffin (1981) and Thompson (1985).

The wage adjusts to exogenous changes in the two product prices and three factor inputs given full employment and competitive pricing. Full employment is stated $v_i = \Sigma_j a_{ij} x_j$ where v_i is the endowment of factor $i = K,L,E$, a_{ij} is the cost minimizing input of factor i per unit of product j, and x_j is the output of product j. Take differences in this full employment condition and introduce factor cost shares θ_{Lj} and substitution elasticities σ_{ik} between the price of factor k and input of factor i in the first three equations of system (1). Cross price substitution elasticities are symmetric $\sigma_{ij} = \sigma_{ji}$ and constant returns imply $\Sigma_i \sigma_{ji} = 0$.

Competitive pricing of product j is written $p_j = a_{Lj}w + a_{Kj}r + a_{Ej}e$ where p_j is the price of product $j = M,S$ and factor prices are the wage w, capital rent r, and energy price e. Take differences and utilize the cost minimizing envelope theorem to derive the last two equations in (1) where industry shares λ_{ij} are portions of factor i employed by sector j.

Variables are transformed to natural logs and the comparative static model is

$$\begin{pmatrix} \sigma_{LL} & \sigma_{LK} & \sigma_{LE} & \theta_{LM} & \theta_{LS} \\ \sigma_{KL} & \sigma_{KK} & \sigma_{KE} & \theta_{KM} & \theta_{KS} \\ \sigma_{EL} & \sigma_{EK} & \sigma_{EE} & \theta_{EM} & \theta_{ES} \\ \lambda_{LM} & \lambda_{KM} & \lambda_{EM} & 0 & 0 \\ \lambda_{LS} & \lambda_{KS} & \lambda_{ES} & 0 & 0 \end{pmatrix} \begin{pmatrix} \Delta \ln w \\ \Delta \ln r \\ \Delta \ln e \\ \Delta \ln x_M \\ \Delta \ln x_S \end{pmatrix} = \begin{pmatrix} \Delta \ln v_L \\ \Delta \ln v_K \\ \Delta \ln v_E \\ \Delta \ln p_M \\ \Delta \ln p_S \end{pmatrix}. \tag{1}$$

The matrix is the Hessian of constrained neoclassical income maximization and Chang (1979) shows its determinant D is negative with three factors given neoclassical concavity.

Solve (1) for wage effects with Cramer's rule,

$$\varepsilon_{wL} \equiv \Delta\ln w/\Delta\ln v_L = \theta_{KE}\lambda_{KE}/D \qquad \varepsilon_{wK} \equiv \Delta\ln w/\Delta\ln v_K = -\theta_{LE}\lambda_{KE}/D \tag{2}$$

$$\varepsilon_{wE} \equiv \Delta\ln w/\Delta\ln v_E = \theta_{LK}\lambda_{KE}/D \qquad \varepsilon_{wM} \equiv \Delta\ln w/\Delta\ln p_M = (\lambda_{KS}\varphi_1 - \lambda_{ES}\varphi_2)/D$$

$$\varepsilon_{wS} \equiv \Delta\ln w/\Delta p_S = (\lambda_{EM}\varphi_2 - \lambda_{KM}\varphi_1)/D$$

where

$$\theta_{KE} \equiv \theta_{KM}\theta_{ES} - \theta_{EM}\theta_{KS} \qquad \theta_{LE} \equiv \theta_{LM}\theta_{ES} - \theta_{EM}\theta_{LS}$$

$$\theta_{LK} \equiv \theta_{LM}\theta_{KS} - \theta_{LS}\theta_{KM} \qquad \lambda_{KE} \equiv \lambda_{KM}\lambda_{ES} - \lambda_{EM}\lambda_{KS}$$

$$\varphi_1 \equiv (\theta_{KE} - \theta_{LK})\sigma_{LE} - (\theta_{LE} + \theta_{LK})\sigma_{KE} \quad \varphi_2 \equiv (\theta_{KE} + \theta_{LE})\sigma_{LK} + (\theta_{LK} + \theta_{LE})\sigma_{EK}.$$

The own labor wage elasticity ε_{wL} is negative since θ_{KE} and λ_{KE} have the same sign and $D < 0$. Factor intensities determine signs of θ_{KE}, θ_{LE}, θ_{LK}, and λ_{KE} implying ε_{wK} and ε_{wE} and either ε_{wK} or ε_{wE} are positive.

Factor intensity plays a role in wage adjustments and estimates suggest labor is in the middle of the factor intensity ranking

$$\theta_{EM}/\theta_{ES} > \theta_{LM}/\theta_{LS} > \theta_{KM}/\theta_{KS}. \tag{3}$$

Given that energy is intensive in manufacturing relative to services, the intensity condition (3) implies $\theta_{KE} < 0$, $\theta_{LE} < 0$, $\theta_{LK} > 0$, and $\lambda_{KE} < 0$. The service sector is then revealed as capital intensive, understandable since it includes business services and real estate. Thompson (1990, 1995) shows US factor shares of labor in manufactures and services are in fact similar. If labor and energy are intensive relative to capital in manufacturing then θ_{LK}, λ_{KE}, and ε_{wE} are positive. Signs of ε_{wM} and ε_{wS} depend on substitution and intensity as do sizes of all wage elasticities.

Partial derivative wage effects can be summarized in the single equation

$$\Delta\ln w = (\lambda_{KE}(\theta_{KE}\Delta\ln v_L - \theta_{LE}\Delta\ln v_K + \theta_{LK}\Delta\ln v_E) - \varphi_M\Delta\ln p_M + \varphi_S\Delta\ln p_S)/D \tag{4}$$

where $\varphi_M \equiv \lambda_{KS}\varphi_1 + \lambda_{ES}\varphi_2$ and $\varphi_S \equiv \lambda_{EM}\varphi_2 - \lambda_{KM}\varphi_1$. The empirical specification of (4) is the difference equation

$$\Delta\ln w = \alpha_0 + \alpha_1\Delta\ln v_L + \alpha_2\Delta\ln v_K + \alpha_3\Delta\ln v_E + \alpha_4\Delta\ln p_M + \alpha_5\Delta\ln p_S + \varepsilon \tag{5}$$

with the constant α_0 and white noise residual ε. Expectations from theory are a negative α_1 and at least one positive sign for α_2 and α_3. Price elasticities α_4 and α_5 can have the four possible sign patterns in Thompson (1985). One pair of inputs could be complements in production complicating possible wage adjustments and there is a literature on whether capital and energy are complements.   .

Substitution does not affect the directions of wage adjustments to endowment changes but does affect their sizes. Signs and sizes of price effects depend on factor intensity. Price changes shift outputs along the contract curve as cost minimizing inputs adjust. Labor in the middle of intensity ranking (3) implies p_M or p_S and perhaps both would raise the wage. If instead of (3) labor were the most intensive input in services, the wage would increase with p_S but fall with p_M. All wage effects diminish with increased substitution.

2. The SVAR Model

Estimating the factor proportions wage effects in (5) with least squares is robust to specification errors but there are empirical issues. Least squares coefficients may be inefficient if the error term is serially correlated, and many economic variables are highly persistent. Estimating (5) is appropriate for simple comparative statics but wage adjustments may take time.

There may also be potential feedback relations among variables in (5) while theory assumes right hand variables are exogenous in the comparative static model. This endogeneity problem can lead to biased estimates, more critical with low frequency data. It is also difficult to render structural interpretations for the error term in (5) without distinguishing sources of shocks, making policy implications difficult.

These concerns lead to the structural vector autoregression SVAR process,

$$\Delta \mathbf{y}_t = \mathbf{A}(L)\Delta \mathbf{y}_{t-1} + \mathbf{C}\mathbf{u}_t \tag{6}$$

where $\mathbf{y}_t = [\ln w, \ln L, \ln K, \ln p_M, \ln p_S, \ln E]'$ is the vector of difference stationary variables, $\mathbf{A}(L) = \mathbf{A}_1 L + \cdots + \mathbf{A}_k L^k$ is the lag polynomial, $\mathbf{u}_t = [u_t^w, u_t^L, u_t^K, u_t^M, u_t^S, u_t^E]'$ is a vector of corresponding structural shocks, and $\mathbf{C}$ is a contemporaneous matrix. Variables are detrended and deterministic terms are omitted in (6).

Consider orthogonalized structural shocks with unit variances $E\mathbf{u}_t\mathbf{u}_t' = \mathbf{I}$ and $E(\mathbf{C}\mathbf{u}_t\mathbf{u}_t'\mathbf{C}') = \mathbf{C}\mathbf{C}' = \Sigma$ where $\mathbf{I}$ is the identity matrix and $\mathbf{\Sigma}$ is the variance-covariance matrix from the least squares estimation of (6). The conventional method of Sims (1980) just-identifies the present system (6). Assume $\mathbf{C}$ is a lower triangular matrix obtained by the Choleski decomposition of the least squares variance-covariance matrix estimate $\hat{\mathbf{\Sigma}}$. The impulse response function of the level variables is obtained by $\mathbf{y}_t = \sum_{j=1}^{k+1} \mathbf{\Gamma}_j \mathbf{y}_{t-j} + \mathbf{C}\mathbf{u}_t$, where $\mathbf{\Gamma}_1 = \mathbf{I} + \mathbf{A}_1$, $\mathbf{\Gamma}_j = \mathbf{A}_{j+1} - \mathbf{A}_j$, $j = 2, \cdots, k$, and $\mathbf{\Gamma}_{k+1} = -\mathbf{A}_k$. Long term responses of the level variables are obtained by $(\mathbf{I} - \mathbf{A}(1))^{-1}\mathbf{C}$ and short term responses are measured by $\mathbf{C}$.

One potential problem of this identification method is that results may not be robust to the variable ordering. The generalized impulse response analysis proposed by Pesaran and Shin (1998) is an ordering free method but Kim (2009) shows it yields response functions based on contradictory assumptions that may lead to misleading inferences. The assumed ordering of system (6) starts with world prices p_S and p_M assumed contemporaneously unaffected by domestic variables, and p_S is placed first since it seems stickier than p_M. Next, labor L is assumed not contemporaneously affected by K and E because labor demand seems to be less elastic. The ordering of K and E is less clear and the assumption is that K is ordered before E. Finally, the wage w is ordered last assuming it is contemporaneously affected by every other variable as suggested by theory. Robustness checks with alternative orderings yields qualitatively similar results.

3. Data and Stationarity Analysis

Annual data from 1949 to 2006 are from the US National Economic Accounts of the Bureau of Economic Analysis (2007) except Btu energy input from the Department of Energy (2007). The wage w is derived from employee compensation averaged across the labor force L and deflated by the consumer price index (CPI). The capital stock K is the deflated net stock of fixed capital assets. Series in Figures 1 are demeaned for comparison.

* Figure 1 *

The labor force L trends upward smoothly while the capital stock K is more irregular. Energy input E is upward trending, more erratic, and has an apparent break with slower growth due to the oil crises during the mid 1970s and early 1980s.

Prices of manufactures p_M and services p_S are indices relative to the CPI and p_M falls as p_S rises. Part of the 68% decrease in p_M is due to import competition. Meanwhile p_S increases 59% over the period and the relative price of services p_S/p_M increases five times. In response, output indices indicate services output relative to manufactures increases by about half.

Plots of differences in Figure 2 appear stationary. Table 1 reports pretests with conventional augmented Dickey-Fuller (ADF) tests for the seven $\mathbf{y}_t$ variables in (6). The number of lags is chosen by the general-to-specific rule of Hall (1994) as recommended by Ng and Perron (2001).

* Figure 2 * Table 1 *

The ADF test with an intercept accepts the null hypothesis of a unit root for all variables except energy. Rejection of the unit root null is unreliable because the ADF test fails to reject with different lag lengths. The ADF test with an intercept and time trend fails to reject the null for all variables except the wage but the rejection of a unit root null is unreliable.

ADF tests strongly reject the unit root null for all variables when differenced both with an intercept and intercept plus time trend, consistent with difference stationary $\mathbf{y_t}$. Cointegration pretests are sensitive to the normalization of the cointegrating equation and cointegration is not pursued.

4. Endogenous Wage Responses in the SVAR Model

Estimates of the contemporaneous matrix **C** are reported in Tables 2 and 3 with standard errors from 10,000 nonparametric bootstrap simulations. Capital K and energy E have strong positive short term wage effects and the energy effect is stronger. Labor L has an insignificant but negative contemporaneous effect.

*Table 2 * Table 3*

Both prices p_m and p_s have insignificant positive effects, the manufacturing price effect stronger. The magnification effect of Jones (1965) implies the elasticity of one factor price with respect to either price must be larger than one and the elasticity of another factor price less than zero. The insignificant price results for w suggest labor is the middle factor in (3) with the magnification effect holding for the capital return and price of energy.

Long term wage effects are reported in Table 4 and elasticities in Table 5 with bootstrap standard errors. Labor L has a highly significant negative effect even though its short term effect is insignificant.

A 1% increase in the labor force L lowers the wage immediately as shown in Figure 4 and the effect accumulates converging to -5.4%.

* Table 4 * Table 5 * Figure 4 *

Capital and energy have positive wage effects and the energy effect is stronger with much tighter confidence bands in Figure 4. The capital effect is insignificant in the long term and the 0.45 capital elasticity insignificant. An increase of 1% in energy input E raises the wage 0.7% contemporaneously, increasing over the next two years to over 1% and converging to 0.9%. The three input elasticities imply labor is the middle factor in intensity ranking (3). Labor groups rightly opposed to immigration should also support policies friendly to energy.

The insignificant price effects are also consistent with labor in the middle of intensity ranking (3). The 1.3% elasticity for the price of services p_S is larger and both price effects converge after 6 years. If labor were intensive in services, the p_S elasticity would be greater than one and the p_M elasticity less than zero.

These weak price effects are consistent with relatively flat contract curves as illustrated by Ford and Thompson (1997). When prices change substitution favors output adjustments over factor price adjustment. Output adjustments are in fact large as illustrated by the almost 50% increase in the ratio of services to manufacturing over this time period.

Tariffs designed to raise the wage through the price of imported manufactures would be unsuccessful. A 10% increase in the price of manufactures would only raise the wage 3.2% assuming a significant effect. That much of an increase in the price of manufactures is beyond the range of tariffs, especially as low wage countries continue to expand manufactured exports.

Immigration restrictions designed to limit labor growth would be more successful in raising the wage. A 1% decrease in the labor force, within the range of enforcing current immigration law, would raise the wage 5.4%.

The wage reacts to its own shock from influences outside the model. A 1% wage shock results in a 0.7% long term wage increase after 8 years. Other variables positively react to their own shocks, notably labor. Labor and the price of manufactures do not react to other variables supporting the assumption they are exogenous. Energy only responds to the wage and that negative reaction suggests labor and energy are complements. Capital has positive responses to energy and service price shocks, while the price of services decreases with capital and labor but increases with the wage. Energy input stimulates investment rather than the other way around. A positive labor shock lowers the wage and the price of services.

Variance decomposition analysis in Table 6 reveals that that only energy *E* continues to play a role in explaining the variance of *k*-step ahead forecast errors of the wage. Capital *K* and the wage *w* itself explain significant portions of total variations only in the short term up to two years while labor *L* explains a significant portion of the wage variance only in the long term. Price contributions to the variance of *w* are not significant.

Table 6

5. Conclusion

The wage impacts of changing labor and capital endowments suggest factor proportions theory should move beyond the capital-labor model, and energy is found to have a stronger wage impact than capital. Labor is its own worst enemy with an elastic wage impact. The wage effects of changing factor endowments imply labor is in the middle of the factor intensity between manufacturing and services. The insignificant wage effects of changing product prices are also consistent with labor as the middle factor and suggest robust substitution in production.

The present approach to directly estimating the factor proportions model can broaden its empirical foundation. Factor price adjustments can be examined for other countries, time periods, factor aggregations, and output aggregations. Systems of equations for all endogenous variables can be estimated simultaneously, and model assumptions can be refined based on empirical evidence.

Assumptions of imperfect competition in input and output markets can be directly tested.

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Table 1. Unit Root Tests

Variable	Specification	ADF_c	$ADF_{c,t}$
w	Level	-2.277	-3.459†
	Differenced	-5.571‡	-5.704‡
K	Level	-0.990	-1.968
	Differenced	-4.654‡	-4.683‡
L	Level	-2.218	-1.624
	Differenced	-2.994†	-3.155§
p_M	Level	5.591	1.028
	Differenced	-3.178†	-7.292‡
p_S	Level	0.250	-1.235
	Differenced	-6.869‡	-6.895‡
E	Level	-3.521‡	-1.535
	Differenced	-5.537‡	-6.166‡

Note: The number of lags is selected by the general-to-specific rule of Hall (1994) following Ng and Perron (2001). ADF_c and $ADF_{c,t}$ refer the ADF-t statistics when an intercept is included and when an intercept and time trend are included. Superscripts § † ‡ indicate the null of unit root is rejected at 10%, 5%, and 1% levels. Asymptotic critical values are from Harris (1992).

Table 2. Short Term Contemporaneous Matrix C

$$\varepsilon_t^{ps} = \underset{(0.001)}{0.005} u_t^{ps}$$

$$\varepsilon_t^{pm} = \underset{(0.002)}{0.000} u_t^{ps} + \underset{(0.001)}{0.013} u_t^{pm}$$

$$\varepsilon_t^{L} = \underset{(0.001)}{0.001} u_t^{ps} + \underset{(0.000)}{0.000} u_t^{pm} + \underset{(0.000)}{0.004} u_t^{L}$$

$$\varepsilon_t^{K} = \underset{(0.002)}{0.005} u_t^{ps} + \underset{(0.002)}{0.004} u_t^{pm} + \underset{(0.002)}{0.001} u_t^{L} + \underset{(0.001)}{0.014} u_t^{K}$$

$$\varepsilon_t^{E} = \underset{(0.003)}{0.002} u_t^{ps} + \underset{(0.004)}{0.008} u_t^{pm} + \underset{(0.003)}{0.001} u_t^{L} + \underset{(0.003)}{0.007} u_t^{K} + \underset{(0.002)}{0.021} u_t^{E}$$

$$\varepsilon_t^{w} = \underset{(0.004)}{0.004} u_t^{ps} + \underset{(0.003)}{0.005} u_t^{pm} - \underset{(0.004)}{0.004} u_t^{L} + \underset{(0.002)}{0.008} u_t^{K} + \underset{(0.002)}{0.015} u_t^{E} + \underset{(0.001)}{0.013} u_t^{w}$$

Table 3. Normalized Short Term Contemporaneous Elasticity Matrix C

$$\varepsilon_t^{ps} = u_t^{ps}$$

$$\varepsilon_t^{pm} = -\underset{(0.398)}{0.022} u_t^{ps} + u_t^{pm}$$

$$\varepsilon_t^{L} = \underset{(0.155)}{0.158} u_t^{ps} - \underset{(0.031)}{0.004} u_t^{pm} + u_t^{L}$$

$$\varepsilon_t^{K} = \underset{(0.493)}{1.056} u_t^{ps} + \underset{(0.162)}{0.292} u_t^{pm} + \underset{(0.607)}{0.413} u_t^{L} + u_t^{K}$$

$$\varepsilon_t^{E} = \underset{(0.661)}{0.508} u_t^{ps} + \underset{(0.283)}{0.590} u_t^{pm} + \underset{(0.958)}{0.385} u_t^{L} + \underset{(0.226)}{0.467} u_t^{K} + u_t^{E}$$

$$\varepsilon_t^{w} = \underset{(0.773)}{0.878} u_t^{ps} + \underset{(0.256)}{0.362} u_t^{pm} - \underset{(1.138)}{1.180} u_t^{L} + \underset{(0.191)}{0.539} u_t^{K} + \underset{(0.095)}{0.709} u_t^{E} + u_t^{w}$$

Table 4. Long Term Effects of One Standard Error Shocks

	u_t^S	u_t^M	u_t^L	u_t^K	u_t^E	u_t^w
p_S	0.004*	0.000	-0.005*	-0.002*	-0.002	0.002
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
p_M	0.000	0.012*	0.001	0.000	-0.003	-0.003
	(0.003)	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)
L	0.001	-0.001	0.010*	0.001	0.001	0.000
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
K	0.012*	-0.007	0.012	0.021*	0.011*	-0.006
	(0.006)	(0.005)	(0.010)	(0.005)	(0.005)	(0.005)
E	0.004	0.006	-0.002	0.002	0.021*	-0.008*
	(0.004)	(0.005)	(0.007)	(0.005)	(0.004)	(0.004)
w	0.006	0.004	-0.019*	0.006	0.019*	0.009*
	(0.007)	(0.006)	(0.009)	(0.005)	(0.005)	(0.005)

Note: Standard errors are in parentheses and obtained from 10,000 bootstrap simulations.
* indicates that the estimate is significant at the 10% level.

Table 5. Normalized Long Term Elasticities

	u_t^S	u_t^M	u_t^L	u_t^K	u_t^E	u_t^w
p_S	0.749*	-0.037	-1.288*	-0.176*	-0.077	0.153
	(0.311)	(0.101)	(0.637)	(0.087)	(0.058)	(0.098)
p_M	0.011	0.949*	0.368	-0.007	-0.156	-0.251
	(0.609)	(0.177)	(1.227)	(0.164)	(0.110)	(0.186)
L	0.156	-0.117	2.772*	0.084	0.046	0.001
	(0.527)	(0.158)	(0.923)	(0.126)	(0.084)	(0.147)
K	2.512*	-0.540	3.446	1.464*	0.520*	-0.499
	(1.270)	(0.464)	(2.943)	(0.401)	(0.259)	(0.443)
E	0.850	0.456	-0.529	0.111	1.107*	-0.637*
	(0.959)	(0.424)	(2.302)	(0.376)	(0.203)	(0.338)
w	1.281	0.322	-5.433*	0.452	0.920*	0.733*
	(1.559)	(0.517)	(2.898)	(0.418)	(0.252)	(0.435)

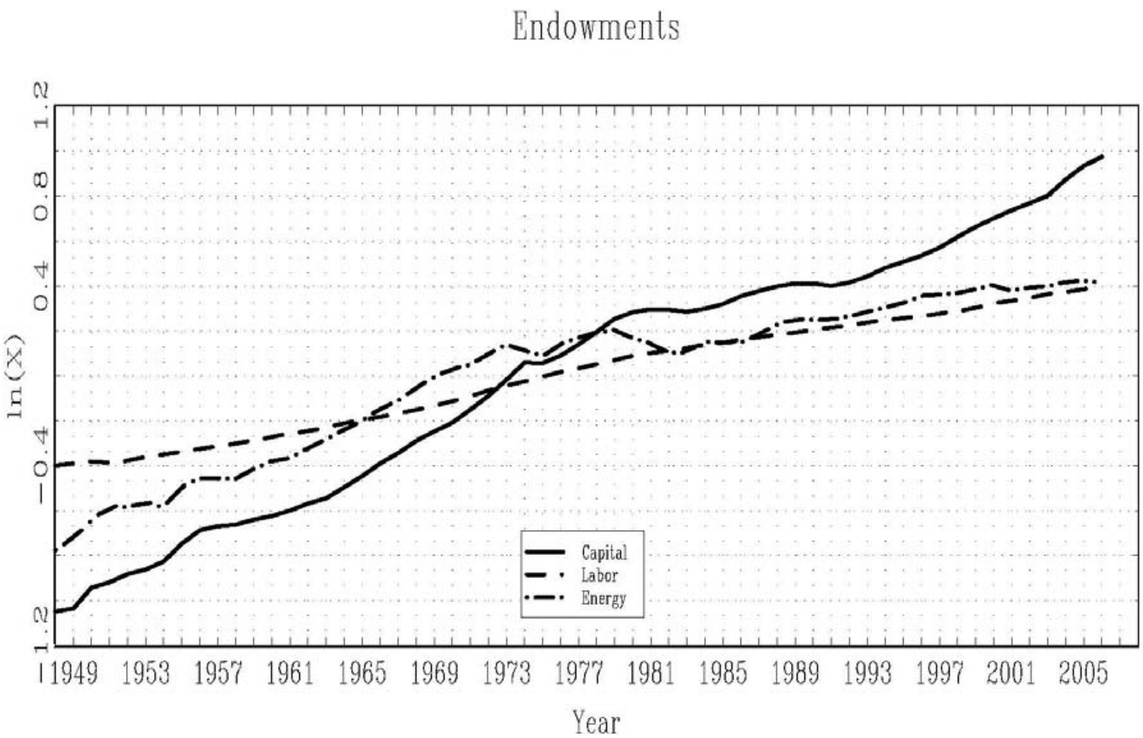
Note: Standard errors are in parentheses and obtained from 10,000 bootstrap simulations.
* indicates that the estimate is significant at the 10% level.

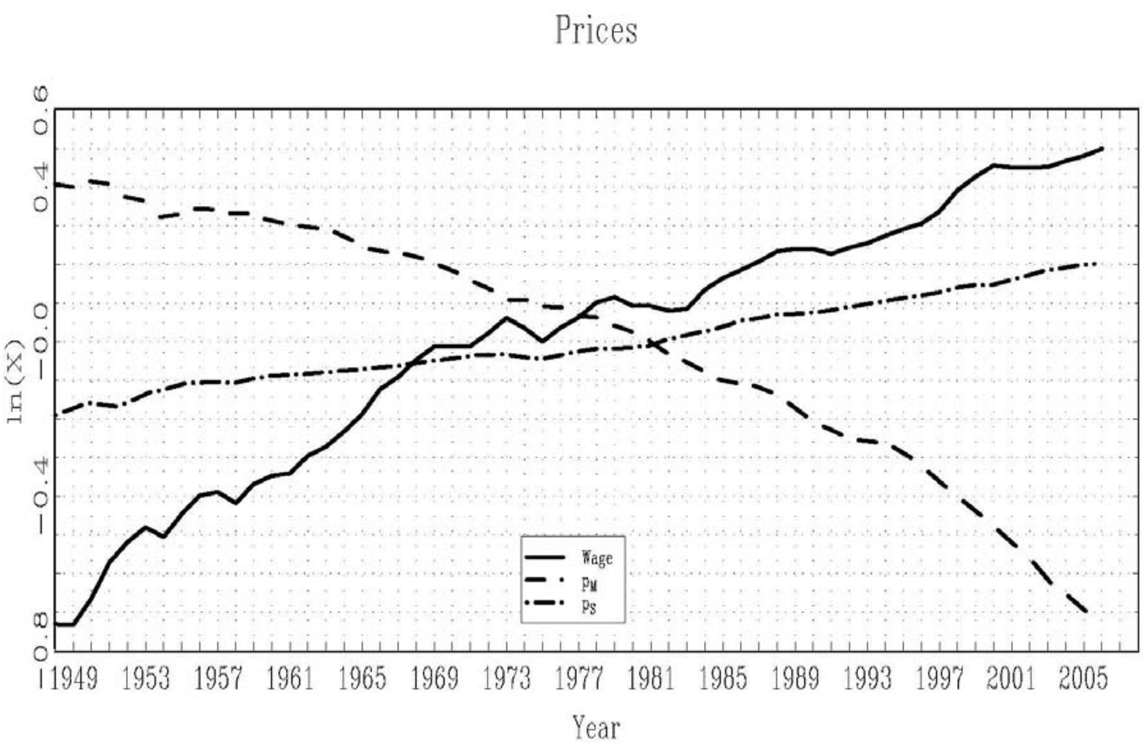
Table 6. Variance Decomposition of *k*-Step ahead Forecast Error

k	p_S	p_M	L	K	E	w
1	0.038	0.044	0.036	0.119	0.437	0.325
	(0.068)	(0.066)	(0.064)	(0.088)	(0.103)	(0.067)
2	0.046	0.016	0.106	0.145	0.534	0.153
	(0.088)	(0.062)	(0.103)	(0.106)	(0.131)	(0.076)
4	0.064	0.007	0.228	0.084	0.536	0.080
	(0.105)	(0.064)	(0.161)	(0.102)	(0.155)	(0.086)
6	0.050	0.013	0.334	0.053	0.455	0.094
	(0.101)	(0.071)	(0.193)	(0.093)	(0.161)	(0.088)
8	0.045	0.018	0.378	0.049	0.415	0.096
	(0.099)	(0.074)	(0.204)	(0.091)	(0.163)	(0.087)
10	0.045	0.018	0.393	0.047	0.404	0.094
	(0.099)	(0.074)	(0.209)	(0.091)	(0.165)	(0.087)

Note: Standard errors are in parentheses and obtained from 10,000 bootstrap simulations.

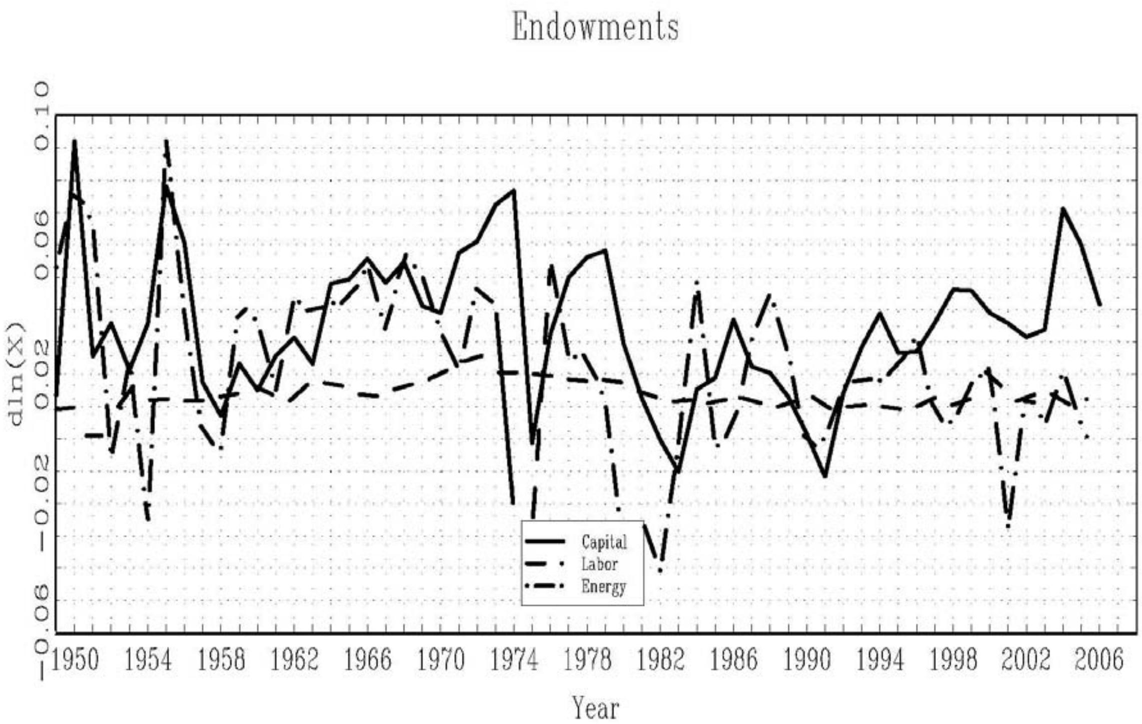
Figure 1. Data series





Note: Each series is demeaned for better visual inspection.

Figure 2. Differenced Series



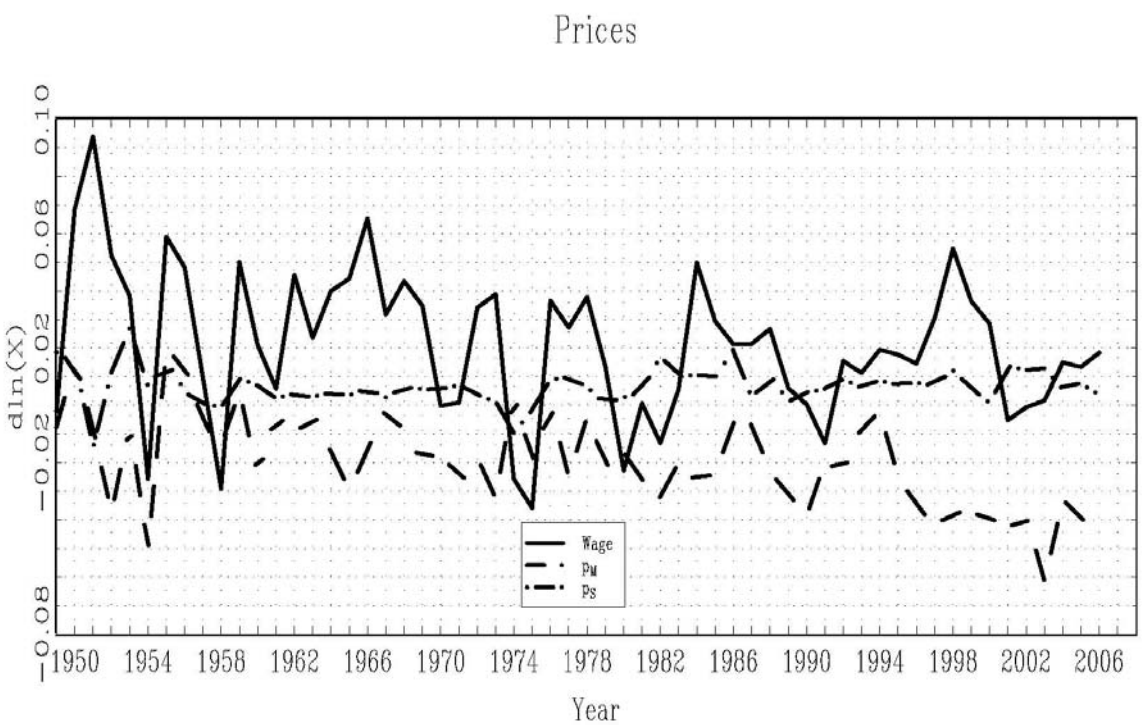
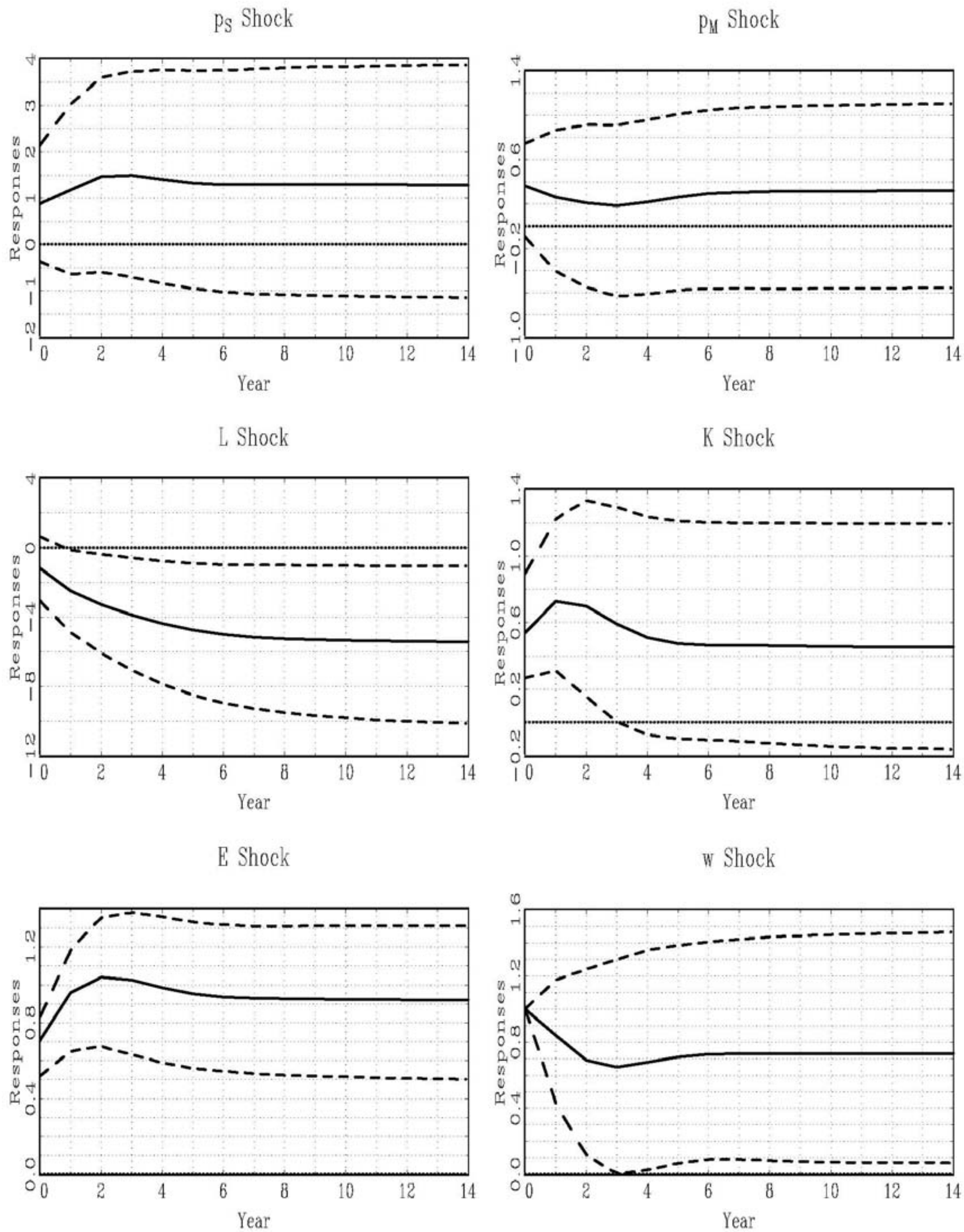


Figure 3. Impulse-Response Function Estimates



Note: The 90% confidence bands (dashed lines) are from 10,000 residual based nonparametric bootstrap simulations following Efron and Tibshirani (1993).