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"Decomposition of Hours based on Extensive and Intensive Margins of Labor"

by

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Decomposition of Hours based on Extensive and Intensive Margins of Labor[1]

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Abstract

We decompose underlying disturbances in total hours into three kinds: disturbances that shift the steady-state level of hours, those that change the sectoral composition of employment in the long-run, and those that cause temporary movement of hours around the steady-state. Our identifying restriction exploits the distinctive nature of the two margins of labor: employment and hours per worker. According to the variance decompostion from a VAR based on Post-War U.S. monthly data, we find that disturbances which eventually shift the steady-state level of hours account for three-quarters of cyclical fluctuation in aggregate hours. This challenges the commonly used restriction of constant hours along the balanced growth path in the business cycle literature. Further, we do not find a significant role for sectoral reallocation shocks in the cyclical fluctuation of hours.

Key Words: *Decomposition of hours, Permanent shocks, Temporary shocks, Sectoral reallocation.*

JEL classification: E32, E24, J2.

1 Introduction

While the implications of a unit root in aggregate output have been studied widely in the business-cycle analysis [e.g., Nelson and Plosser (1982), Cochrane (1988), Watson (1986), Blanchard and Quah (1989), King, et al. (1991)], the existence of a unit root in aggregate hours has not been seriously addressed in the literature.[1] This is probably due to the fact that prototype aggregate business-cycle models [e.g., Kydland and Prescott (1982), and King, Plosser, and Rebelo (1988)] restrict hours to be a stationary process around the steady state by imposing restrictions on preference or disturbances.[2] Yet the existence of a unit root in aggregate hours seems apparent in the data.

How should the finding of stochastic trends in hours affect business cycle analysis? Had the presence of a unit root little to do with the movement of hours at the business-cycle frequency, then imposing stationarity on hours in business cycle analysis might be acceptable. However, given that the success of models of business cycles is often measured by their ability to match the cyclical behavior of the labor market, if the unit root component in hours plays a significant role in the fluctuation of hours at business cycle frequencies, then the common practice of ruling out the possibility of stochastic trends in hours may be misleading.

In particular, the existence of a unit root in hours is incompatible with business cycle models that rely on persistent productivity shocks. For example, a permanent increase in productivity, under the commonly used preferences in the literature, ends up with little variation in hours as the income effect offsets the substitution effect in labor supply.[3,4]

Another common abstraction in the analysis of the aggregate labor market is "sectoral shifts." The idea that sectoral reallocation of labor, due to a permanent shift in technology

[1] An exception to this convention is Shapiro and Watson (1988) who explicitly allow a stochastic trend in labor supply in their structural VAR model.

[2] For example, with utility separable in consumption and leisure, log utility in consumption guarantees the stationarity of hours despite stochastic or deterministic trend in technology.

[3] It generates only a small increase in hours through interest rate channel as the inherited capital stock is below the steady-state. Yet this increase in hours is short-lived.

[4] Unit root tests may not provide a sharp discrimination between a unit root and a highly persistent stationary process. However, highly persistent hours is still incompatible with a highly persistent stationary productivity shifts because such a shift accompanies a sizable income effect.

or demand, could be an important cause or contributor to cyclical fluctuations in aggregate hours has been debated since David Lilien (1982)'s seminal paper. While many researchers [e.g., Davis (1987), Rogerson (1987), Phelan and Trejos (1996), and Swanson (1999)] investigate various economic mechanisms through which sectoral disturbances manifest themselves as an aggregate recession, its empirical importance seems still far from sensible consensus. For instance, Abraham and Katz (1986) argue that the statistical finding of a positive correlation between the dispersion index and aggregate unemployment by Lilien (1982) does not even require workers to be changing sectors. Murphy and Topel (1987), based on the March CPS on prime-age males, report that only 24% of the total incidence of unemployment is explained by sectoral shifts. Yet Davis and Haltiwanger (1990) report that frictions involved in sectoral reallocation of workers is an important source of aggregate employment fluctuation. Loungani and Rogerson (1989), based on PSID, report that permanent job switchers may account for about 40% of the total weeks of unemployment during recessions.

In this paper, based on the vector autoregressive (VAR) method, we propose a simple way of decomposing the underlying disturbances of total hours into three types of shocks: disturbances that shift the steady-state aggregate hours (permanent aggregate disturbances), disturbances that change the sectoral composition of employment in the long run (sectoral reallocation disturbances), and disturbances that cause temporary movement of hours around the steady-state (temporary disturbances). We then ask whether permanent components in hours, either aggregate or sectoral, have a significant impact on aggregate hours at business cycles frequencies.

Our identifying restrictions rely on the distinctive nature of the two margins of total hours, employment (the extensive margin) and hours per worker (the intensive margin): While employment exhibits strong nonstationarity, average hours per worker tends to be a stationary process around a deterministic trend. Figure 1 shows the total employee hours in nonagricultural establishments (divided by population) over the period from 1947 to 1997.[5] It shows a strong positive trend and clearly rejects the notion of constant hours along the balanced growth path. In Figure 2, we decompose hours into extensive and intensive

[5] We normalize the series by dividing by the annual total available hours per household (=.5 × [population over age 16] × [365 days]× [16 hours]).

margins. Employment is shown as a ratio of the total number of workers on non-agricultural payrolls to the population of 16 years and over and hours per worker is calculated as weekly hours per worker. While employment exhibits strong persistence, hours per worker appears to be a stationary process around a deterministic trend. According to the unit root test in Section 3 below, employment both at the aggregate and at the one-digit level contains a stochastic trend, and average hours per worker both at the aggregate and industry level exhibits stationarity around a deterministic trend.

Although most aggregate macroeconomic models dismiss one margin or the other, this distinction reveals useful information regarding the nature of underlying changes in the economic environment. For example, in need of a permanent increase in labor input, firms find it optimal to increase employment rather than hours per worker in the long-run because they face an upward sloping hourly wage schedule due to the overtime wage premium. This justifies our first identifying restriction that temporary disturbances do not affect employment levels in the long-run. Similarly, a permanent increase in the demand for labor in one sector relative to the others, possibly due to a permanent shift in technology or demand, will show up as a change in the long-run ratio of sectoral to aggregate employment. This allows us to identify the sectoral reallocation shocks.

According to the variance decomposition from a VAR model based on monthly data for employment and average hours per worker for 1947:1-1997:07 for seven industries in the U.S. (durables, non-durables, construction, transportation and utilities, wholesale and retail trade, finance-insurance & real estate, and services), we find that most variation of total aggregate hours at business cycle frequencies are due to disturbances that shift the long-run level of hours. For instance, at a 6-month to 2-year horizon, aggregate permanent disturbances account for 70-85% of the variation in aggregate hours. This implies that potentially about three-quarters of the cyclical variation in hours is due to the economy-wide disturbances that eventually shift the steady-state level of hours. Disturbances responsible for sectoral reallocation account for 7-12% of the variation in aggregate hours at a 6-month to 2-year horizon. The disturbances that cause temporary movement of hours account for only 8-18% of variation of aggregate hours at a 6-month to 2-year horizon.

Our finding of a remarkably important role for stochastic trends in hours is consistent with Shapiro and Watson (1988) who found a significant role of permanent labor supply shifts in the cyclical movement of output. Our finding may be interpreted in favor of models that include persistent preference shocks [e.g., Bencivenga (1992), or Baxter and King (1991)] or models with an explicit non-market sector where productivity shifts in the non-market sector play a significant role [e.g., Benhabib, Rogerson, and Wright (1991), or Greenwood and Hercowitz (1991)]. Alternatively, it challenges the validity of a utility function that imposes constant hours along the balanced growth path.

Our work is in line with previous VAR analyses on the decomposition of aggregate employment into aggregate versus sectoral [e.g., Campbell and Kuttner (1996), and Clark (1998)] and on the decomposition of output into permanent versus temporary [e.g., Blanchard and Quah (1989), Shapiro and Watson (1988), and King, et al. (1991)]. While previous studies investigate the aggregate/sectoral *or* permanent/temporary decomposition, we propose a unified framework for the decomposition of permanent/temporary and aggregate/sectoral shocks.

The paper is organized as follows. In Section 2, to illustrate our identifying restrictions, the distinctive nature of employment and hours per worker in the demand and supply sides of labor market is described. Section 3 presents the econometric model and results. Section 4 is the conclusion.

2 Economic Background

2.1 Demand for Employment and Hours

We first illustrate our identifying restrictions based on simple profit maximization by firms. Consider the following profit-maximization problem of a representative firm in a competitive industry:

$$\Pi_t = \max_{\{H_\tau, N_\tau\}_{\tau=t}^{\infty}} \mathrm{E}_t \sum_{\tau=t}^{\infty} Z_{t,\tau} \left[Y_t - \widetilde{W}_\tau(H_\tau) N_\tau \right]. \tag{1}$$

E_t is a mathematical expectation based on the information available at period t. $Z_{t,\tau}$ is the discount factor for profit at τ as of t: $Z_{t,\tau} = 1/(1+r_{t+1}) \cdots (1+r_\tau)$ if $\tau \geq t+1$, and

$Z_{t,t} = 1$, where r_t is the real interest rate. Y_t denotes output net of adjustment cost of changing employment:

$$Y_t = A_t[F(N_t H_t) - \Phi(N_t - N_{t-1})], \tag{2}$$

where N_t, H_t, A_t are employment, hours per worker, and the shift factor of the production function, respectively. The gross-production function is concave in total labor: $F' > 0, F'' < 0$. The adjustment cost $\Phi(\ )$ represents costs in changing the level of employment. Such a cost may include hiring and training costs [e.g. quasi-fixed labor illustrated by Oi (1962)], firing costs, or search/matching frictions. The adjustment cost is a convex function: $\Phi(0) = 0$, $\Phi'(0) = 0, \Phi'(\varepsilon) > 0$, for $\varepsilon > 0$, $\Phi'(\varepsilon) < 0$, for $\varepsilon < 0$, and $\Phi''(\cdot) > 0$. For simplicity, the price of output is normalized to one so that W_t represents the real cost of labor (the real wage). This implies that shifts in A_t may represent productivity shifts, changes in input prices other than labor, or changes in the nominal price of output relative to the wage.

The firm faces an overtime premium for extra hours of work. Specifically,

$$\widetilde{W}_t(H_t) = W_t[\overline{H} + \gamma(H_t - \overline{H})], \tag{3}$$

where W_t is the market wage rate for the straight time $\overline{H}$ and γ (>1) represents the wage premium for overtime. $\overline{H}$ may vary over time and across sectors. In fact, we will allow a linear time trend in $\overline{H}$ in both unit root tests and the VAR analysis below to capture a deterministic time trend in hours in our sample.

The first order conditions for the optimal hours and employment are

$$\begin{aligned} A_t F'(N_t H_t) &= W_t \text{ when } H_t = \overline{H}, \\ &= \gamma W_t \text{ when } H_t > \overline{H}, \end{aligned} \tag{4}$$

$$A_t[F'(N_t H_t)H_t + \mathrm{E}_t[(1 + r_{t+1})^{-1} A_{t+1}\Phi'(N_{t+1} - N_t)] = \widetilde{W}_t(H_t) + A_t\Phi'(N_t - N_{t-1}). \tag{5}$$

Due to the overtime premium, the firm would increase the employment in response to a permanent increase in A (given W) in the long run. In a steady-state where $N_{t+1} = N_t = N_{t-1}$, equation (5) becomes

$$A_t F'(N_t H_t) H_t = W_t[\overline{H} + \gamma(H_t - \overline{H})]. \tag{6}$$

From (3), the demand for hours per worker in the steady-state is

$$H = \overline{H}. \tag{7}$$

This justifies our identifying restriction that permanent shifts in labor demand are reflected in the level of employment rather than hours per worker. As described below in detail, this accords with the stochastic properties of employment and hours per worker in the data. However, in transition, due to the convex adjustment cost, the firm would want to smooth its employment path over time. This creates temporary fluctuations of hours per worker during the transition. In response to temporary disturbances, the firm adjusts both margins considering the trade-off between the adjustment cost in employment and the increasing wage due to the overtime premium.

In addition to the distinction between permanent and temporary disturbances in aggregate hours, we decompose the permanent disturbances into those that cause shifts in aggregate employment (permanent aggregate shocks) and those that change the sectoral composition in employment in the long run (sectoral reallocation shocks). Sectoral reallocation shocks are identified by the long run employment ratios. This can be described as different shifts in the shift factor such as A across sectors without a change in the aggregate employment. That is, sectoral reallocation shocks are those that changes the ratio of sectoral employment to aggregate employment without changing the aggregate employment level in the long-run.

2.2 Supply of Employment and Hours

The supply side of the labor market also provides a clear distinction between employment and hours. Suppose a typical worker i maximizes her expected discounted utility:

$$\max_{\{H_\tau(i), C_\tau(i), B_{\tau+1}(i)\}_{\tau=t}^{\infty}} \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t}[u(C_\tau(i)) - q_\tau(i)v(H_\tau(i))], \tag{8}$$

$$\text{subject to } C_t(i) + B_{t+1}(i) = \widetilde{W}_t(H_t(i)) + (1+r_t)B_t(i).$$

The worker derives utility from consumption, $u(C_t(i))$, and disutility from working, $v(H_t(i))$:

($u' > 0, u'' < 0, v' > 0, v'' > 0$). Convexity in the disutility from hours of work, $v''(H) > 0$, implies that workers ask a higher wage rate for longer hours of work. The term $q_t(i)$ represents individual i's value of time in nonmarket activities. It varies across workers and is the source of heterogeneity among workers. Asset holdings at time t are $B_t(i)$ and yield a return r_t.

The first order conditions are

$$W_t u'(C_t(i)) < q_t(i) v'(\overline{H}) \text{ and } H_t(i) = 0, \tag{9}$$

$$\gamma W_t u'(C_t(i)) \geq q_t(i) v'(H_t) \text{ and } H_t(i) \geq \overline{H}, \tag{10}$$

$$u'(C_t(i)) = \beta E_t[(1 + r_{t+1}) u'(C_{t+1}(i))]. \tag{11}$$

The first order condition for labor supply illustrates how to interpret stochastic trends in hours. Suppose the cross-sectional distribution of $q_t(i)$ in the economy at time t is denoted by $\theta_t(q)$. The supply of workers in the labor market (or the labor market participation rate) is

$$N_t = 1 - \int_{W_t u'(C_t(i)) < q_t(i) v'(\overline{H}))} d\theta_t(q_t(i)). \tag{12}$$

Any stochastic shift in the distribution of $q_t(i)$, would create changes in labor market participation rate. Therefore, a permanent shift in the distribution of $q_t(i)$, possibly due to changes in demographic structure or shifts in relative productivity between market and non-market activities, will generate a permanent shift in N_t. Such a shift has been introduced in the literature in the form of preference shocks or in the form of productivity shifts in a non-market sector.

An alternative way to generate stochastic trends in hours is just to give up the conventional restriction on preferences that imposes constancy of hours along the balanced growth path. For example, with a unit-elastic constant relative risk aversion in consumption, $u(C) = \log C$, as is assumed in standard models of business cycles, a permanent shift in the wage does not induce a change in hours, H, as income effects offset substitution effects.[6] Deviation from log utility allows a stochastic trend in hours in the presence of stochastic trends in productivity. Otherwise, stochastic trends in total hours have to be attributed to permanent shifts in labor supply.[7] In general, the supply of hours of a worker is affected by a permanent shift in preferences. However, in equilibrium, hours per worker remains stationary because the long-run demand for hours per worker is independent of wage rates.

3 Econometric Model

3.1 Data

We use seasonally adjusted monthly U.S. data for 1947:01-1997:07 based on Citicorp's Citibase data. The seven sectors analyzed are durable goods, nondurable goods, construction, transportation & public utilities, wholesale & retail trade, finance-insurance & real estate, and services. The mining and government sectors are excluded. A detailed explanation of the data is provided in the Appendix. Each of the VAR models includes three variables: aggregate employment, sectoral employment, and aggregate hours per worker.[8] All employment variables are divided by the civilian noninstitutional population of 16 years old and over. Aggregate average hours per worker is constructed by dividing total employee hours in nonagricultural establishments by the total number of workers on non-agricultural payrolls. To check the stationarity of average hours per worker in each sector, we use average hours of production workers. Logarithms of all variables are used.

[6] Under log utility $W_t u'(C_t)$ $(= W_t/C_t)$ remains the same as consumption moves with the same magnitude as wage in response to a permanent shift in wage.

[7] Although we discuss the utility that is additively separable between consumption and work effort here, the same argument is true for the multiplicatively separable utility.

[8] To control a strike by the Communications Workers and Telecommunications International Union against AT&T (a drop of 640,000 in the employment) in August 1983, we included a dummy variable when we ran a VAR using the transportation and utilities as a sector.

3.2 Stationarity of Employment and Hours

We investigate the existence of permanent shifts in hours based on unit root tests. According to Table 1, we cannot reject the existence of a unit root in the employment series, both at aggregate and one-digit industry level, except for the construction industry. Because most of the series show significant time trends, we include a time trend in unit root tests and VAR's. In contrast, unit roots in average hours per worker are strongly rejected except for the wholesale and retail trade industry and the service industry. In the VAR's below, employment is treated as nonstationary and average hours per worker as stationary. The employment ratios show unit roots as well except for construction, suggesting the existence of permanent sectoral shifts in most industries.[9] The nonstationarity found in the employment variables also makes total aggregate hours nonstationary, which is confirmed by the existence of a unit root in the total employee hours worked in nonagricultural establishments (the Phillips-Perron test statistic is -2.88 with 5 truncation lags suggested by Newey and West. see Phillips (1987), Phillips and Perron (1988), or Hamilton (1994), pp. 506-516). Following Stock and Watson (1988), in the three variable VAR model with two nonstationary variables and a stationary variable, we can identify two stochastic trend shocks and a temporary shock with the identifying restrictions described below.

3.3 Econometric Model and Identifying Restrictions

Consider a structural VAR with three variables, composed of aggregate employment growth $\Delta \log N_t$, sectoral employment growth $\Delta \log N_t^S$, and the log of aggregate hours per worker, $\log H_t$. Time trends are included in all equations.

$$X_t = \left[\begin{array}{ccc} \Delta \log N_t & \Delta \log N_t^S & \log H_t \end{array} \right]' . \tag{13}$$

Because all variables are now stationary, we can represent X_t by a Wold moving average:

$$X_t = A(L)\nu_t, \tag{14}$$

[9]The existence of unit roots in the sectoral employment ratios implies that aggregate employment and sectoral employment do not have a cointegrating vector of $(-1, 1)$, if any. In fact, there are two VAR systems that have cointegrating relations. The transportation & utilities industry and the service industry show the existence of cointegrating relations, suggesting that during the sample period permanent sectoral shifts did not play a significant role in these sectors.

where

$$A(L) = \sum_{i=0}^{\infty} A_i L^i, \ E[\nu_t] = 0, \ E[\nu_t \nu_t'] = I, \ \nu_t = [\psi_t^A \ \psi_t^S \ \phi_t]'. \tag{15}$$

L is a lag operator, ν_t is a vector of white noise structural shocks including two stochastic trend shocks, aggregate (ψ_t^A) and sectoral (ψ_t^S), and one transitory shock (ϕ_t), and I is an identity matrix. The response matrices for the structural shocks can be identified starting from a finite-order VAR as follows.

$$B(L)X_t = \epsilon_t, \tag{16}$$

where

$$B(L) = \sum_{i=0}^{p} B_i L^i, \ B_0 = I, \ E[\epsilon_t] = 0, \ E[\epsilon_t \epsilon_t'] = \Sigma. \tag{17}$$

Then we invert the estimated coefficient matrices B_i's to get

$$X_t = C(L)\epsilon_t, \tag{18}$$

where

$$C(L) = B^{-1}(L) = \sum_{i=0}^{\infty} C_i L^i. \tag{19}$$

>From $\epsilon_t = A_0 \nu_t$, $A_j = C_j A_0$, and $A(1) = C(1)A_0$, it suffices to get A_0. The 3×3 matrix A_0 has nine unknowns and can be recovered from the covariance matrix of the finite VAR, $A_0 A_0' = \Sigma$ (6 equations) and the following three identifying restrictions. We require three restrictions on $A(1)$ to identify the three structural shocks: aggregate permanent, sectoral permanent, and temporary shocks.

The following identifying restriction provides a distinction between permanent disturbances and temporary disturbances.

Identifying Restriction (I) *Temporary shocks have no effect on employment, both aggregate and sectoral, in the long run.*

Identifying restriction (I) imposes two restrictions on the long-run matrix $A(1)$. That is, if the long-run multipliers of the structural shocks can be described as

$$\begin{bmatrix} \Delta \log N \\ \Delta \log N^S \\ \log H \end{bmatrix} = A(1)\nu = C(1)A_0\nu = \begin{bmatrix} c_{11}^l & c_{12}^l & c_{13}^l \\ c_{21}^l & c_{22}^l & c_{23}^l \\ c_{31}^l & c_{32}^l & c_{33}^l \end{bmatrix} \begin{bmatrix} a_{11}^0 & a_{12}^0 & a_{13}^0 \\ a_{21}^l & a_{22}^l & a_{23}^0 \\ a_{31}^0 & a_{32}^0 & a_{33}^0 \end{bmatrix} \begin{bmatrix} \psi^A \\ \psi^S \\ \phi \end{bmatrix}, \tag{20}$$

the identifying restriction can be summarized as

$$c^l_{11}a^0_{13} + c^l_{12}a^0_{23} + c^l_{13}a^0_{33} = 0, \tag{21}$$

and

$$c^l_{21}a^0_{13} + c^l_{22}a^0_{23} + c^l_{23}a^0_{33} = 0. \tag{22}$$

The two stochastic trend shocks named as aggregate and sectoral permanent shocks are identified by the restriction (II).

Identifying Restriction (II) *Sectoral reallocation shocks change the employment ratios without changing aggregate employment in the long-run.*

This identifying restriction is given as the following equation.

$$c^l_{11}a^0_{12} + c^l_{12}a^0_{22} + c^l_{13}a^0_{32} = 0. \tag{23}$$

Then, the long-run matrix $A(1)$ becomes a lower-triangular matrix, in which the matrix A_0 can be recovered by $A_0 = C^{-1}(1)A(1)$, where $A(1)$ is the Cholesky factor of the covariance matrix, Σ, following $A(1)A(1)' = \Sigma$. It is well-known that structural shocks with a lower-triangular long-run matrix can be identified with the Cholesky factor, which is unique up to the signs of the diagonal elements.

3.4 Variance Decomposition of Aggregate Hours

Our primary interest is whether disturbances responsible for the shift in steady-state level of hours plays a significant role in the variation of aggregate hours at business cycle frequencies. Table 2 shows the k-month ahead forecast-error variance decomposition (k =1, 6, 12, 24, 60, 120) of aggregate hours for each of the VAR's and their weighted average. The weights are calculated from the sample average of employment shares in aggregate employment.[10] According to the weighted average of variance decomposition at 6-month to 2-year horizon,

[10] The employment shares or the ratios of total sectoral hours to aggregate hours have changed over the sample period (1947 to 1997). We tried other weights calculated as the sub-sample period averages (the first 16 years and the last 16 years) and shares in total hours (employment $\times$ hours per worker). We did not find any significant differences in the results.

aggregate permanent shocks account for 70-85% of variation in total hours. About three-quarters of the cyclical variation in aggregate hours is due to disturbances that change hours in the long-run. As will be discussed below, this may present a potentially serious problem for the current convention in business-cycle research of not allowing for a stochastic trend in hours.

We find that the contribution of sectoral reallocation shocks to the cyclical variation of aggregate hours is moderate. At a 6-month to 2-year horizon, sectoral shocks explain 7-12% of fluctuations in aggregate hours. This is somewhat smaller than the estimate reported in the literature [e.g., Campbell and Kuttner (1996)].[11] The contribution of disturbances that cause stationary variation around the steady-state is 8-18% at a 6-month to 2-year horizon.

We interpret our findings from the variance decomposition as follows. With utility that assumes constant hours along the balanced growth path, in order to explain the persistent cyclical variation in hours, one needs a model with persistent preference shocks [e.g., Bencivenga (1992), or Baxter and King (1991)] or a model with an explicit non-market sector in which productivity shifts in the nonmarket sector play a significant role [e.g., Benhabib, Rogerson, and Wright (1991), or Greenwood and Hercowitz (1991)]. Alternatively, the conventional restriction on the preferences that rules out shifts in steady-state hours in the presence of permanent or persistent shifts in productivity may have been misplaced.

3.5 Long-run Multipliers

To gauge the importance of permanent aggregate shocks and sectoral allocation shocks in the long run, the long-run multipliers for disturbances are calculated in Table 3. The numbers represent long-run responses of percentage changes in aggregate employment and

[11] The decompostion of aggregate versus sectoral shocks we use is different from that in Campbell and Kuttner (1996). Our sectoral reallocation shocks are those that change the employment ratio without affecting aggregate employment in the long run (pure allocation shocks). In contrast, in Campbell and Kuttner sectoral shocks are allowed to affect aggregate employment in the long-run and the aggregate shocks not to affect employment ratios. When we adopt their identifying restriction, the contribution of aggregate sectoral disturbances increases to 41-45% at business cycle frequencies. Yet given the orthogonal property in our identifying restrictions on permanent and temporary disturbances, the role of temporary disturbances in aggregate total hours remains the same.

sectoral employment to a one percent standard deviation increase in the aggregate permanent shock and in the sectoral reallocation shock, respectively, from each VAR composed of the three variables described above. For example, when there is a one percent standard deviation increase in the aggregate permanent shock, aggregate employment increases by 0.66 percent in the long-run and sectoral employment in the durable goods industry increases by 1.31 percent. A one percent standard deviation increase in the sectoral allocation shock which changes sectoral composition of employment has a long-run effect of 0.59 percent on the sectoral employment with no change in aggregate employment as imposed in the identifying restriction. The numbers in parentheses provide the 95 % confidence intervals calculated from 1000 simulations. The long-run multiplier for aggregate disturbances to aggregate employment is very similar (0.57 to 0.68 percent increase in the long-run) across the seven different VAR's even though we do not impose any restriction. This implies that we have identified the aggregate disturbances consistently across sectors. We find that aggregate permanent disturbances dominate sectoral-shift shocks in the long-run behavior of sectoral employments. Except for construction industry and finance, insurance and real estate industry, the long-run multiplier of aggregate disturbances is greater than that of sectoral shift disturbances.

3.6 Impulse Responses

We investigate the impulse responses for aggregate employment, sectoral employment, and aggregate hours per worker from the estimated VAR. Figure 3 shows the responses to a one percent standard deviation innovation in the three shocks from the VAR using durable goods as a sector. Solid lines are responses to aggregate permanent shocks, dash-dotted lines are responses to sectoral shocks in the durable goods industry, and dashed lines are responses to temporary shocks. Aggregate employment shows a large and hump-shaped response to aggregate shocks. However, the response of aggregate employment to the sectoral shocks is relatively small. The response to temporary disturbances is also small. Employment in durable goods shows similar responses to the two permanent shocks. The aggregate shock has a large effect on sectoral employment, which implies that much of the fluctuation in sectoral employment is due to aggregate shocks. Temporary shocks have a relatively small effect on sectoral employment. However, hours respond very strongly to temporary shocks.

Another interesting finding in the impulse response analysis is the timing of the response of hours per worker and employment. In response to all three shocks, but most strikingly to temporary shocks, hours per worker strongly lead employment. This is consistent with Table 4, which shows the lead-lag cross correlations between employment and hours per worker with the HP-filtered data. Hours lead employment by at least one quarter except for the construction industry. Our impulse responses also suggest that the persistence in hours is not likely a consequence of labor market frictions. Employment approaches the new steady-state level within a year in most industries responding to both aggregate and sectoral reallocation shocks.

Impulse responses from the VAR's for other industries show similar behavior to the impulse responses from the VAR with durable goods. In particular, the impulse responses of aggregate employment to the aggregate permanent shock and the temporary shock are consistent in terms of size and shape of the response across the seven VAR's for each sector.[12] Thus, we do not report impulse responses from the VAR's for other industries.

4 Summary and Concluding Remarks

This paper proposes a simple way to decompose total aggregate hours into the disturbances that cause shifts in the steady-state level of aggregate hours, those that change the sectoral composition of employment in the long run, and those that cause temporary movement around the steady-state. Our identifying restrictions exploit the distinctive nature of the two margins of labor: employment and hours per worker. Based on VAR analysis using U.S. monthly data for 1947:01-1997:06, we find that even at the business cycle frequency, about three-quarters of the variation in aggregate total hours are explained by disturbances that eventually shift the steady-state level of hours. Pure sectoral reallocation shocks account for only 7–12% of the cyclical variation of total hours. Only 8-12% of the variation in

[12] We found that sectoral reallocation shocks in some sectors such as construction, wholesale & retail trade, and finance-insurance & real estate have a negative effect on aggregate employment in the short-run. This finding may be consistent with the idea of "sectoral shifts" in the previous literature, that sectoral reallocation may create unemployment.

aggregate hours is affected by disturbances that cause the transitory movement of hours around the steady-state.

We interpret the above findings as follows. In order to explain fluctuations in the aggregate labor market, one needs a model that allows a permanent shift, or at least a high persistence, in hours. With conventional preferences that impose constant hours along the balanced growth path, one needs highly persistent preference shocks or productivity shifts in the non-market sector. Alternatively, the conventional restriction on preferences that rules out shifts in steady-state hours along the balanced growth path may have been misplaced.

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Appendix – Data Description

The following describes all the data used in this study and the names of variables from the Citicorp's Citibase data set over the period from 1947:01 to 1997:07.

Aggregate Employment = (LPNAG/P16SA), where LPNAG is the total number of workers on non-agricultural payrolls by the establishment survey and P16SA is the seasonally adjusted P16 (the civilian noninstitutional population of 16 years and over) with the X-11 procedure in the SAS.[13]

Aggregate Average Hours = (LPMHU/LPNAG), where LPMHU is the total employee hours worked in nonagricultural establishments.

Sectoral Employment

1. Durable Goods (LPED/P16SA)
2. Nondurable Goods (LPEN/P16SA)
3. Construction (LPCC/P16SA)
4. Transportation and Public Utilities (LPTU/P16SA)
5. Wholesale and Retail Trade (LPT/P16SA)
6. Finance, Insurance, and Real Estate (LPFR/P16SA)
7. Services (LPS/P16SA)

All variables are taken logarithm before the VAR's are run.

[13]The civilian noninstitutional population of 16 years and over is not available as seasonally adjusted. It is seasonally adjusted by the X-11 procedure in the SAS. The other seasonally adjusted variable for population is the noninstitutional population of 16 years and over but it lasts a shorter period from 1950:01 to 1993:12.

TABLE 1. Unit Root Tests[1), 2)]

Variables	Employment	Employment ratio	Hours per worker
Aggregate	−2.63		−4.40*
Durable Goods	−2.24	−1.84	−4.53*
Nondurable Goods	−2.17	−1.62	−5.33*
Construction	−3.54*	−4.10*	−11.91*
Transportation & Utilities	−1.51	−1.20	−4.57* [3)]
Wholesale & Retail Trade	−2.06	−1.76	−0.17 [3)]
Finance & Insurance	0.03	−0.49	−14.20* [3)]
Services	−2.11	−2.40	−2.16 [4)]

1) Each test is based on the Phillips-Perron Test (5 truncation lags suggested by Newey-West) with a linear trend.

2) The sample period is from 1947:1 to 1997:08, unless otherwise specified.

3) 1964:1−1997:8.

4) 1964:1−1996:2.

5) Asterisk (*) indicates a rejection of a unit root at the 5 percent significance level (the critical value: −3.42.).

TABLE 2. Variance Decomposition of Total Aggregate Hours ($\log NH$) **for Each Pair of VAR's**

Variable	Shock	1	6	12	24	60	120
Durables	ψ_A	0.20	0.62	0.73	0.79	0.85	0.90
	ψ_S	0.12	0.15	0.13	0.08	0.05	0.03
	ϕ	0.68	0.23	0.15	0.13	0.03	0.07
Nondurables	ψ_A	0.31	0.80	0.90	0.93	0.94	0.96
	ψ_S	0.01	0.00	0.00	0.00	0.00	0.00
	ϕ	0.68	0.19	0.09	0.07	0.05	0.04
Construction	ψ_A	0.23	0.69	0.82	0.87	0.91	0.94
	ψ_S	0.38	0.21	0.13	0.07	0.04	0.03
	ϕ	0.39	0.10	0.06	0.06	0.05	0.04
Transportation & utilities	ψ_A	0.37	0.82	0.92	0.95	0.97	0.98
	ψ_S	0.08	0.04	0.02	0.01	0.00	0.00
	ϕ	0.56	0.14	0.06	0.04	0.03	0.02
Wholesale & Retail Trade	ψ_A	0.19	0.63	0.71	0.76	0.82	0.87
	ψ_S	0.34	0.24	0.22	0.17	0.11	0.08
	ϕ	0.47	0.13	0.07	0.07	0.07	0.05
Finance, Insur., Real Estate	ψ_A	0.44	0.77	0.88	0.93	0.96	0.98
	ψ_S	0.27	0.18	0.11	0.06	0.03	0.02
	ϕ	0.29	0.04	0.01	0.01	0.01	0.01
Services	ψ_A	0.27	0.74	0.85	0.88	0.91	0.94
	ψ_S	0.01	0.01	0.01	0.00	0.00	0.00
	ϕ	0.72	0.25	0.15	0.12	0.09	0.06
Weighted Average	ψ_A	0.26	0.70	0.80	0.85	0.89	0.92
	ψ_S	0.16	0.12	0.10	0.07	0.04	0.03
	ϕ	0.58	0.18	0.10	0.08	0.07	0.05

ψ_A: aggregate permanent shock
ψ_S: sectoral reallocation shock
ϕ: temporary shock

TABLE 3. Long-Run Effects of Permanent Shocks

Variable / Shock	$\Delta \log N$ ψ_A	$\Delta \log N$ ψ_S	$\Delta \log N^S$ ψ_A	$\Delta \log N^S$ ψ_S
Durable Goods	0.66	0	1.31	0.59
	(0.39, 1.05)	–	(0.75, 2.25)	(0.34, 0.77)
Nondurable Goods	0.0057	0	0.43	0.28
	(0.37, 0.88)	–	(0.23, 0.71)	(0.20, 0.44)
Construction	0.60	0	1.04	1.28
	(0.39, 0.94)	–	(0.40, 2.07)	(0.71, 1.70)
Transportation & Utilities	0.61	0	0.65	0.22
	(0.38, 0.93)	–	(0.38, 1.06)	(0.12, 0.35)
Wholesale & Retail Trade	0.60	0	0.49	0.39
	(0.39, 0.96)	–	(0.25, 0.93)	(0.17, 0.49)
Finance, Insur., Real Estate	0.68	0	0.24	0.64
	(0.40, 1.03)	–	(−0.13, 0.80)	(0.29, 0.87)
Services	0.62	0	0.36	0.23
	(0.39, 0.91)	–	(0.18, 0.59)	(0.16, 0.33)

ψ_A: aggregate shock
ψ_S: sectoral reallocation shock
Numbers in parentheses indicate 95% confidence intervals calculated from 1000 simulations.

TABLE 4. Leads and Lags between Employment and Hours

$corr(N_t, H_{t+i})$ (HP filtered)

leads & lags (i)	−12	−8	−4	0	4	8	12
Aggregate	0.28	0.46	**0.59**	0.46	0.06	−0.27	−0.42
Durable Goods	0.31	0.57	**0.69**	0.51	−0.03	−0.42	−0.54
Nondurable Goods	0.06	0.32	**0.47**	0.35	−0.08	−0.37	−0.47
Construction	−0.09	−0.02	0.10	**0.32**	0.06	0.02	0.02
Transportation & Utilities	0.20	0.24	**0.28**	0.21	0.01	−0.13	−0.20
Wholesale & Retail Trade	0.16	0.19	**0.23**	0.13	−0.10	−0.28	−0.31
Finance & Insurance	0.06	0.05	**0.12**	0.04	0.04	−0.01	−0.02
Services	0.06	0.09	**0.15**	0.11	0.10	−0.06	−0.11

Figure 1: Total Aggregate Hours

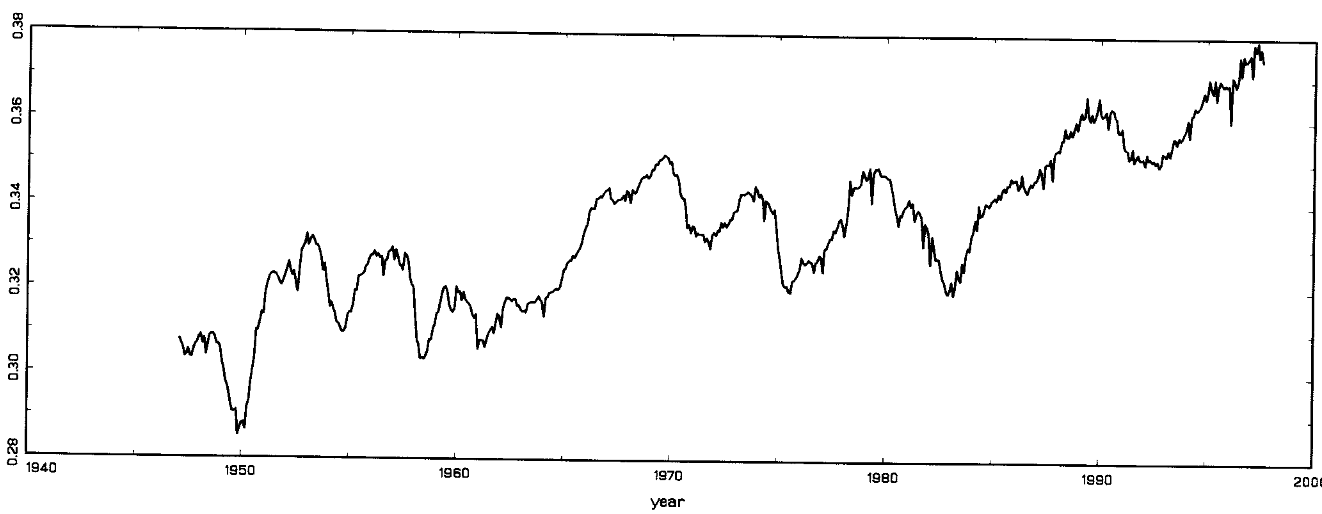
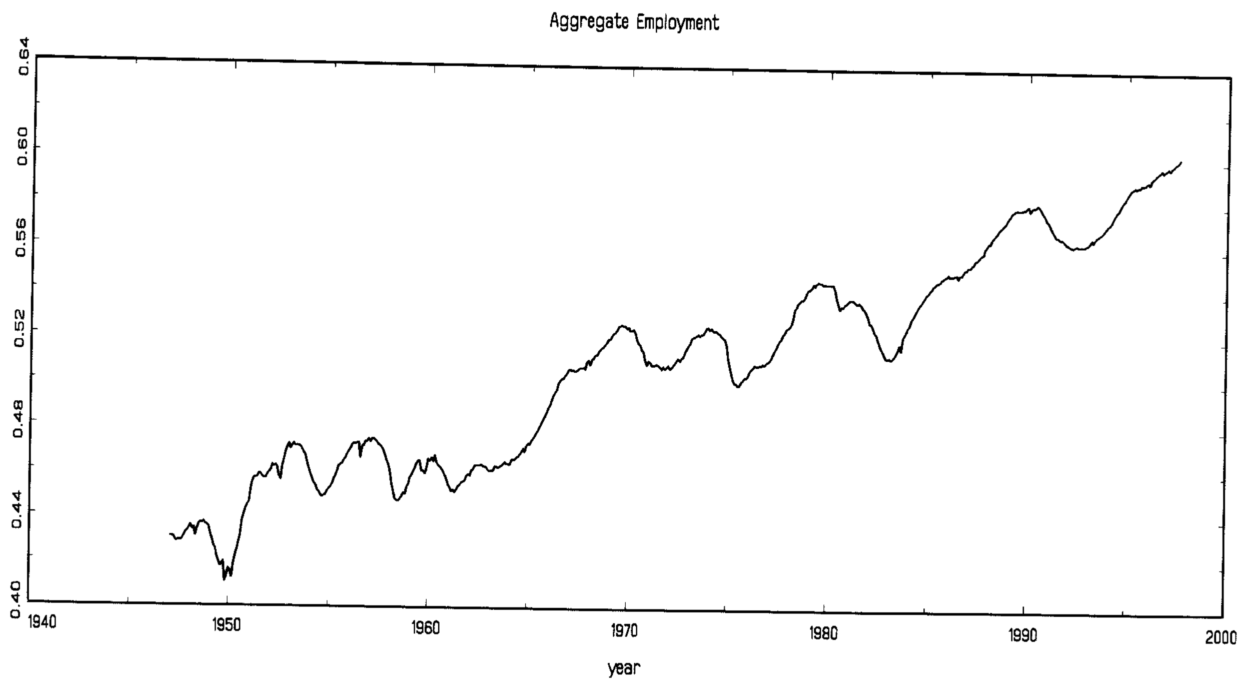


Figure 2: Aggregate Employment and Weekly Hours



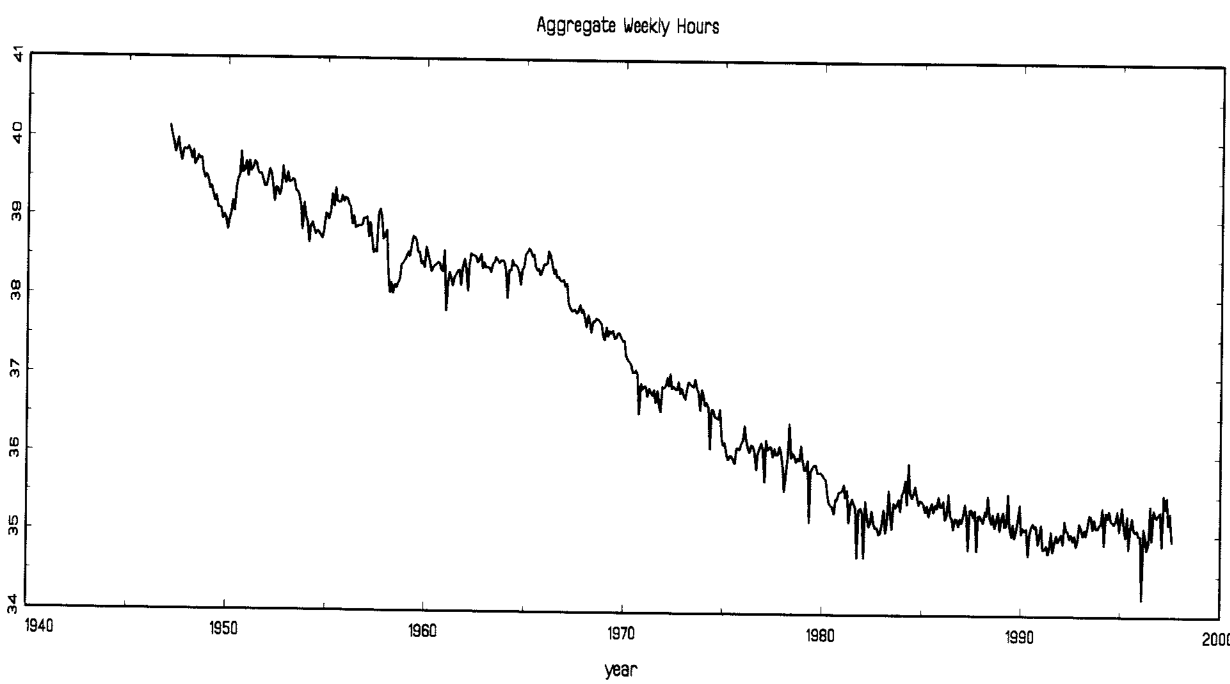


Figure 3: Impulse Responses: Aggregate vs Durables (Aggregate Permanent ——, Sectoral Permanent -·-·-, Temporary - - -)