THE KOREAN ECONOMIC REVIEW
Volume 6, Number 2, Winter 1990.

AN UNSKILLED LABOR MARKET IN THE U.S.—A VAR EXPLANATION

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I. INTRODUCTION

Since the beginning of this century, one of most remarkable changes in the U.S. labor structure has been the movement of the female labor force from home to office (Bancroft, 1958; Rotella, 1977; Smith and Ward, 1984). Such change was partly affected by social factors, e.g., feminism, but occurred largely because of economic and technological factors, e.g., the long-term increase in earning power of female (especially married), and industrial technology progress.[1]

The female's earning power increased remarkably as the U.S. economy developed, including the rapid expansion of the service sector. The growth in their earning power raised the foregone value of their time spent at child care and other household activities, which reduced the demand for children and encouraged a substitution away from parental, especially mother's, time. The progress in industrial technology provided time-saving household materials and durable goods at inexpensive prices which cut down the time women devoted to housework. With lower costs, the increased stock of time-saving household appliances resulted in a remarkable labor productivity gain in household production. These two factors changed the traditional input structure of household production substantially. The technical change in household production is labor saving rather than neutral. As a consequence, housewives, who were traditionally in charge of housework such as food preparation, cleaning, laundry, and child rearing, now work for wage income outside home.[2]

*The Bank of Korea. This paper is a revised version of Chapters 2 and 4 of the author's Ph.D. Dissertation, Iowa State University, Ames, Iowa. An earlier draft was presented at the 4th Conference of International Korean Economists, August 1990. The author would like to thank Drs. Wallace E. Huffman, Wayne A. Fuller, and two anonymous referees for useful comments and suggestions.

[1]In addition, some other economic and demographic factors, such as a significant rise in female's school completion, the decline in sexual division of labor, decreasing family size, the urbanization of population, and the long-term secular decline in fertility are also widely accepted as the major determinants of the growth in female's work. For more comprehensive discussion, see Smith and Ward (1984), and the special issue of *J. Labor Economics* 3 (January 1985).

[2]It is suggested that this paper be understood in the context of the household production model. More general discussion on the topics covered here is given in Kim (1987). For technical information about household production and its technical change, see Becker (1965), Gronau (1986), and Bryant (1986).

The U.S. labor structure change was accelerated by World War II. Female workers made up for the shortage of male labor which occurred during the War. However, the increase in the female labor force participation rate ceased and went into reverse with the ending of the War. The downward trend continued until the end of the baby boom. Since then female participation in the labor force has increased steadily.

It is expected that, as an unskilled labor market, the market for domestic services plays an important role in explaining the increasing share of the female labor and the structural changes in household production. Domestic service workers have some unique socioeconomic characteristics. They are largely female, unskilled and low schooling, and from black or colored minorities. These characteristics would be helpful in identifying the essential economic forces underlying the market for domestic services. The supply side is significantly affected by foreign female immigrants and the condition of other labor markets. Domestic service might be a suitable job for newly arrived foreign women lacking specific skills or ability. The condition of labor markets is proxied by the unemployment rate since the chances of domestic service workers being taken on or laid off are quite sensitively affected by conditions in other labor markets. The demand side is largely explained by household income and the prices of household durable goods. In the main, the employers of domestic service workers are households in which housewives are working for wage income. Based on the opportunity costs, they decide whether to employ domestics or purchase durable goods.

A few economic studies about the market for domestic services have been completed. Their results, however, are somewhat patchy owing to the unorganized nature of the market for domestic labor and the significant failure to report wage income or other data. stigler (1946) and Mattila (1973, 1975), however, provide reliable findings.

This paper explores the long-term relationships among the major economic forces associated with the market for domestic services. To search for relationships among variables implies the imposition of a rigid structure on the relationships that are of interest. The justification for such an approach is frequently weak.[3] An alternative approach is represented by the vector autoregressive modeling methdology.

Vector autoregression (VAR) is an econometric methodology for summarizing relationships among economic variables. It has been employed to study macroeconomic time series and to make projections. It has special appeal in those areas where macroeconomic dynamic theory is unable to identify statistically the unerlying structural system (Sims, 1980, 1986; Sargent, 1979). If this econometric

[3]Preliminary estimates of a structural model for the market for domestic services are reported in Kim (1987). As a whole the results using long-run time series data were plausible and largely consistent with other previous studies.

methodology is applied to our long historical aggregate time series data, it is possible that some meaningful economic interrelationships among variables can be uncovered and other possible relationships eliminated from consideration. The results from this approach can also be useful in constructing a structural model.[4]

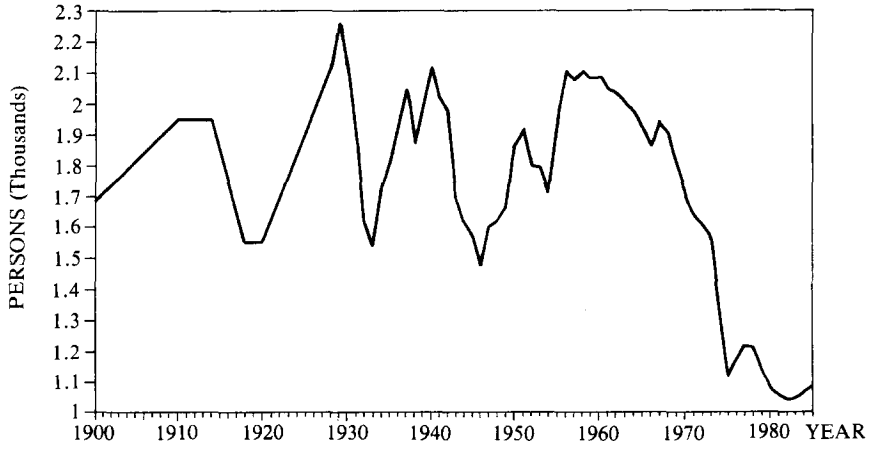
This paper examines the relationships among six key variables by fitting and interpreting the results from a six-variable vector autoregression system. The variables included in the study are number of immigrants, price of household durable goods, the unemployment rate, average household income, total number of domestic service workers, and their wage rates. Annual data from the time period 1990 to 1985 are employed for analysis.

The paper is organized as follows. The following section presents a short historical overview of the major economic forces constructing the VAR model. Second, the econometric framework is presented. Next the empirical results from estimation are reported and interpreted. The final section provides a summary and concluding remarks.

II. HISTORICAL OVERVIEW

1. The Number of Domestic Service Workers

Form the occupational data of the U.S. decennial censuses, and the Current Population Survey, a series on the number of domestic service workers can be constructed starting in 1990. The historical trend is given in Figure 1.



[**Figure 1**] Number of Domestics

[4]Sargent (1981) argues that in a well formulated equilibrium framework based on optimizing agents who form expectations in a manner consistent with the equilibrium model, restrictions on the parameters across the equations of the VAR will be implied. The underlying structural parameters in this context are those related to preference functions and technological constraints. Note that structural econometric models are not structural in this sense.

From the Civil War to World War I

The time period between the end of the Civil War and World War I is characterized as one of very rapid industrialization and concomitant urbanization in the U.S.. From 1870 to 1910, the number of domestic service workers increased steadily. The growth can undoubtedly be explained by the influx of unskilled female immigrants with low schooling. Domestic work might be the only type of job available to many of the newly arrived women. They often replaced other household workers, particularly native-born white women, who were leaving their jobs for a variety of reasons, such as marriage, childbirth, or work in other occupations. After the Civil War, emancipation of slaves and industrialization in the North accelerated a large migration of blacks from the South to northern cities. A large proportion of the freed southern blacks entered the domestic services market (Crew, 1987).

During 1910-1920, the U.S. labor force was reshaped. The number of new immigrants dropped sharply. A wider range of jobs, such as school teaching, clearical work, and certain manufacturing (e.g., textile, tobacco industries) occupations became available to women. The number of young girls who were working as domestic service workers decreased significantly as the State compulsory education laws were widely spread.[5]

From World War I to 1960

During the four decades from 1920-1960, the trend in the number of domestics showed sharp fluctuations. After the first World War, as men took over positions that had been temporarily made available to women, females had to seek alternative lower-lvel occupations such as domestic service or leave the labor market. Also, the rapid economic expansion of the 1920s contributed to increasing demand for domestics.

During the Great Depression, the number of household workers decreased sharply from 2.4 million in 1929 to 1.7 million in 1933. In the post depression recovery period, the number of domestics increased but the trend was again reversed as World War II broke out.

During World War II, the female labor force participation rate steadily increased from 27.9% in 1940 to 36.3% in 1944. Women in the civilian labor force replaced males who were serving in the military. The overall shortage of labor gave domestics more chances being employed in other occupations. The number of domestics sharply decreased and their wages jumped during this period.

Following the end of World War II, as the U.S. economy temporarily slowed down and the male labor force came back from the War, there was a sudden deterioration in the wage rates and employment opportunities for women, especially those without special skills. Also, the number of female immigrants surged (par-

[5]Young girls ages 10 to 15 accounted for 9.4% of household workers in 1900. Thereafter the portion dropped to 5.8% in 1910, and 3.0% in 1920, due to the State compulsory education laws.

ticularly in 1946), mainly due to the special nonquota provisions for war brides, and certain refugee groups. The number of domestics steadily increased until the late 1950s (except for the Korean War period) due not only to these reasons on the supply side but also to reasons on the demand side such as the growing number of middle and upper income households having a working mother and employing domestics, especially for child care during the baby boom.

From 1960 to the Present

In the sixties and seventies, and U.S. economy has been characterized by rapid employment growth. The increases in the female labor force participation rate and its share of the total labor market are remarkable. On the other hand, the number of domestics has steadily decreased since 1960. Several factors can be listed as follows.

Since the 1960s, employment oportunities for women have expanded and schooling completion levels of women, especially of black females, have increased. The average years of school completed by black females increased from 8.8 years in 1960 to 12.0 years in 1980. For white women, the average years of school completed increased only 1.3 years from 11.2 years in 1960 to 12.5 years in 1980. Relatively more black women with higher schooling levels left the market for domestic services. The percentage of private household workers among all employed women decreased steadily from 8.9% in 1960 to 2.5% in 1980.

From the early 1960s, some public assistance programs, such as AFDC (Aid to the Families with Dependent Children) and job (skill) training programs became widely available. Such programs raised the opportunity cost of unskilled women and resulted in a reduction in the supply of labor to low skilled jobs (Tacker, 1970; Duvall, et al., 1982).

2. The Characteristics of Domestic Service Workers

Today, domestic service is overall viewed as an increasingly low-skill and low-status occupation. Young women, particularly black women are shying away from it. Black domestic female workers, who tend to be older cleaners or servants, and white domestic workers, who tend to be young baby-sitters, often receive less than the minimum wage. Some characteristics of domestic services workers are reviewed below.

Sexual Distribution

A century ago, private household work was the predominant occupation of all gainfully employed women and girls 10 years old and over. In 1870 those in domestic work accounted for more than half of all female wage earners. Details about the sexual composition over time are given in Table 1.

[Table 1] Sexual Composition of Domestic Service Workers, U.S., 1870-1980a

	1870	1900	1910	1920	1930	1940	1950	1960	1970	1980
(1) Total Labor Force (1000)	12,506	29,073	38,167	41,614	48,830	53,011	59,643	69,643	82,897	97,639
(1)′ Female (%)	14.7	18.3	21.2	20.5	22.0	24.3	27.8	32.1	37.2	42.1
(2) Total Domestics (1000)	853	1,579	1,851	1,417	1,998	2,412	1,539	1,825	1,217	589
(2)′ Female (%)	..	96.6	96.4	96.4	95.5	94.4	94.8	96.4	96.8	95.6
(3) = (2)/(1) (%)	6.8	5.4	4.8	3.4	4.1	4.5	2.6	2.6	1.5	0.6
(4) $\frac{\text{Female Domestics}}{\text{Female Labor Force}}$ (%)	52.3	28.7	24.0	15.7	17.8	18.1	8.9	7.9	3.8	1.4

[a]Sources: U.S. Decennial Censuses.

There are two facts that should be noted. First, the proportion of female domestics is relatively stable over time, around 95%. This implies that domestic service is primarily a female occupation. Secondly, as more and more women were employed in professional (school teacher, nurse, etc.), clerical, manufacturing, and sales jobs, the share of female domestics in the female labor force decreased more rapidly. This decrease gathered speed with the ending of the baby boom.

Racial and Ethnic Compositions

The racial and ethnic composition of domestic service workers can be explained throughout the whole period by the occupation's low social status, the absence of vocational or educational requirements, and the discrimination against women in many other lines of employment. Historical summary statistics are given in Table 2.

The trends in the share of foreign-born whites and of blacks employed as domestics given in Table 2 reflect the well known trends in immigration and the northward migration mentioned earlier. Before 1950, immigrants from the European countries made up a relatively high proportion of total domestics. This posi-

[Table 2] Nativity and Race of Female Domestics, U.S., 1900-1980[a]

	1900	1910	1920	1930	1940	1950	1960	1970	1980
			Percentage		Distribution				
Native-born Whites	42.8	37.4	36.8	37.7	52.6	41.6	45.9	45.5	55.2
Foreign-born Whites	23.0	21.4	17.4	14.7					
Blacks	34.0	41.0	45.6	47.4	47.1	58.0	54.1	53.1	42.7
Others	0.2	0.2	0.2	0.2	0.3	0.4		0.4	2.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	% of females of each nativity in Labor force who were Domestics								
Native-born Whites	22.3	15.0	9.6	10.4	11.0	4.0	4.1	2.1	0.8
Foreign-born Whites	42.5	34.0	23.8	26.8					
Blacks	41.9	39.5	44.4	54.9	56.4	41.3	34.3	15.9	5.0
Others	24.8	22.9	22.9	19.4	16.7	12.0			
Total	28.1	24.0	15.7	17.8	18.1	8.9	7.9	3.8	1.4

[a]Sources: U.S. Decennial Censuses.

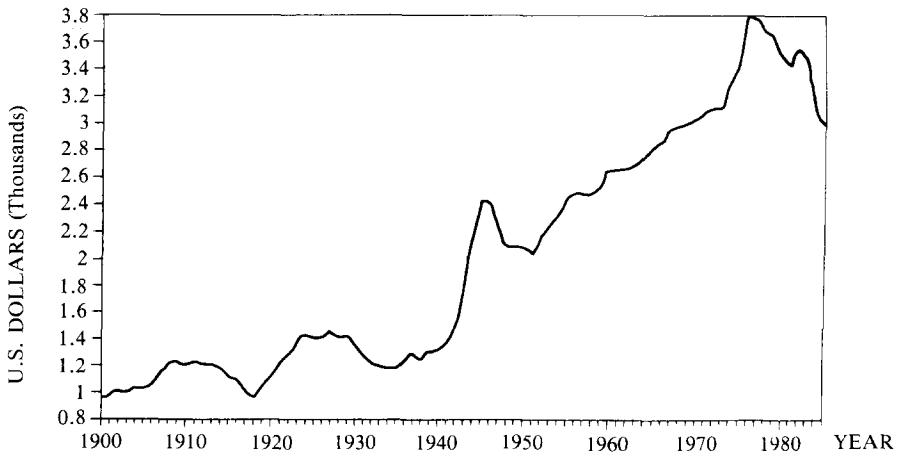
tion could not be continued due to stricter restrictions on immigration. Following enactment of immigration legislation in 1954, the potential supply of immigrants for domestics was cut off, so that the percentage of foreign-born whites decreased thereafter.

The share of black domestics has increased since 1900. This might be explained by the fact that depressed labor markets discouraged the northward migration and increased the competition by white women for jobs as household workers. In 1910, about 90% of black workers were still in the South and nearly three-fourths were confined to the two traditional black occupations, farming and menial service activities. Black migration increased greatly with industrialization after World War I (Crew, 1987). In general, throughout the whole period, the percentage of black workers in the labor force among domestics remained relatively stable. After reaching a peak in the 1950s, blacks' portion has been decreasing. As observed in the first section, the steady decrease of the number of domestics since 1960 can be explained both by slack demand and diminished supply. The exodus from this occupation was relatively more pronounced among blacks than among whites. Along with the advent of smaller families, continuous progress in household production technology eliminated a lot of time-consuming household chores that had primarily been done by black domestics. The only type of domestic services that needed outside help might be child-care, but this was largely taken over by young white females. At the same time, increased educational attainment and higher availability of public assistance, along with the large expansion of employment opportunities, accelerated the departure of black women from this field. Consequently, black domestics were likely to be older cleaners or servants, while white domestics were mainly young baby-sitters.

The effects of social attitudes and occupational requirements are documented by a comparison of the ratios of domestics to all women in the labor force, given in the lower half of Table 2. In 1900, this ratio was almost twice as high for immigrants and blacks as for native-born white females, and it was three times as high for blacks as for whites in 1980. The fact that during the period of mass immigration there was a high ratio for foreign-born whites can be matched with the fact that the immigrants were a major source of the supply of domestic workers.

3. Real Wage Rates of Domestic Service Workers

A detailed study of the fluctuations of domestic workers' wages and hours would be of great interest. It is, however, difficult to find reliable information because domestic service is the one among various occupations whose wages have never been significantly affected by employee or employer combinations or by social legislation, and in addition, the market is not well organized. such factors severely restrict us in evaluating the economic status of the workers and in investigating market behaviors. The historical trend is given in Figure 2.



[**Figure 2**] Real Wage Rate of Domestics

In the early decades of this century, earnings in domestic work were competitive with those in other female unskilled and semiskilled occupations, but were below earnings in professional, clerical, and skilled work. The earnings gap between domestics and others has been getting bigger since the late 1940s. This trend was accelerated after the 1960s, because labor productivity in other occupations was growing relatively faster, and domestic service was least preferred, being open to workers with little schooling and skill.

The pattern and extent of the geographical differentials in domestic servants' earnings persisted until the mass immigration and the northward migration of the 1950s. According to the 1940 census, the mean earnings of domestics in the North were more than two times higher than in the South, in the West they were also about two times higher than in the South while in the North Central they were 1.5 times higher.

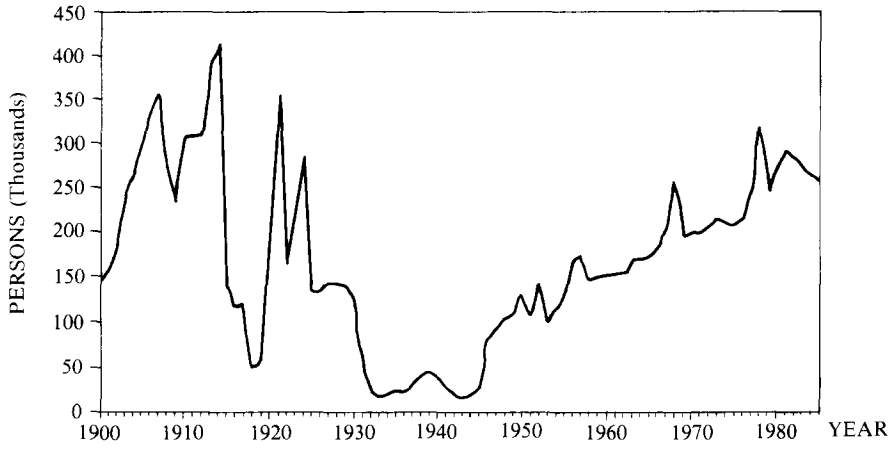
Within regions, the community size and ethnicity seem to explain some of the differences. In larger cities, earnings are larger than in smaller cities; and earnings decrease as the percentage of domestics who are non-white increases. In the case of domestics, differences in costs of living are not an important consideration affecting geographical mobility because a large proportion of domestics receive food and lodging from their employers. Incidentally, it may be noted that the receipt of room and board as a means of partial payment for domestic service helps to explain why wages paid are so low.

Although domestic service seems like a homogenous occupation, some jobs require more skill than others, and the greater the skill or specialization involved in work, e.g., cooks, the higher is the wage. Many of these skills have become obsolete as new goods have become available in the market and new technology has been employed in household production, e.g., labor saving appliances.

4. Immigration Laws and Immigrants

During the first 20 years of this century, a great influx of female immigrants provided a major source of supply of domestic services workers. The newly arrived foreign white women largely replaced the native white female domestic service workers. Another aspect of immigration is the increasing numbers of illegal immigrants due to the tightening restrictions on the unskilled and poorly educated. It is presumed that a large portion of illegal female immigrants entered the market for domestic services. Immigrants still serve as a major potential reservoir for the supply of domestic services workers. The historical trend is given in Figure 3.

The annual inflow of female immigrants since 1900 rose steadily and reached a plateau, averaging 320,000 per year, between 1905 and 1914. The numbers dropped sharply during the World War I period. Another interesting fact is that during the 1910s proportionately more immigrants from Russia, Poland, Hungary, and Italy were entering the U.S. than during earlier decades, and they were less inclined to work in domestic service than the women from Germany, Ireland, and the Scandinavian countries who had been in the majority among earlier waves of imigrants. The 1900 census shows that among female employed, 60.5% of Irish-born women, 61.9% of Scandinavian-born women, and 42.6% of German-born women worked as domestic workers. Russian-Polish-, and Italian-born women, on the other hand, had only a relatively low reported proportion in domestic work: 20.6% of Russian and Polish women, and 11.6% of Italians. These attitudes continued in succeeding generations. The average percent of second generation German, Irish, and Scandinavian women in domestic services was 37.7%, but the corresponding percentage of Russian, Italian, Hungarian, and Polish women was only 16.6%.



[**Figure 3**] Number of Female Immigrants

A branching line was imposed on the influence of immigration on the domestic service workers by the immigration legislation, enacted in 1921. Before that time, the United States' policy had been one of virtually unrestricted immigration. The era of mass immigration, however, was effectively terminated by the legislation, which established an immigration quota system whose effect was, with certain exceptions, to limit the overall number of immigrants of any nationality admitted each year, based on the percentage of foreign-born persons of that national origin residing in the United States as of a base census year. A revised law, enacted in 1924, reduced the quota from 3.0% in 1921 based on the 1910 census to 2.0%, and substituted the 1880 census as the base year, thus systematically curtailing the inflows of certain ethnic groups. This fundamental reversal of American immigration policy was due to a combination of influences, including intensified opposition by organized labor to a resumption of large scale immigration, widespread ethnic unrest and the near hysteria concerning the danger of imported Bolshevism or anarchism (Lescohier, 1935). The 1924 Act was to continue as the basic statutory framework of the U.S. immigration policy for a period of more than several decades.

Following enactment of the 1924 law, female immigration fell to a rate of about 137,000 per year in the period 1925-1929, and it remained well below 33,000 per year during the depression decade of the 1930s and the World War II period.

In 1952, special preference within quota limits was provided for individuals with specialized skills or abilities. The combined effects of the 1924 law and this constraint sharply curtailed the volume of immigration and significantly changed the composition of later immigrant groups. Other than illegal immigrants, no more poorly educated or unskilled immigrants were, in fact, available as a potential supply source for domestics from the mid-1950s. This largely explains why the percentage of immigrants working in the market for domestic services among total female immigrants has been continuously decreasing since the mid-1950s.

Another fact to note is the influences of illegal immigrants. Due to the continuing restrictions imposed on the unskilled and less educated immigrants, large number of illegal immigrants are believed to enter the U.S.. The numbers have been growing since the end of the Bracero program in 1965. There is, however, scant reliable information about this, although some studies have reported that a large proportion of them are working in some simple labor-intensive sectors, such as farms specializing in fresh Winter vegetables (Torok and Huffman, 1986). the domestic services market is an attractive one for them. For more information about illegal U.S. immigrants and their influences on the U.S. labor market, see Chiswick (1982).

5. Patenting Activity and Household Durable Goods Prices

It is widely perceived that the technological progress in producing time-saving

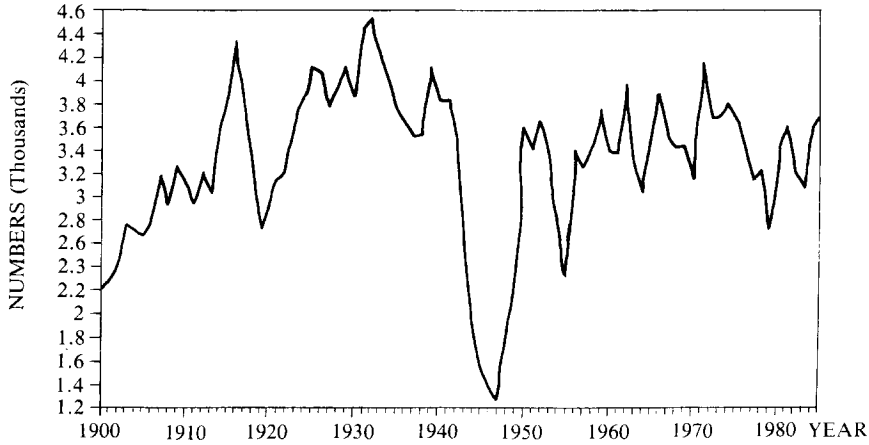
household material and durable goods has been growing steadily since the 1930s. The technological progress made it possible for households to purchase durable goods at inexpensive prices. With lower costs, the increased stock of time-saving household appliances resulted in a remarkable labor productivity gain in household production. Another important issue in the household sector is technical changes in household production. In household production, a significant share of technical change is "embodied". The embodied technical change would appear in household durable inputs that households purchased. This effect is implicitly incorporated in the production through the prices of (services of) durable goods. "Disembodied" technical change represents an increase in real household income, although relative prices and real cash income are held constant. Disembodied technical change could be proxied by the patenting activity of consumer goods in the United States.

About 5 million United States patents have been issued since the first one was granted on July 31, 1790. The Patent and Trademark Office has assembled them to facilitate the huge collection of technology literature. Patents have been "classified" (categorized) into about 400 broad technological groupings (called Class) and over 100,000 specific technological categories (called Subclass). Together, these classes and subclasses form the structure of the patent system. Due to the increasing number of foreign inventions patented in the United States, the U.S. patent activity is representative not only of the U.S. technological effort but, to a large extent, of foreign technological effort as well.

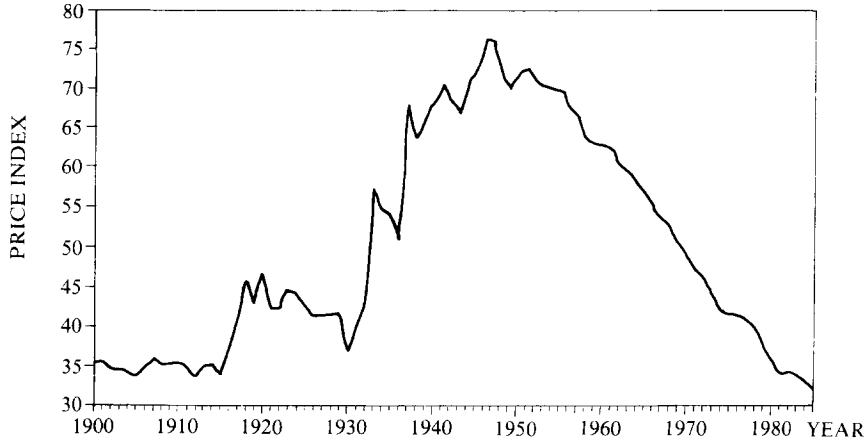
Technology is the social pool of useful knowledge. The pool grows as more new technology (invention) is devleoped. Thus, the pool of knowledge may be represented by cumulating the patents granted. A large part of knowledge, however, becomes obsolete over time as more advanced knowledge is introduced, so there is a need to take account of decreasing weights over time for cumulating patent activities.

Household related inventive activities are mainly concentrate don the patents for food preparation, heating and lighting, and clothes and laundry. The historical trend of patent activities is given in Figure 4. During the two wars and reconstruction periods, the patenting activities were not relatively active. The trend of the total number of patents issued shows steep upward movement after World War I and in the period from the later 1950s to the early 1970s. After temporarily decreasing in the mid-1970s, it is now increasing again. Except for the war periods where it exhibits sharp decreases, it generally shows a relatively stable cycle over time. The unweighted cumulative patent activities give overall support to the public perception that there was relatively high technological progress during the decades after World War I, and in the 1960s.

The investigation of the price of household durable goods yields two important result, allowing us to make: i) distinction between substitution and (embodies) technical changes in the household production, and ii) inference of the households' demand behavior for domestic services and other related inputs for household pro-



[**Figure 4**] Patenting Activities for Consumer Goods



[**Figure 5**] Real Price of Household Durables

duction. The changes in the relative prices of inputs result in changes in the inputs ratio, that is the substitution of the household durable goods services for human time. Changes in prices also explain how the decision between employing domestic service workers and purchasing durable goods is made. The historical trend of household durable goods prices is given in Figure 5.

Except for the two wars (World Wars I and II) and the reconstruction periods, their prices were relatively stable before 1940. Some studies have argued that a large part of household durable goods which are commonplace in modern households had been introduced into households and were in widespread use by 1940 (Lebergott, 1964: pp. 524, 528; Wilson, 1978). But since the price level was relatively higher than the cost of human time, it seems that not much substitution

of the durable goods for human time or embodied technical changes occurred. Due to the continued technological progress and the mass production to meet the increasing demand for the goods mainly caused by the increasing female labor force participation since the late 1950s, prices of durables have decreased steadily over time. The net stock of the durable goods, such as kitchen and household appliances, per household increased nearly three times from 1950 to 1985. A significant substitution of the durable goods services for female labor in the household sector has occurred in the last three decades. Such a phenomenon is closely related with the remarkable increases in the labor force participation of women with children and the decreasing demand for domestics after the post war baby boom was over.

III. AN ECONOMETRIC FRAMEWORK: VECTOR AUTOREGRESSION

The econometric methodology adopted in this paper was suggested in the work of Sims (1980), and has been applied mainly in the analysis of macroeconometric time analysis. Sims argued that the traditional macroeconometric analysis style in which model builders construct claims for a connection between their models and reality—the style in which "identification" is achieved for the models—is not appropriate. According to him, the identification claimed for existing large-scale model is incredible. The dynamic elements of the models are not well specified, a weak distinction exists between endogenous and exogenous variables, and expectation formations are incompletely treated.[6] Instead, he proposed the alternative of estimating an unrestricted vector autoregression system (VAR). VAR can be interpreted as the reduced form relationships that arise from macroeconometric structural models.

Suppose we have time series observations on economic variables. To make the above argument more precise, we assume a linear structural system as:

$$(1)\quad A_0Y_t + A_1Y_{t-1} + \ \dots\ + A_mY_{t-m} = B_0X_t + B_1X_{t-1} + \ \dots\ + B_nX_{t-n} + E_t$$

where Y_t is a $(p \times 1)$ vector of *endogenous* variables, X_t is a $(k \times 1)$ vector of *exogenous* variables and E_t is $(p \times 1)$ vector of random distrubances. The matrices, A_is are each $(p \times p)$, the B_js are $(p \times k)$.

As proposed by Sims, the VAR techniques are not based on particular economic

[6]This argument was also developed in some detail by Lucas and Sargent (1979), who argued that dynamic economic theory gives rise to restrictions of a very different form than those that are currently implemented or even implementable in existing computer econometric procedures. The upshot is that no good reason exists from dynamic economic theory to believe that the restrictions on existing structural macroeconometric models are even approximately correct.

theory. Instead, economic theory is used to narrow the set of variables over which one will search for relationships. The vector autoregression model has many free parameters to be estimated. Restrictions can be imposed on the VAR, but they are not motivated directly by economic theory. They are aimed simply at forecasting performance, i.e., delivering estimators with small mean squared errors. Therefore, constructing a specific structural model like (1) is not very meaningful. Thus, the VAR technique permits an examination of a full range of possible interrelationships among economic variables, and the distinction between endogenous and exogenous variables is not important.[7]

If all variables are endogenous, the structural equations (1) can be written as a g-th order VAR for Z_t (for simplicity the deterministic terms, such as constant and trend were omitted.):[8]

$$(2)\quad A(L)Z_t = U_t$$

where $Z_t = [Y_t, X_t)'$ is an $n \times 1$ $(n = p + k)$ vector, A(L) is an $(n \times n)$ matrix of polynomials in the backward-shift operator, L, i.e., $A(L) = A_{.0} - A_{.1}L - A_{.2}L^2 - \ldots - A_{.g}L^g$, and U_t is an $(n \times 1)$ vector of random disturbances, each of which is independent and identically distributed with zero mean and finite variance.[9] A(L) is normalized so that the first entry of each polynomial in As diagnoal is unity.

Under the assumptions about the error term U_t and equal length lag structure across the model, the ordinary-least-squares estimator (OLS) for each equation turns out to be identical with the joint conditional maximum likelihood estimator. This conclusion holds even when variance-covariance matrices Σ_U is unrestricted (Litterman, 1979). The vector autoregression system (2) has $[n(ng + d)]$ free coefficients to be estimated, where g is the lag length and d is the number of deterministic componets. For even moderate sizes of n and g, OLS estimation either is simply not possible due to exhaustion of degrees of freedom or estimates have large sampling errors because the number of degrees of freedom is small. Therefore, restrictions on the number of variables and lag length for each of them must be imposed so that a reasonable number of degrees of freedom exists.

Once the As in the VAR system (2) are estimated, we can express Z_t as a linear

[7]In general, (unconstrained) VAR imposes no prior restrictions on the interactions among variables. Litterman (1981),however, suggested the use of Bayesian priors, which filters the useful signal from the accompanying noise and produces biased but mean squared error superior forecasts. The Bayesian procedure is a compromise between the extremes of standard structural specification (with highly objectionable priors) and unconstrained VARs.

[8]The lag length of the VAR is initially unspecified, but it may be determined with the aid of statistical tests, e.g., asymptotic Chi-square test.

[9]Sims (1980) assumed that each of U is serially uncorrelated, with zero mean and finite variance. This assumption, however, is sometimes too weak to apply the central limit theorem for normality for large samples. For more information, see Fuller, et al. (1981).

combination of current and past disturbances (Us) or as a distributed lag on U_t. By drawing upon the Wold moving average representations (MAR) for an autoregressive model,

$$(3)\quad Z_t = \sum_{s=0}^{\infty} B_s U_{t-s}$$

where B_s is an $(n \times n)$ matrix of parameters.[10]

A useful way of describing the performance of the VAR model is to examine the system's response to random shocks. Except for scaling, this is equivalent to tracing out the system's moving average representation by matrix polynomial long division. To see that we can write the MAR as:

$$(4)\quad Z_t = [A(L)]^{-1} U_t$$

recognize that

$$(5)\quad \sum_{s=0}^{\infty} B_s L^s = [A(L)]^{-1}$$

exists, i.e., finding the B_s is equivalent to inverting the estimated coefficients of the matrix polynomial. Here we can regard the i,j-th componet of B_s, $b_{ij}(s)$ as the "average" response, s period ahead, of the i-th variable, to an initial shock in the j-th variable. If the system is stable, the impulse responses will dampen out as time wears on.

The interpretation of these impulse responses critically depends upon the extent to which the random shocks that generate the responses are distinct. In the interpretations we choose to give for the impulse responses, the contemporaneous cross-equation correlation of shocks is assumed to be small, i.e., we assume the variance-covariance matrix of the residuals is diagonal. However, the contemporaneous correlation among the residuals for the different equations in the system is an epidemic phenomenon in the empirical analysis. Because it is not possible to partition the variance of Z into pieces accounted for by each *innovation,*[11] it is appealing to apply an orthogonalization transformation to U′, or $e_t = TU_t$where

[10]A finite stationary autoregressive (movign average) time series which has all roots of the auxiliary (or characteristic) equation are less than one in absolute value can be inverted to an infinite moving average (autoregressive) time series. For the inversion from a finite autoregresive representation (ARR) to an infinite moving average representation (MAR), see statistical time series analysis books, e.g., Fuller (1976).

[11]Sims (1980) called the residuals "innovations" because the residuals are "new" in the sense of not being predicted from past values of variables in the system.

T is a matrix chosen to make the variance-covariance matrix of e_t the identity matrix. There is, however, no uniquely best way to choose T. One way is to choose T's so that they have a triangular form. The connection between elements of e and Z are such that, if T is lower triangular, e_{jt} is the normalized error in forecasting $Z_{i,t}$ for i<j (Choleski Factorization). We can write the autoregressive model (3) as:

$$(6)\quad Z_t = \sum_{s=0}^{\infty} B_s T^{-1} e_{t-s}.$$

Now the interpretation for the components of MAR can be applied to the components of the matrix function B_sT^{-1}, since the elements of e are uncorrelated.

This type of orthogonalization is equivalent to restricting the system such taht it is recursive or a "shock" in Z_1 has a contemporaneous effect on all remaining n-1 variables, one in Z_2 has contemporaneous effects on all n-2 variables (excluding Z_1, and Z_2), ..., and Z_n only on itself. Hence, each triangularization imposes a particular *block recursive* system on the contemporaneous relation among the variables. Thus, it is important to test this procedure by changing the ordering of the variables to see whether there are important changes in the results.

Once the As in the VAR have been estimated, the matrix B_sT^{-1} for s = 0,1,2, ..., k, ... can be computed. Let the i,j-th componet, $\tilde{b}_{ij}(s)$, of B_sT^{-1}, be the response of Z_i to an innovation or exogenous shock of one standard deviation in Z_j, then

$$(7)\quad w_{ij}^2(k) = \sum_{s=0}^{k} \tilde{b}_{ij}^2(s) \Big/ \sum_{j=1}^{n} \sum_{s=0}^{k} \tilde{b}_{ij}^2(s)$$

is the proportion of the forecast error variance in Z_i, k period ahead, produced by an innovation in Z_j. The vector $w_{\cdot j}^2(k)$ for large k is called the *variance decomposition* of the variable Z_i. Under the condition that variance-covariance matrix is time invariant, stationarity of the VAR is equivalent to the condition that

$$(8)\quad \lim_{s\to\infty} \tilde{b}_{ij}(s) = 0, \text{ for all i and j}$$

i.e., shocks dampen out over time. Under this condition, $w_{ij}^2(k) \to w_{ij}^2$ as $k \to \infty$, and w_{ij}^2 is the overall variance proportion of Z_i due to a one standard deviation shock in Z_j.

The techniques described above are still being refined by researchers, and some parts of them are still the subject of debate. For the latest developments, see Sims (1987). Although the techniques were developed partly in response to criticisms of standard simultaneous equations macroeconometric models, they are not intended to remedy all the defects in the standard models pointed out by critics like

Lucas (1976). Furthermore, the VAR may be complementary to traditional structural analysis in the sense that it permits an analysis of error structures or of the causal relationships among variables.

IV. ESTIMATION[12]

The choice of variables included in this analysis is based largely on the structure model of the market for the domestic services (Kim, 1987) and some previous studies, e.g., Mattila (1973).[13] The choice is technically and critically constrained by the available data. In this study we have 86 observations. Thus, only a maximum of 6-8 variables could be included and results be significant.

The system consists of six aggregate variables for the U.S. economy for the time period 1900 to 1985: IMMT (total number of U.S. immigrants), DPRICE (U.S. real price of household durable goods), UNEM (U.S. unemployment rate), INCOME (average U.S. real household income), WAGE (annual real earnings of U.S. domestic household workers), and DMST (number of U.S. domestic household workers). Also, deterministic components are added for intercept, time trend, and time square.

The first task in the empirical analysis is to determine the lag length or the order of the polynomials operator A(L) in the VAR model (2). This is accomplished by application of statistical tests on the coefficients in (2). According to Sims (1980), the conventional likelihood ratio test for determining lag length is too conservative in favor of acceptance of the null hypothesis. As an alternative, he suggests a modified test statistic of

$$(9)\quad (N-k)[\log/\Sigma_R/ - /\log/\Sigma_U/] \sim x^2_{df}$$

where N is the number of observations, k is the number of explanatory variables in each equation, $/\Sigma_R/$, $/\Sigma_U/$ are determinants of variance-covariance matrices of restricted, and unrestricted model, respectively, and df is the degrees of freedom (number of linear restrictions).

A statistical test was performed to determine the lag length of the VAR system. Four lags specification was tested as a restriction model on five lags specification using the Sims' modified likelihood ratio test. The chi-square, $x^2(df = 36) = 47.12$ with 36 restrictions, so the four-lags specification can not be rejected at the 5%

[12]The empirical work reported in this paper was performed with the RATS computer package, Version 2.00, written by Doan and Litterman (1986).

[13]Although the VAR techniques are not based on a particular equation specification of economic theory, economic theory is useful as a guide to the set of variables that might be related. We, however, can not say anything about the underlying economic system by looking merely at the magnitude of the coefficients of the As in the VAR system (2).

level. Thus, the VARs were estimated with a lag length of four.

Table 3 presents the estimated parameters of the six equation system where each equation was fitted using OLS equation-by-equation. Note that the autoregressive coefficients are difficult to interpret because many of the variables are highly correlated. Statistical tests for individual coefficients are not very meaningful because of near multicollinearity in each equation. Equivalent, but more comprehensible, information is contained in the MAR coefficients. They will be discussed in the

[**Table 3**] Estimated Parameters of the VAR system, 1900-1985

Regressor		Dependent Variables					
	lag	IMMT	DPRICE	UNEM	INCOME	WAGE	DMST
Const.		−0.341***	−0.789	−7.942	5.045	0.164	0.369
Trend		0.003	0.003	−0.130	−0.088	−0.007	0.028**
Trend²		$96*10^{-7}$	$37*10^{-6}$	$55*10^{-5}$	$34*10^{-5}$	$-17*10^{-6}$	$-37*10^{-6}$
IMMT	1	1.507*	−0.018	3.862	−0.691	−0.643***	0.021
	2	−0.374***	−0.272	−11.433**	−2.580	0.320	0.296
	3	−0.074	0.387	11.600**	12.185	1.055	−0.045
	4	−0.086	0.135	−2.813	−4.761	−0.836**	−0.172
DPRICE	1	0.006	1.236*	0.607	0.720	0.144	−0.100
	2	−0.039	−0.401***	0.094	−0.089	−0.046	−0.158
	3	0.013	0.070	−1.520***	0.739	−0.129	−0.202
	4	−0.005	−0.164	1.025***	−0.560	−0.049	0.241
UNEM	1	0.012***	0.068**	0.863*	0.204	−0.015	−0.002
	2	−0.022*	−0.098**	−0.473*	−0.518**	−0.045***	0.016
	3	−0.025*	0.039	0.371**	0.224	0.008	0.062
	4	−0.009	−0.020	−0.463*	−0.312	0.012	0.019
INCOME	1	0.015***	0.038	−0.143	0.857*	0.040***	−0.025
	2	−0.008	−0.028	−0.004	−0.542**	−0.002	0.053
	3	−0.004	−0.022	0.063	0.341	0.003	−0.037
	4	−0.001	0.028	0.162	−0.051	0.006	0.009
WAGE	1	0.004	−0.108	−2.014**	−1.406	1.179*	0.340
	2	−0.026	0.124	1.124	4.187***	−0.270	−0.370
	3	0.008	−0.012	1.455	−3.096	−0.312	0.216
	4	0.024	0.020	−2.178**	−0.509	−0.073	0.136
DMST	1	0.050	−0.254	0.744	−0.755	0.071	1.077*
	2	−0.046	−0.086	−1.412	−0.204	−0.012	−0.188
	3	−0.003	0.198	1.408***	1.395	0.150	−0.291
	4	−0.042	−0.064	0.202	0.785	−0.091	−0.107
R^2		0.998	0.998	0.944	0.934	0.995	0.998
Sig.	Level	0.486	0.371	0.719	0.108	0.875	$23*10^{-4}$

*, **, *** indicate that the coefficients are significantly different from zero at the 1%, 5%, and 10% level, respectively.

[**Table 4**] F Statistic for Hypothesis that Coefficients on Designated Lagged Variable are Jointly Zero

Designated Variable	Dependent Variables					
	IMMT	DPRICE	UNEM	INCOME	WAGE	DMST
IMMF	757.18*	1.43	3.77	1.70	1.76	0.39
DPRICE	0.61	30.28*	1.25	0.67	1.36	1.90
UNEM	2.91**	1.97	8.94*	2.06***	1.17	1.76
INCOME	1.11	0.67	1.14	3.98*	1.35	0.29
WAGE	0.23	0.10	1.85	1.47	31.61*	0.50
DMST	1.77	1.17	1.26	1.38	0.81	8.76*

*, **, *** indicate that the null hypotheses are rejected at the 1%, 5%, and 10% level, respectively.

following section.

Granger tests of statistical causality (Granger, 1969) can also be performed on the varialbes in a VAR model. They boil down to tests of the hypotheses that all coefficients of a particular variable are jointly zero. There are a number of different ways of implementing these tests. Some tests are reported in Table 4. According to the table, the causal relationships between variables in the VAR system are not quite straightforward. Some relationships are noted as follows. Immigration causes unemployment, and unemployment causes immigration and household income. Price of household durables and unemployment rate weakly cause domestics, but not significant. The results of these tests may represent the real causal relationships in a very limited context because of the misleading possibility of the OLS estimates as pointed out previously. Rather than using this F test, more substantial causal relationships can be explored using the impulse responses or error decompositions. This is discussed in detail in the following section.

V. DESCRIPTION AND INTERPRETATIONS: IMPULSE RESPONSES AND ERROR DECOMPOSITIONS

Autoregressive systems are difficult to describe succinctly. It is especially difficult to make sense of them by examining the coefficients in the regression equations themselves. The estimated coefficients on successive lags of a given variable tend to oscillate in sign because this is a requirement for a stable difference equation system, and there are complicated cross-equation feedbacks. Therefore, the common econometric practice of summarizing distributed lag relations in terms of their implied long-run equilibrium behavior may be quite misleading.

The best descriptive device is anlaysis of the system's response (reaction) to typical random shocks. This procedure was formularized in (5) inthe previous section. The "typical shocks" are positive residuals of one standard deviation unit in each equation of the system. The ordering of the variables is based on the primary

interests of this study. The block recursive ordering of variables adopted here is: IMMT - DPRICE - UNEM -INCOME - WAGE - DMST. The orthogonalization method is Choleski. (See p. 12-24 of Doan and Litterman (1986)).

Impulse responses in the triangularized system are presented in the set of Figures 6-a through 6-f, given at the end of this paper. The figures show the responses of the six variables to one standard deviation shock in a particular variable, in the system. We discuss specific response patterns and interrelationships between variables after first establishing several general features of the responses.[14]

The first characteristic to note is the overall stability of the system. Responses to shocks in time period 1 tend to dampen a little slowly, but they converge to zero (i.e., to mean values) within a 50 to 60 year period. The second notable feature is the relatively long cycle of the responses, which supports the evidence of relatively long persistence of the variables in the system.

Throughout the figures, the responses to exogenous shocks exhibit quite interesting patterns in which we find some common patterns which are consistent with the hypothetical interrelationships between variables in the structural model sense. UNEM and DMST react in the same fashion to exogenous shocks in the variables in the system as does IMMT. WAGE reacts in the opposite fashion to shocks as do UNEM and DMST. Also it is notable that the variables, INCOME, DPRICE, and WAGE react in the opposite fashion to shocks as does DMST. These common response patterns to shocks throughout the system can be interpreted in terms of market structure for domestic service workers as hypothesized by the structural model. The patterns also can be interpreted along with the historical trends of the variables given in the second section in which we found that the fluctuations in the domestics and their wage rates sensitively responded to the general economic cycle. In a recession, an increase (a positive innovation) in IMMT or in UNEM increases DMST, and decreases INCOME and WAGE. Note that in a recession, domestic work might be the only available job for (female) workers who have low-skill and low-schooling. The influx of such workers into the domestic service sector might plausibly resulted in the decrease in WAGE and increase in DMST. The decrease in INCOME would be expected to reduce the demand for household durable goods, but a reduction of DPRICE would be expected to increase the demand for household durable goods. A decrease in demand for domestics due to a decrease in INCOME is the straightforward relationship ex-

[14]The discussions in this section are largely focused on the response patterns of domestics and their wage rates. In the structural model context, these two variables are classified as endogenous and others are treated as exogenous. Even though the VAR does not require such explicit treatment or a specific structural model, it is reasonable to interpret the VAR resuts implicitly in terms of structural sense. Note that the impulse responses describe the interrelationships or causal relations through identifying the effects of exogenous shocks. One of the purposes of this study is to draw some synthetics from the VAR and the traditional structural modelling.

pected. The actual quantity of domestic services demanded by households, however, would be decreased, i.e., in a recession the number of domestics in labor force which includes unemployed domestics is increased but the quantity of domestic services demanded is decreased. The reverse of these relationships are quite obvious for a period of economic expansion.

All effects on WAGE (of domestic servants) from shocks in other variables become insignificant after 30 years. Also the magnitude of the WAGE responses over the whole period is small. This inactive responsiveness may explain the failure of structural models of the market for domestic service workers. However, the response pattern of DMST is different. Through the 6 figures, there is persistence of effects, lasting around 15 years. Such a pattern is largely consistent with the periodical fluctuations in the number of domestics, and their low rate of turnover as seen in Figure 1.

Now let us turn to the more specific patterns for each of the variables. Discussions are mainly focused on the response patterns of DMST and WAGE to shocks in the first four variables (IMMT, DPRICE, UNEM, and INCOME). Some important findings are summarized below.

i) The responses of UNEM, INCOME, and WAGE to a shock in IMMT are remarkable in the first 30 years (Figure 6-a). This indicates that IMMT innovations have very persistent effects on the U.S. economy as a whole and on the wage rates of lower-income occupations such as domestics. However, their effects on the other variables, DPRICE and DMST, are not significant. These response patterns imply that IMMT innovations affect domestics indirectly through the effects on unemployment rate and household income or their wage rates.

ii) Figure 6-b depicts the responses to an innovation in DPRICE. Overall the responses are active during the first 40 years. The responses of INCOME and UNEM are notable. UNEM and IMMT respond in a similar fashion, but the magnitude of IMMT's response is relatively small. DMST responds in the opposite direction to a shock in DPRICE as do INCOME and DPRICE, but DMST responds in the same fashion to a shock in DPRICE as does IMMT.

iii) There exist lags of a few years between the responses of DMST and those of other variables (IMMT, UNEM). The lags between DMST, and IMMT and UNEM suggest that it takes time for these variables to affect the supply side of domestic service workers through the market mechanism.

iv) In Figures 6-c and 6-d, IMMT reacts less actively to exogenous shocks in UNEM and INCOME. Recall the very active responses of UNEM and INCOME to shocks in IMMT in Figure 6-a. We may interpret that these response patterns represent the causal relationships, i.e., IMMT causes in Granger sense UNEM and INCOME.

v) Figures 6-c through 6-f reinforce the response patterns mentioned above. DMST and WAGE move in the opposite direction for the first 30 years, thereafter the WAGE responses converge to the mean value. The response patterns of the

variables, INCOME, DPRICE, and DMST are easily identifiable. DMST reacts in a quite opposite direction to shocks in the variables in the system as do DPRICE and INCOME. These patterns imply that the demand side could be more easily identifiable than the supply side of the market for domestic service workers in a structural sense.

The decomposition of the variance of the variable is a useful way to show the main channels of influence in the model. This issue is pursued with the aid of the information presented in the Table 5. The numbers in the table were derived using equation (7) which represents the allocation of the variance of forceast error.[15]

A variable which is strictly exogenous would, if no sampling error existed in the estimated system, have entries of 1.00 on its diagonal cell in the table and zeroes in all other cells in the table. Strict exogeneity is equivalent to the condition that a variable's own innovations account for all of its variance. Some important findings are summarized below.

i) IMMT and DPRICE have more than half of their variances accounted for by own-innovations at all time horizons shown. No other variable has so much variance accounted for by its own-innovations. Thus, interactions among the remaining four variables are strong, and the remaining variables have some feedback effects from IMMT and DPRICE.

ii) IMMT does not have any sources of strong feedback, but it feeds into the other variables, such as UNEM, and WAGE.

iii) DPRICE also does not have any source of strong feedback. However, INCOME innovations of a moderate size feed into DPRICE which suggests the demand-pull effects. Over the whole horizon, DPRICE innovations are the main sources of variation in the other four variables, UNEM, INCOME, WAGE, and DMST. Among these variables, the feedback effects for DMST and WAGE are remarkable. These findings suggest that the effects of DPRICE are closely related to the effects of other variables in the system, and DPRICE plays an important role in the market for domestic services.

iv) The main sources of feedback to UNEM are IMMT and DPRICE innovations. UNEM also has sizable effects on the variance of INCOME and DMST.

v) The variations in WAGE are largely explained by IMMT, DPRICE, and INCOME, but not by the variations in DMST.

vi) For DMST, a large proportion of its variation is explained by the feedback effects of other variables except for IMMT. At the initial step, only 34% of the variance is explained by its own innovations, and the percentage declines as time after the shock passes. During the early phase, the dominant effects come from INCOME, but after 5 steps, DPRICe is the dominant explanatory factor. Also,

[15]Different orderings may yield quite different apportionment of variances. In this study, several different orderings were used to check whether they yield significant differences. No significant differences were observed.

[**Table 5**] Decomposition of Variance: Proportions of Forecast Error Variance k Years Ahead Produced by Each Innovation (w_{ij}^2)

Forecast Error in	Triangularized Innovations in (j)							
	ik	S.E.	IMMT	DPRICE	UNEM	INCOME	WAGE	DMST
IMMT	1	0.0102	1.00	0.00	0.00	0.00	0.00	0.00
	3	0.0273	0.93	0.00	0.04	0.01	0.00	0.02
	5	0.0433	0.90	0.03	0.05	0.01	0.00	0.01
	10	0.0802	0.82	0.12	0.04	0.01	0.00	0.00
	30	0.1227	0.56	0.18	0.08	0.03	0.07	0.08
	50	0.1292	0.52	0.19	0.09	0.03	0.08	0.09
DPRICE	1	0.0506	0.00	1.00	0.00	0.00	0.00	0.00
	3	0.1305	0.01	0.77	0.02	0.13	0.04	0.04
	5	0.1893	0.01	0.65	0.02	0.13	0.08	0.11
	10	0.2527	0.01	0.53	0.15	0.14	0.07	0.09
	30	0.2864	0.03	0.52	0.15	0.12	0.08	0.08
	50	0.2994	0.04	0.52	0.16	0.12	0.08	0.09
UNEM	1	0.2105	0.02	0.01	0.97	0.00	0.00	0.00
	3	0.3298	0.01	0.01	0.73	0.17	0.07	0.01
	5	0.3866	0.05	0.14	0.55	0.18	0.06	0.01
	10	0.5060	0.20	0.25	0.35	0.11	0.05	0.03
	30	0.6297	0.24	0.21	0.30	0.10	0.08	0.07
	50	0.6402	0.24	0.21	0.29	0.10	0.09	0.07
INCOME	1	0.3227	0.00	0.03	0.04	0.93	0.00	0.00
	3	0.5061	0.03	0.10	0.06	0.77	0.01	0.02
	5	0.6067	0.06	0.24	0.08	0.58	0.01	0.03
	10	0.7021	0.09	0.25	0.18	0.44	0.01	0.03
	30	0.8030	0.09	0.26	0.18	0.36	0.05	0.06
	50	0.8120	0.09	0.27	0.18	0.35	0.05	0.06
WAGE	1	0.0313	0.00	0.06	0.02	0.03	0.88	0.00
	3	0.0747	0.05	0.20	0.00	0.17	0.57	0.00
	5	0.0980	0.09	0.24	0.01	0.26	0.39	0.00
	10	0.1129	0.14	0.23	0.06	0.26	0.30	0.02
	30	0.1358	0.16	0.21	0.08	0.24	0.25	0.06
	50	0.1364	0.17	0.21	0.08	0.24	0.25	0.06
DMST	1	0.0645	0.00	0.10	0.01	0.47	0.08	0.34
	3	0.1247	0.00	0.15	0.01	0.40	0.15	0.29
	5	0.1608	0.01	0.30	0.05	0.27	0.15	0.22
	10	0.1963	0.01	0.34	0.16	0.19	0.13	0.17
	30	0.2181	0.02	0.36	0.16	0.17	0.13	0.16
	50	0.2226	0.02	0.36	0.16	0.16	0.13	0.16

it is interesting to note that DMST has a moderate amount of feedback from WAGE, but not vice versa.

The findings based on Table 5, suggest that the U.S. market for domestic services is largely explained by the variables in this VAR system. Among them, the variations in DPRICE caused by the technological progress in the industry sector and change in input prices have strong feedback effects on DMST and WAGE. Also the feedback effects of the variations in INCOME in DMST and WAGE are significant. The direct interaction between the domestics and their wage rates is not bidirectional. As pointed out above, the number of domestics receives some feedback effects from the wage rate, but the wage rate does not receive feedback from the number of domestic service workers. The wage rate has been largely determined by the exogenous environmental factors rather than by the number of domestics itself.[16]

The second column in Table 5 displays the standard error of forecasts over various forecasting horizons for the model when sampling error in the estimated coefficients is ignored.[17] Actual forecast errors will of course be substantially larger, even if the model's parameters do not change, because the statistical estimates are imperfect. Pretending that the estimated trend coefficients are known exactly,, we see that the size of the forecast error increases steadily as the forecasting horizon lengthens to 30 years. For a stationary process, forecast standard errors tend to converge on some upper bound as the horizon increases. This system seems to converge very slowly, but overall the standard error of forecast indicates that the system is slowly dampened.

VI. SUMMARY AND CONCLUDING REMARKS

In this study, we adopted a descriptive analysis framework, so called VAR techniques. This approach could be effectively used for the analysis of macroeconomic behaviors in which the traditional structural modeling with highly objectionable maintained hypotheses is not appropriate. The results from this study support the approach.

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[16]This may suggest that the wage rates for domestic service workers are determined by the U.S. wage rates in general and not by the number of one type of labor. Thus, to verify this statement, the VAR system including the wage rate in the manufacturing sector was estimated again. However, the results reveal that the feedback of the wage rate of domestic service workers from the manufacturing wage rate was not significant.

[17]The standard errors of forecasts are computed from the same MAR's used in computing Table 5. They use the formula for the t-step ahead expected squared forecast error in variable i:

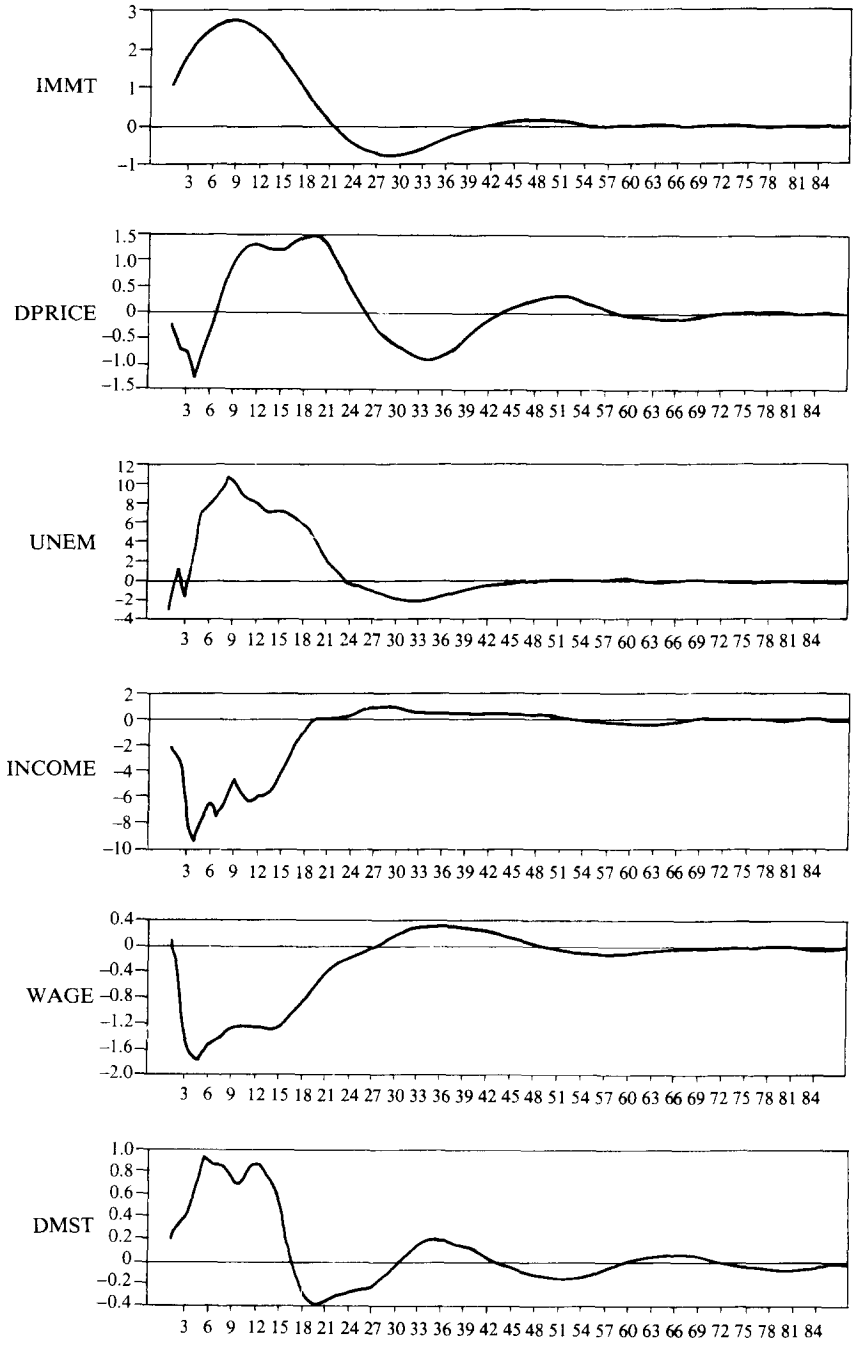
$$s^2(i,t) = \sum_{i=1}^{p} \sum_{v=0}^{t-1} a_{ij}(v)^2 s_j^2,$$

where there are p variables in the system, $s_j^2 = s^2(j,1)$ is the variance of the j-th innovation, and $a_{ij}(v)$ is the coefficient on the v-th lag of the j-th innovation in the MAR equation for variable i (Sims, 1980).

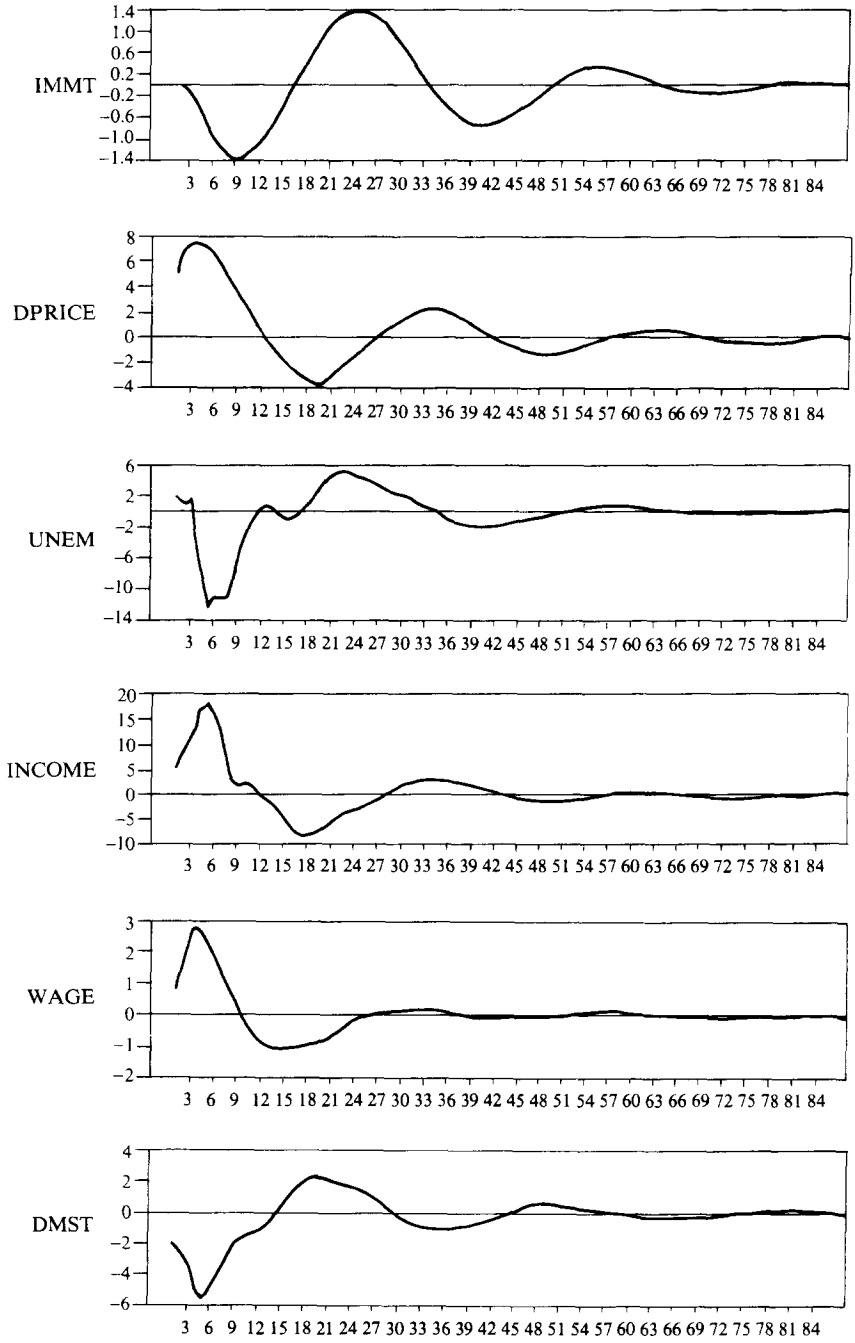
In general the interactions and causal relations among variables in the system are significant and quite straightforward. The fluctuations in the number of domestics and their wage rates have been largely determined by variations in other variables. These are the total number of immigrants, the real price of household durable goods, the unemployment rate, and the average real household income. These variables could be classified as the exogenous variables in the structural modeling for the market for domestic services. In particular, the effects of the variations in household durable goods prices caused by technological progress, proxied by the patenting activity, on other variables in the system are remarkable. We also found that there is only a uni-directional interaction between the number of domestics and their wage rates, from wage rates to domestics. Relatively wage rates did not respond significantly to the shocks in other variables in the system. These findings suggest that further studies are needed to identify the determination of the wage rate of domestic service workers.

Our experience in this study suggests that the VAR analytic can be effectively used for the analyses of simplified economic behaviors represented by small number of variables that have presumed strong interactions or causalities. However, VAR may be not appropriate for the well specified economic behaviors with a large number of variables. Some minor unsatisfactory results of this study may be explained in this context, because the VAR system is based on the behavioral model for the market for services of domestics. For the market behavior, we need to incorporate quite different characteristics to identify the demand and supply, respectively. The identification results in extending the system, but such a step throws doubt on whether the VAR could handle such a big system efficiently. In practice extremely long time series rarely are avaiable, and the OLS estimation for the many AR coefficients involves some statistical problems.

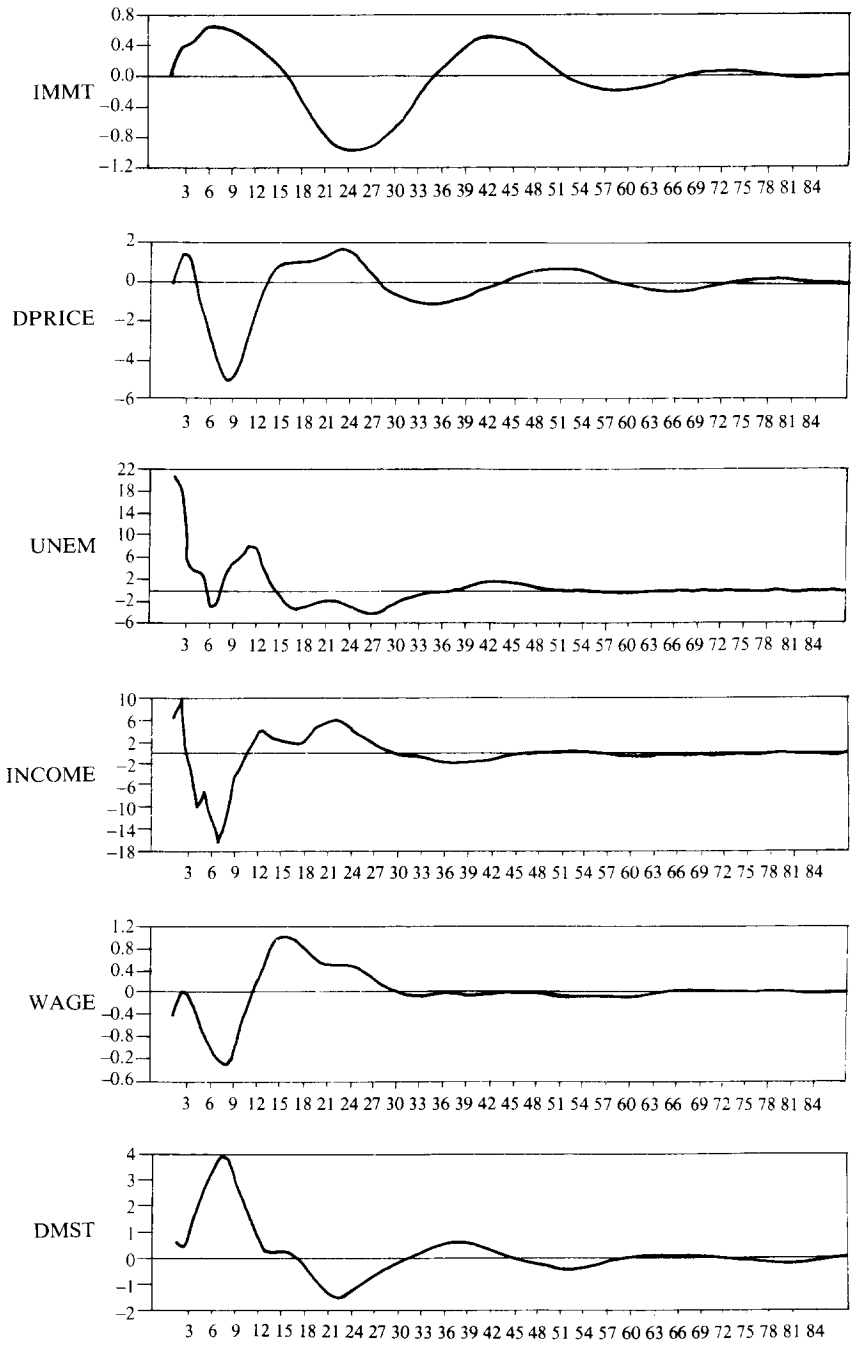
Fianlly, it should be noted that VAR techniques have many unsolved technical problems, such as some testing procedures, orderings and orthogonalizations. Still these procedures seem quite robust. Different procedures may yield somewhat different results. So it may need a few more experiments to give additional support to the current results.



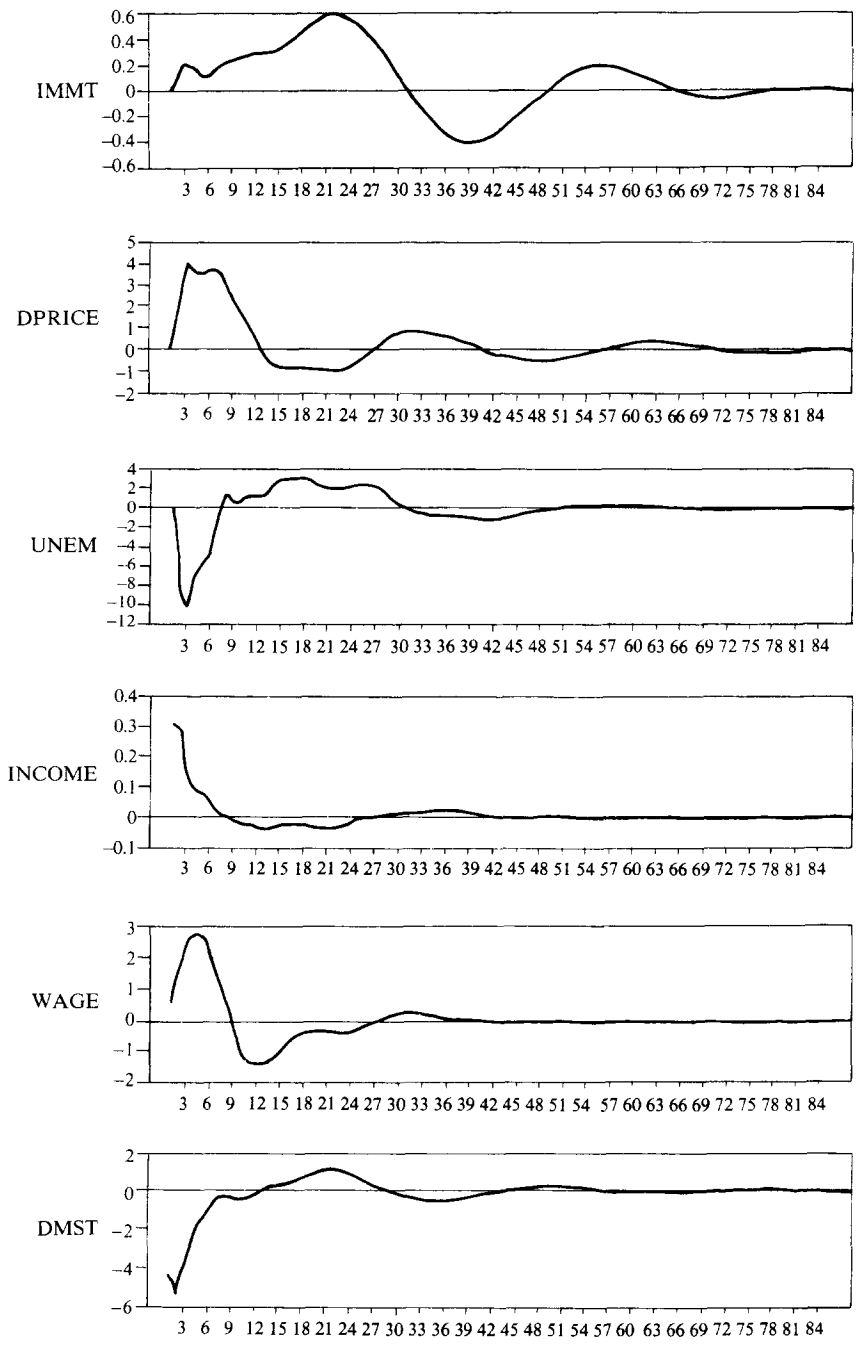
[**Figure 6-a**] Responses of IMMT, DPRICE, UNEM, INCOME, WAGE, and DMST to a Shock in IMMT



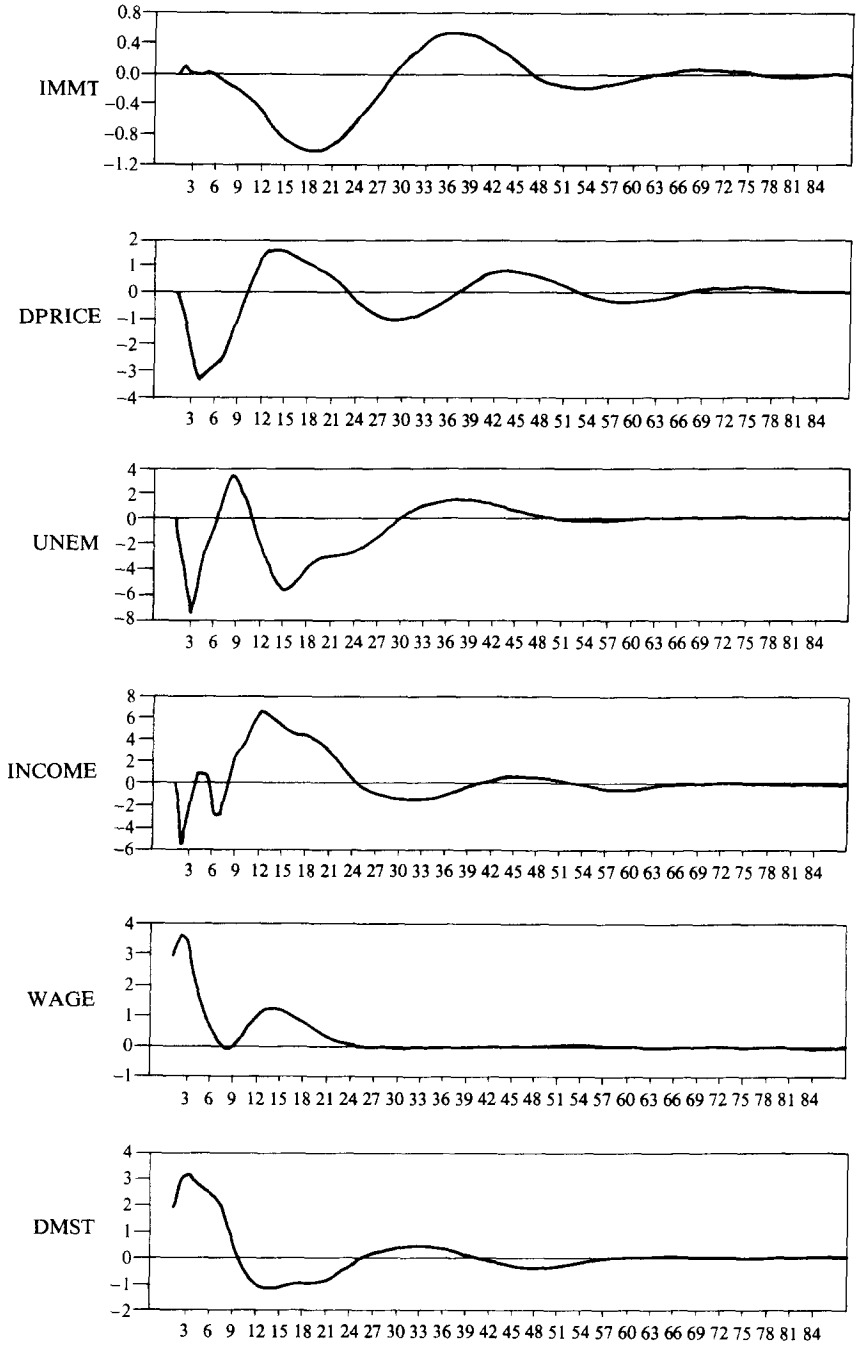
[**Figure 6-b**] Responses of IMMT, DPRICE, UNEM, INCOME, WAGE, and DMST to a Shock in DPRICE



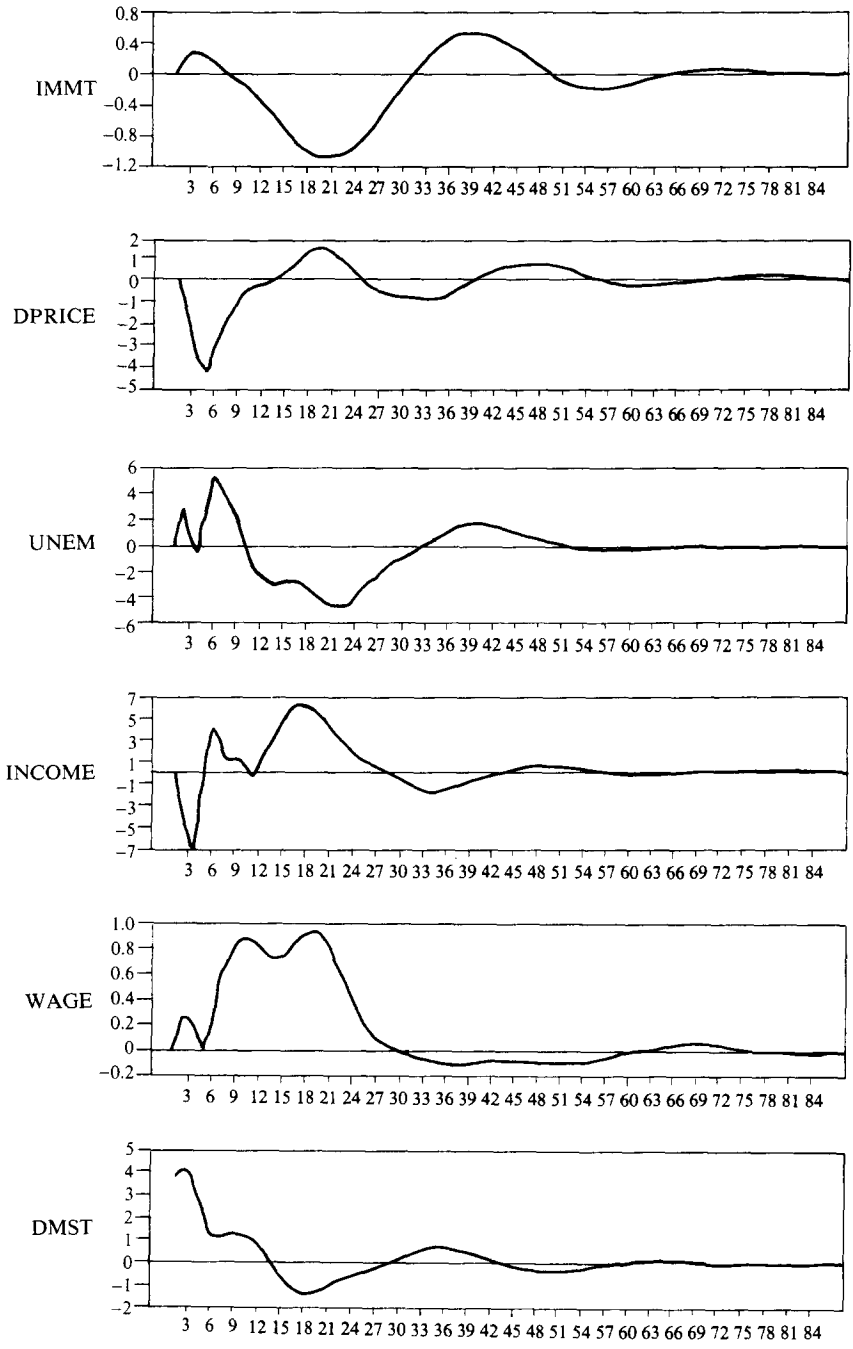
[**Figure 6-c**] Responses of IMMT, DPRICE, UNEM, INCOME, WAGE, and DMST to a Shock in UNEM



[**Figure 6-d**] Responses of IMMT, DPRICE, UNEM, INCOME, WAGE, and DMST to a Shock in INCOME



[**Figure 6-e**] Responses of IMMT, DPRICE, UNEM, INCOME, WAGE, and DMST to a Shock in WAGE



[Figure 6-f] Responses of IMMT, DPRICE, UNEM, INCOME, WAGE, and DMST TO A Shock in DMST

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