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Is labour becoming more or less flexible? Changing dynamic behaviour and asymmetries of labour input in US manufacturing

Stuart Glosser and Lonnie Golden*

Have employment and hours become more flexible over time? Vector autoregressions are estimated using monthly time-series data to generate impulse responses, which reflect the dynamic response of employment and average hours of labour input following a given shock in output demand. A marked change in the US manufacturing sector occurred after 1979. Although there is heterogeneity by industry and asymmetry over the business cycle, hours have become somewhat more and employment considerably less flexible, particularly during expansion phases. Employers are apparently delaying hiring and relying more on using hours as a buffer to absorb fluctuations in output demand.

Key words: Hours of work, Employment adjustment, Labour flexibility, Labour markets, VARs
JEL classifications: J2, J4, E3

1. Introduction

Much of the empirical research on the issue of labour market flexibility focuses on the degree of flexibility of wages and employment in a firm, single industry, aggregate labour market or country. The research on adjustment behaviour of the 'quantity-side' variables, i.e., the employment and hours components of labour input, focus more on the former than the latter. Moreover, there are many more investigations of labour adjustment behaviour in European cases than US.[1] The sparse research on the

Manuscript received 18 September 2001; final version received 13 August 2003.
Address for correspondence: Lonnie Golden, Division of Social Sciences, Penn State University, Abington College, Abington PA, 19001, USA; email Lmg5@psu.edu.

* University of Wisconsin at Whitewater, and Penn State University, Abington College, respectively.

[1] Cross-country comparisons tend to focus on institutions that may alter the cost of employment adjustment, such as regulatory or collectively bargained provisions that provide dismissal and layoff protection, lifetime employment or short-time compensation (Kraft, 1997). While intended to promote job security, they create fixed labour costs that quite unintentionally hinder future hiring, suppressing upward adjustment of employment (Burgess and Dolado, 1989; Hamermesh, 1993; Van Audenrode; 1994; Hogan and Ragan, 1995; Kraft, 1997; Hunt, 2000). Labour unions appear to suppress employment adjustments and enhance hours adjustments (Haskell *et al.*, 1997; Hunt, 2000). However, the slower adjustment of employment (mean lag time following output shocks) in Europe does not appear to be attributable to employment protection institutions, since the lag time did not decrease after the loosening of protections (Abraham and Houseman,

aggregate US labour market has focused more on levels of work hours than on adjustment responses, surely in part because of the apparent upwards trend of average weekly and overtime hours from the early 1980s to the late 1990s (see Fig. 1).[1] Finally, previous research has focused only rarely on inter-period or inter-industry comparisons of hours and employment adjustment behaviour. The US labour market has been found to exhibit relatively greater employment adjustment and relatively smaller hours adjustment than that in comparable countries. In addition, employment adjustment tends to occur faster, with less lag time, in the US than in European countries.[2] However, there is conflicting evidence regarding whether the degree and speed of adjustment in production worker hours or employment, in response to a shock in output, had declined progressively over time (Hamermesh, 1993) or has not changed in 1970s and 1980s relative to earlier years in the US (Abraham and Houseman, 1993A). In the UK, hours adjustments appear to occur mainly in response to short-run shocks in demand, while employment adjusts in response to longer-run shocks. There is a business cycle asymmetry in the sense that employment responses are more common following positive shocks than negative shocks (Haskel *et al.*, 1997).

This study explores whether the hours and employment components of labour input in the US have become either more or less flexible. It extends the period of analysis into the 1990s, uses monthly time series data, investigates a larger set of industries than previous studies and observes the degree of asymmetry in employment and hours adjustments at the opposing stages of the business cycle. Sections 2, 3 and 4 develop several empirically testable and sometimes conflicting hypotheses, derived from the literature, such as the economics of labour flexibility, flexible firms and employment adjustment costs. Section 5 specifies the framework for the empirical estimation using a vector autoregression (VAR) system. A sensible sequence is derived regarding the direction and magnitude of both work hours and employment adjustment following a one-time ('short-run') shock to output demand. VAR system techniques are applied to identify the systematic, dynamic inter-relationship between output and the two labour input components, using time-series data. Impulse responses from a simulated temporary shock to output demand gauge the dynamic responses of hours and employment. The system is estimated for both aggregated and 15, two-digit standard industrial classification (SIC) industries in US manufacturing. Section 6 shows that since 1979, a marked structural change has occurred in the behaviour of hours vis-à-vis employment in the last two decades. US labour markets exhibit more intensive adjustment of hours relative to employment levels, although there are differences observed over expansion and contraction of the business cycle and some heterogeneity by detailed industry. Sections 7 and 8 draw implications of the findings for explaining

1993B). Of course, using data within a single country and a single major industry precludes a test of the effect of differing labour market institutions due to labour law, policy or collective bargaining restraints on firing and layoffs (e.g., Abraham and Houseman, 1993A; Hogan and Ragan, 1995; Kraft, 1997).

[1] Overtime hours in US manufacturing rose in the 1990s (Hetrick, 2000). No upward linear trend in overtime was found from 1956 to 1977 after controlling for pro-cyclical variation (Ehrenberg and Schumann, 1982). However, overtime hours did trend upwards from 1967 to 1984 (Hashimoto, 1993). Updated trend regressions controlling for output, confirm an upward trend in overtime from 1979 to 1995, of about 1% per year, accelerating with time.

[2] Abraham and Houseman, 1993A, 1993B; Cho and Cooley, 1994; Hashimoto, 1993; Van Audenrode, 1994.

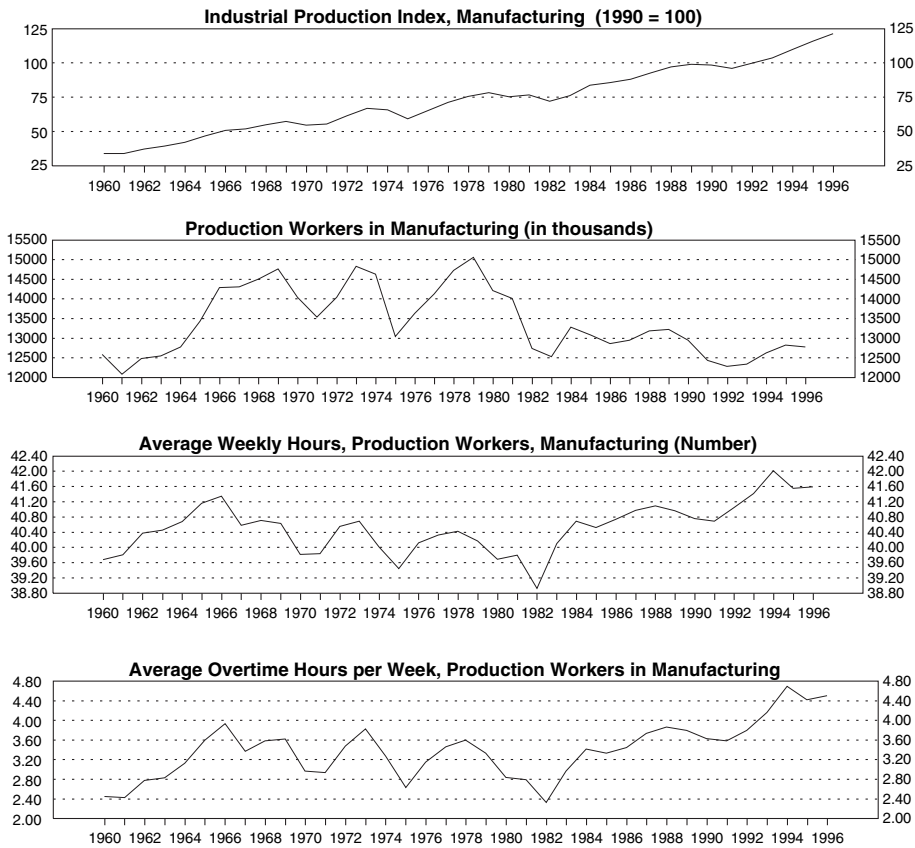

Fig. 1. *Trends in manufacturing output, employment and hours, 1960–96.*
Source: US Department of Labor, Bureau of Labor Statistics, Current Employment Statistics series, monthly survey of establishment, for average weekly hours and overtime hours, production and non-supervisory and average weekly earnings. Federal Reserve Board's monthly Industrial Production Index for output.

the increasingly 'jobless recoveries' experienced in the US and policies to counteract them.

2. In pursuit of labour flexibility: the flexible firm

Typologies of 'labour flexibility' have been developed in the context of both labour markets and labour input utilisation (e.g., Atkinson, 1987; OECD, 1996; Bettio and Rosenberg, 1999; Regini, 2000; Valverde *et al.*, 2000). One distinction is between macro and firm- or establishment-level flexibility of labour. In the macroeconomic context, flexibility can mean the responsiveness of unemployment or real wages to aggregate labour demand or supply shocks (Beckerman, 1986; Salvanes, 1997). At the micro-level, there is both internal and external labour flexibility for firms. The former typically refers to strategies or responses within the enterprise regarding the re-deployment of the work force as part of a re-organisation of the structure of work, production or internal labour market. This includes functional flexibility, which is arguably the most heavily relied upon strategy and

perhaps most effective.[1] External flexibility involves the interaction of organizations with outside market forces. This may involve numerical flexibility (NF) and/or worktime flexibility (WF). The former refers to the ease with which firms are able to increase or decrease the total size and composition of their workforce on short notice (Standing, 1999). Numerical flexibility is intended to match continuously the volume of work and labour input. This is most often pursued best through changes in the level of employment. This involves expediting hiring and layoffs within regular jobs or expansion of contingent or limited duration employment contracts, principally temporary and other casual jobs, which facilitate more rapid hiring or dismissal (Atkinson, 1987; Kanawaty, 1989; Grenier *et al.*, 1997; Valverde *et al.*, 2000). Similarly, there is often a dichotomy conceived between adjustment of labour along an extensive margin, which reflects the costliness of adjusting the size of firms' work force, and along an intensive margin, which reflects the degree to which firms can deploy that work force without external constraints (Hart and Malley, 1996; Haskel *et al.*, 1997). Working time flexibility, or variation in the length, scheduling or distribution of work hours, is usually treated separately, even re-characterised as 'temporal flexibility' (Regini, 2000), although initially it was often considered a variant or part of numerical flexibility (e.g., see Streek, 1987; Kalleberg, 2001).

Intensifying market competition is believed to lead firms to seek internal organisational and work process changes that allow them to position themselves for a more rapid response to shifts in uncertain demand (e.g., Boyer, 1988; Pollert, 1988, Hunter, *et al.* 1993; Gooderham and Nordhaug, 1997; Kalleberg, 2001). 'Flexible firms' may be seeking ways to both restrain unit labour cost and capture more sales revenue. Greater uncertainty in product markets may be leading more firms to alter the composition of their dynamic labour input adjustments as a strategy or tactic. In the past, firms may have been more willing or able to incur short-run cost increases associated with hoarding labour or carrying larger inventories during a downturn. During upturns, firms may be increasingly less prepared to risk losing sales because of unfilled orders or job vacancies.

3. Labour demand adjustment models: implications for hours and employment flexibility

Conventional demand for labour services functions have established that the presence of fixed costs of employment adjustment may influence the size and speed with which the demand for employment or total employee-hours adjusts to changes in output.[2] One subset of such models demonstrates the effect of fixed labour costs on a firm's static, optimal ratio of hours to employment composition of their total labour input, stressing the influence of employee benefit costs.[3] Dynamic adjustment of labour input models emphasise the effect of the fixed costs of hiring and the training costs of adding new employees, which are assumed to be positive in the (firm- or industry-specific)

[1] Valverde *et al.* (2000). Examples of internal flexibility include cross-training, job-sharing job rotation and flexible scheduling. While important, neither this functional flexibility nor financial (pay) flexibility are within the scope of this paper.

[2] See Kraft, 1997; Smyth and Karlson, 1991; Estevao, 1993; Abraham and Houseman, 1993B. Such studies typically include independent variables such as lagged values of output, employment, relative factor prices (wages), average hours, inventory (unsold finished goods or unfilled orders). However, even the sophisticated production functions and hours demand models that incorporate fixed labour costs often do not sufficiently distinguish between the impact of hiring, benefits or payroll tax costs (e.g., Booth and Schiantarelli, 1987).

[3] E.g., Ehrenberg and Schumann, 1982; Cutler and Madrian, 1998.

skill level requirements of jobs.[1] Models of labour hoarding and overhead labour, suggest firms will rationally delay adjusting employment downwards in response to a cyclical downturn, particularly as labour's specific human capital is greater.[2] If employment falls by proportionally less than a preceding decline in output demand, then hours might be relied upon more to absorb reductions in demand.[3] By implication, such models suggest that when output demand recovers, employers would choose to meet it first through longer hours per worker. Indeed, the models of business-cycle forecasting, which analyse the high frequency, cyclical pattern of employment and hours, presume both that employment tracks output closely and that changes in average work hours correspond to the business cycle but are transitory.[4] Thus, firms may be implementing internal changes that promote either or both a greater degree of NF and WF.[5]

4. The changing degree of labour flexibility: testable hypotheses

A changing degree of NF and WF ought to be detectable when we examine empirically the adjustment behaviour of employment and hours on a dis-aggregated and perhaps aggregate basis. The responses of hours and employment levels to a given shock in output demand may remain similar and/or constant across industries, time periods and stages of the business cycle. This constitutes the null hypothesis, contrasting with the following hypotheses.

1. If more firms in an industry indeed are attempting to become 'flexible firms', adopting a strategy of NF, to gain greater internal flexibility in response to external shocks, complemented by greater WF, this should create larger and quicker (shorter lagged) responses of both employment and hours to given shock.[6]

[1] E.g., Hamermesh, 1995; Fleischman, 1996.

[2] E.g., Costrell, 1982; Raisian, 1983; Gordon, 1993; Perry and Schultze, 1993. Analyses of the low-frequency, secular trend in hours of work also point to the skill content of labour as one of the key mediators reducing or increasing average hours, and the extent to which such changes affect the rate of job creation (Booth and Schiantarelli, 1987; Holm and Kiander, 1993; Bluestone and Rose, 1998; Jacobson and Ohlsson, 2000; Bosch and Lehndorff, 2001).

[3] The adjustment of hours will be more sluggish the greater is the human capital cost of re-scheduling work hours relative to the cost of carrying inventory (Hart and Moutos, 1995) and a higher capital capacity (Haskell *et al.*, 1997).

[4] See Whitely and Wilson (1988). The sensitivity of hours to the business cycle in the US waned in the 1954–1982 period, attributable perhaps to greater macroeconomic stability and rigidity in labour input adjustment (Bernanke and Powell, 1986). The average workweek is becoming less associated with the cycle, and thus a less reliable leading indicator of impending changes in either output or employment (Glosser and Golden, 1997).

[5] Firms in a dynamic, uncertain environment face a tradeoff between twin objectives of static efficiency and flexibility, sacrificing higher average costs if they wish to attain maximum flexibility in labour input and output responses (Mills and Schumann, 1991; Fleischman, 1996). With fluctuating demand, statically inefficient firms can survive in the long run only if they are flexible. Greater uncertainty has reduced manufacturing employment (Price, 1994), in part because labour is more vulnerable to price uncertainty than capital (Appelbaum and Kohli, 1998). By implication, industries where the prevailing labour strategy is using a 'lean' (efficient) but inflexible workforce may therefore exhibit more responsive hours during cyclical upturns, to the extent that the latter entail relatively smaller adjustment costs. Alternatively, if the flexibility strategy is dominant, firms intentionally carry a buffer stock of employees, allowing firms to shed employees and reduce their hours during downturns and expect more overtime hours from employees during upturns (Hart and Malley, 1996).

[6] Greater internal flexibility becomes more prominent when a shock is permanent rather than temporary, since adjustment occurs in the short-run via hours and long run via employment (Haskell *et al.*, 1997).

Alternatively, if firms are choosing to adopt production and staffing strategies that prioritise efficiency over flexibility in output and input, a given fluctuation in output would trigger smaller-sized employment adjustment responses. The magnitude of corresponding changes observed in the hours adjustment response depend on the degree to which employers use hours as a net complementary (or substitute) labour adjustment mechanism.

2. If work hours are being adjusted upwards by employers following expansions in output more than they are adjusted downwards during contractions, then such an asymmetry across stages of the cycle suggest hours are no longer just a transitory adjustment mechanism.
3. If greater uncertainty in a given industry, time period or stage of the cycle manifests itself through longer lags in the employment adjustment process, such lags could be asymmetrically stronger during downturns if layoff responses are delayed more than hiring responses.[1] Again, the corresponding responsiveness of hours would be shorter if employers use hours predominantly as a substitute, more than a complementary labour input.

5. Modelling the empirical dynamic relationship of labour input adjustments to output

This section estimates the dynamic responses of hours and employment to an exogenous shock in output demand. The various literatures imply there is a sequence to the adjustment in labour input variables, represented as a recursive (Wold) system for the observable variables of output demand (Q), hours (H), employment (E) and average wages (W), in equation (1):

$$\Delta Q^{d}_{t} \rightarrow \Delta \varepsilon_{t} \rightarrow \Delta H_{t+k} \rightarrow \Delta E_{t+m} \rightarrow \Delta Q^{s}_{t+n} \quad [0 \leq k \leq m \leq n], \quad (m+n)/2 > k \qquad (1)$$

Employers respond to fluctuation in output demand (Q^{d}) in the concurrent period by varying the pace of work [extrinsic effort intensity (ε_{r}), assuming intrinsic employee effort constant]. After a short lag (k number of months), firms begin adjusting the number of average hours (H), most likely through overtime. After m number of months, firms start hiring or laying off employees (E). These adjustments eventually alter the level of output supplied (Q^{s}).[2] The dynamic relationships between Q, H and E variables (W is not reported) are represented by a four-part VAR equation (2), in the Appendix. Dynamic multiplier analysis assumes *a priori* the causal, recursive ordering of the vector, (Q_{t}, H_{t}, E_{t}, W_{t}), using a Choleski decomposition.[3] Equation (1) is

[1] Note that the same effect, the delayed employment response, may be produced by a strengthening of institutions that protect employment, although this is dubious in the US manufacturing where union density has declined and employment-at-will remains the dominant legal doctrine.

[2] For support for this sequencing order, see DeLeeuw, 1991; Quandt and Rosen, 1989. For an alternative modeling, see Millard *et al.* (1997), who found that all versions underpredicted the actual volatility of employment and the actual length of unemployment following shocks in the UK labour market. The resulting change in output supplied is not estimated here.

[3] VAR estimates one, not separate dynamic adjustment equations for employment, employee-hours or average hours. Estimating a VAR does not require imposing any identifying restrictions. However, once the VAR is estimated, calculating orthogonal impulse responses does require imposing identifying restrictions on the variance-covariance matrix's decomposition. The Choleski decomposition technique is used to impose these restrictions.

estimated using log levels. Thus, taking first differences of the variables or correcting for a trend are not necessary. When data are in levels, the estimated parameters used to construct the impulse response functions will be consistent.[1] This precludes a need to perform tests for unit root or cointegration.

Each VAR is estimated using a lag length (selected using likelihood ratio tests) of 13 months for all four variables. Impulse response functions trace the effect of innovations in output on hours and employment. Estimates of standard errors of the dynamic multipliers are used to construct 95% confidence intervals, to test the significance of an impulse response. Standard errors for the impulse responses are obtained from a Monte-Carlo simulation procedure using 500 random normal drawings from the distribution of estimated VAR coefficients.[2]

6. VAR results: the changing employment and hours responses to an output shock

A structural change occurred in the interrelationship between variations in output, hours and employment across two subperiods in the time series. The impulse responses of employment and hours span two periods, the first from January 1960 to December 1978 (hereafter, the 'pre-1979' period). These are compared with impulse responses conditioned on parameters estimated from January 1979 to December 1995 (the 'post-1979' period). Figure 1 provides visual evidence that the end of 1978 serves as a natural cut-off point for both theoretical economic and empirical reasons. Evidence of a structural break point in the VAR system in 1979 is verified using Lutkepohl's (1989, 1993) test for stationarity.[3] Moreover, the average correlation in log differences of trend values between employment and overtime hours in all the detailed industries, switched from positive (0.16) before to negative (-0.11) after. In addition, the US became more susceptible to exchange rate and oil price shocks, as import penetration and exports surged. Finally, macroeconomic policy from 1979 through the mid-1980s underwent a fundamental shift towards tighter monetary control and consequently, higher real interest rates, disproportionately burdening the manufacturing sector, particularly the interest-sensitive, durables production.

An impulse response (dynamic multiplier) traces the effect of an innovation in one variable on other variables in a VAR system. For each period, the impulse responses of monthly employment and average hours to an orthogonal innovation in output are estimated for total, durable and non-durable manufacturing and then 15 of the total 20 two-digit level SIC manufacturing sectors.[4] The standard errors generated are used to test whether the impulse response is significant in a period, i.e., if the lower bound of the confidence interval exceeds zero. The standard errors are also used to test for

[1] Sims *et al.*, 1990.

[2] This procedure is described in Doan (1992, p. 10.1).

[3] Lutkepohl's *F*-test (see Zellhorst and Hahn, 1995) reveals that parameter estimates for the three aggregates from the 1960-78 period yield poor, high-error forecasts of actual variation observed in the subsequent 1979–82 period, supporting the notion of a structural break in the system in 1979.

[4] Four two-digit SIC industries not analysed—Petroleum/coal (29), Leather (31), Electrical equipment (36), and Instruments (38)—begin too late in the pre-1979 period to yield reliable inter-period comparisons. The US BLS's Establishments' Survey average weekly hours and overtime hours, production worker employment and average weekly earnings, and the Federal Reserve Board's Industrial Production Index are the data sources.

significant differences between the pre- and post-period responses. A difference in means test determines whether the pre-1979 and post-1979 employment and hours responses to output shocks are different significantly. A change is considered significant if any absolute Z value within the first 12 months after an innovation obtains a 10% or less level of significance.[1]

6.1 Manufacturing aggregates

Impulse responses to an output innovation in the pre-1979 and in the post-1979 period are analysed and tested for total (TM), durable (DM), and non-durable (NDM) manufacturing. Because the data are in log form, the responses of employment and hours measured on the vertical axis represent percentage changes to the unit shock in the output measured by the industry index of industrial production.[2] The impulse responses for hours in the manufacturing aggregate for the pre-1979 and post-1979 period and the lower bound of its 95% confidence interval are shown in Figs 2 and 3. With regard to the differences from the earlier to later time period, plots reveal an increase in the magnitude in the response of hours to an innovation in output. In general, the impulse responses show that the largest ('peak') response of hours in both subperiods tends to occur in the initial month immediately following an output innovation, becoming smaller in subsequent months and becoming insignificant after the eighth month.[3] However, the peak response in this first month rises from 0.25 in the pre-period to 0.34 in the post-period; a statistically significant increase over time.

A similar picture emerges in the DM sector. For the immediate period following the shock, the hours response is relatively larger in the post-1979 period, 0.38 versus 0.28 in the initial period, which was also the peak month. No significant difference exists between the responses thereafter, although the full hours response is completed slightly faster in the post-period, occurring after 7 months rather than the 9 months in the pre-period. In the ND sector, the hours response increases as well. Again, the increased size of the peak response is significant and somewhat more concentrated in the periods closer to the initial shock. The change tends to be more prominent in the durables sector, but the significant difference actually persists for a longer period for the non-durables sector.

A profound change occurs from pre- to post-period for the impulse response of employment in TM. Figure 4 shows that the employment response tends to build up gradually, peaking in 8–12 months following the unit shock in output. The response of employment for TM in the pre-period climbed to 0.75 by the 12th month, hardly tapering off thereafter. In the post-period, the impulse response is significantly lower in the first three periods and has a lower peak value of only 0.66. Moreover, the response diminishes to zero after 16 months, whereas the response remains significant

[1] This Z-test statistic is the difference between the post- and pre-period's impulse response divided by the standard error of the difference (the square root of the sum of the impulse response variance for the periods).

[2] Alternative measures of output are discussed, e.g., in Quandt and Rosen, 1989; Kraft, 1989; Gordon, 1993; Abraham and Houseman, 1993A. Substituting shipments as a proxy for output would probably increase the size and/or speed of the hours response estimate (Abraham and Houseman, 1993B). One shortcoming of using shipments is that they are inherently less smooth than the production series when de-trended (Krane, 1994).

[3] The concentrated response of hours in the first period, dissipating thereafter, while the employment response lags and builds up in the 'out' periods is consistent with Estevao's (1993) model and findings.

Fig. 2. *Hours impulse response, pre-1979, aggregate manufacturing, with 2 SE lower bound. Source: US Department of Labor, Bureau of Labor Statistics, Current Employment Statistics series, monthly survey of establishment, for average weekly hours and overtime hours, production and non-supervisory and average weekly earnings. Federal Reserve Board's monthly Industrial Production Index for output.*

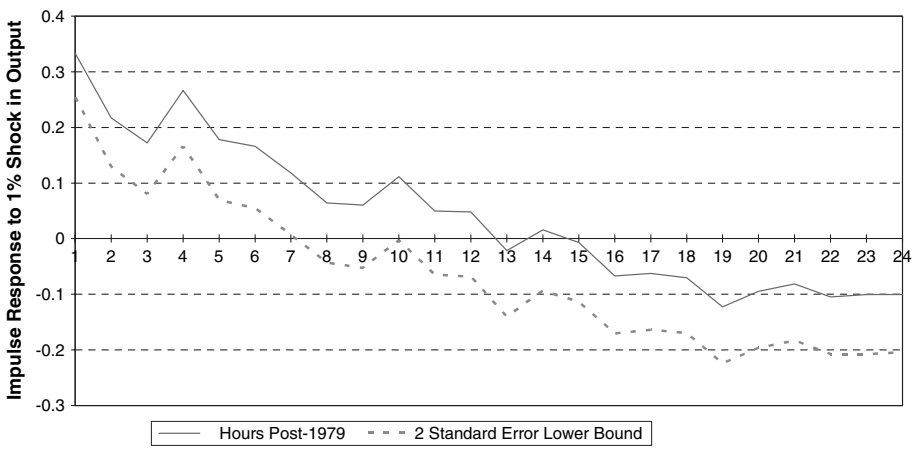

Fig. 3. *Hours impulse response, post-1979, aggregate manufacturing, with 2 SE lower bound. Source: US Department of Labor, Bureau of Labor Statistics, Current Employment Statistics series, monthly survey of establishment, for average weekly hours and overtime hours, production and non-supervisory and average weekly earnings. Federal Reserve Board's monthly Industrial Production Index for output.*

indefinitely in the pre-period. In the durables sector, the response of employment was halved in its intensity in the initial period compared with the pre-period. A unit shock that previously sparked a 0.62 increase up to 1.03 peak response in the eighth month, fell post-1979 to a response of only 0.31 in the initial month up to only 0.63 peak in the eight month. Through the first 2 months, the employment response is significant in the post-period. The non-durables sector is similar, but the declining response of

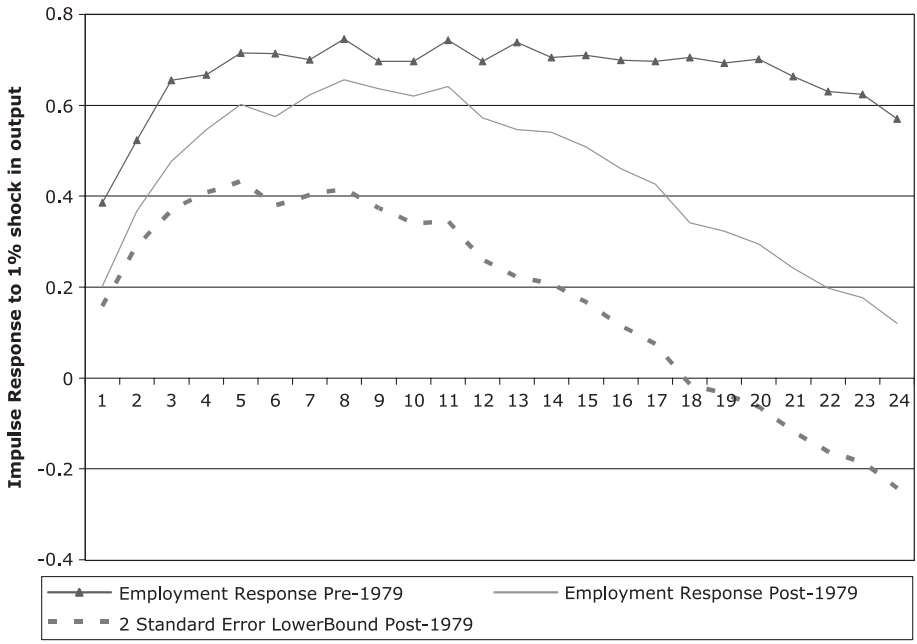

Fig. 4. *Employment impulse response, pre- vs. post-1979, aggregate manufacturing, with lower bound for post-1979.*
Source: US Department of Labor, Bureau of Labor Statistics, Current Employment Statistics series, monthly survey of establishment, for average weekly hours and overtime hours, production and non-supervisory and average weekly earnings. Federal Reserve Board's monthly Industrial Production Index for output.

employment is even more evident. This decline is significant in the first 5 months after the perturbation. However, the employment responses are smaller in magnitude to start with.

6.2 Detailed SIC industries

Analysis of detailed industries reveal which particular industries appear to be driving the observed increase in relative intensity of hours in the manufacturing aggregates, and which deviate from the general trend. Table 1 contains a summary of the results for the 15 detailed SIC industries. In 14 industries, there is either a significant increase in the hours response, a decline in the employment response, or both. A change from pre- to post-period response is judged as significant if at least one period following the shock exhibits a statistically significant standardised difference from the earlier period. Noteworthy are the eight industries that experience a significant decline in the employment response coupled with an increasing response of hours in one or more periods following a shock. These eight are the Food (20), Tobacco (21), Textiles (22), Paper (26), Chemicals (28), Primary Metals (33), Fabricated Metals (34) and Machinery (35) industries. An additional three of 15 industries saw their employment response decrease significantly, without a corresponding rise in the hours response—Furniture (25), Stone/Clay/Glass (32), and Transportation Equipment (37). Another two industries experienced a significant increase in their hours response, with no

Table 1. *Summary of standardised responses of employment and hours, post-1979 vs. pre-1979*

	Employment response ↓ *and* hours response ↑	Employment response ↓ hours response same	Employment response same, hours response ↑	Employment response ↑, hours response ↑	Employment and hours response both same
SIC Industry no.	20, 21, 22, 26, 28, 33, 34, 35 plus all 3 aggregates)	25, 32, 37	23, 24	39	27
Total of $n = 15$	8	3	2	1	1

Data sources: See Figs 1–4. For the list of SIC industry names, see Table 4.

significant change in employment response—Apparel (23) and Lumber (24). In just one industry, Print and Publishing (27), was there no change across both periods in either employment or hours responsiveness. And in just one industry there was a significant increase in the employment response, Miscellaneous (39), but this is coupled with an increase in the hours response as well. Some industries, while demonstrating a shift towards hours adjustment, break with the dominant pattern in the more distant months following a shock. Four industries, (28), (32), (33) and (35), experienced a reduced employment response in the post-period in the months immediately following the output shock, but exhibited a significantly positive employment response in months that lagged far beyond the shock. However, there is no such reversal in their hours responses in these later months. In sum, only two of 15 industries (27) and (39) did not conform to the general pattern of intensifying relative hours response.

Table 2 reports the values for the ratio of the relative responses for manufacturing aggregates and the 15 two-digit SIC industries. It contains the 'relative hours response intensities', a ratio of hours vis-à-vis employment adjustment response, for 8 selected months following a unit shock, in each industry, in the two subperiods. It also reports the number of months out (from a total of 21) for which the impulse response value is statistically significantly different from the pre-1979 period. In TM, prior to the 1979 structural change, in the first month following the output shock, 39% of the adjustment in labour input was in the form of hours adjustment. This rises dramatically to over 62% in the post-1979 period. In durables, the proportion of labour input adjustment made up by hours rises from 31 to 56%. In non-durables, hours adjustment comprised only half the adjustment in total labour input but became two-thirds in the post-period. Thus, the change is proportionately larger in the durables sector, but the hours intensity itself is actually greater in the non-durables sector.

In all but two industries, the share of hours adjustment in total labour input adjustment clearly increases in size after 1979. The ratio of relative impulse responses (in percentage terms) of hours to total labour input, increased significantly in every industry with the sole exception of the six industries where only one response changed significantly; the first month witnessed greater intensity in hours adjustment as a share

Table 2. *The relative hours response, by industry and subperiod*

SIC	Period	Month after shock								No. of months significantly different	
		1	2	3	4	5	6	9	12	employment	hours
Mfg (TM)	Pre	0.392	0.2784	0.2081	0.2479	0.2219	0.1552	0.1222	0.1173		
	Post	0.622	0.3718	0.2653	0.3279	0.2284	0.2238	0.0864	0.0771	3	1
Durable (DM)	Pre	0.31	0.2254	0.1967	0.2261	0.2094	0.1477	0.1113	0.1113		
	Post	0.5546	0.3399	0.2636	0.2832	0.1964	0.2033	0.0939	0.0939	3	1
Non-durable (ND)	Pre	0.5011	0.3011	0.1845	0.2564	0.1951	0.1275	−0.133	−0.43		
	Post	0.6643	0.494	0.3876	0.4504	0.3471	0.3774	0.1186	0.1175	5	3
20	Pre	0.3138	0.1435	0.1564	0.0589	−0.353	−3.441	−1.17	−0.592		
	Post	0.6305	0.6105	3.8907	1.2385	0.4797	−1.393	−0.071	0.2977	6	11
21	Pre	0.7684	−0.0251	0.2173	0.21	0.1374	−0.133	−29.14	−2.859		
	Post	1.107	1.2471	0.9174	1.1377	1.3434	2.9136	4.8153	1.1114	7	8
22	Pre	0.6392	0.5329	0.4376	0.408	0.4002	0.3444	0.1818	0.1053		
	Post	0.713	0.6766	0.5935	0.5336	0.5237	0.3523	0.1745	0.1651	6	2
23	Pre	0.5543	0.1196	0.1307	0.3879	0.3502	0.3204	0.0915	−0.792		
	Post	0.7223	0.5365	0.3366	0.3877	0.2495	0.171	−0.233	−0.139		3
24	Pre	0.5281	0.2909	0.2324	0.237	0.2309	0.2454	0.1508	0.1225		
	Post	0.5867	0.3496	0.2394	0.2899	0.2426	0.1835	0.0983	0.2185		3
25	Pre	0.1265	0.2289	0.2401	0.2188	0.1756	0.1091	0.0516	0.092		
	Post	0.3482	0.3231	0.434	0.796	1.6067	0.5655	−0.194	0.2051	21	
26	Pre	0.3523	0.3587	0.2345	0.2169	0.1298	0.132	−0.35	0.1182		
	Post	0.4413	0.4388	0.4329	0.3925	0.3792	0.3476	0.0619	0.2131	7	10
27	Pre	0.2551	0.3334	0.2731	0.6218	0.4023	0.3394	0.139	0.1531		
	Post	0.5131	−0.6707	−0.495	0.0506	0.1888	0.2714	0.1916	0.2871		
28	Pre	0.2561	0.0653	0.1589	0.2606	0.1966	0.1863	0.0328	−0.086		
	Post	0.5417	0.3294	0.3689	0.3282	0.3006	0.3007	0.1618	0.112	2	4
32	Pre	0.2796	0.3017	0.2563	0.26	0.222	0.1708	−0.174	−0.757		

	Post	0.5268	0.3982	0.2787	0.2448	0.2427	0.2081	0.042	0.1247	2	
33	Pre	0.3124	0.2779	0.2434	0.2369	0.2089	0.1725	−0.1	−0.491		
	Post	0.402	0.353	0.2877	0.2568	0.234	0.2127	0.1078	0.1387	3	10
34	Pre	0.3585	0.2728	0.1498	0.173	0.1661	0.142	0.1549	0.159		
	Post	0.5527	0.4254	0.2433	0.3122	0.2836	0.2479	0.1463	0.1436	4	1
35	Pre	0.2834	0.2757	0.2235	0.2993	0.3039	0.2622	0.1977	0.1491		
	Post	0.6208	0.4254	0.2999	0.2568	0.2145	0.2186	0.1757	0.1181	2	1
37	Pre	0.2074	0.2108	0.1775	0.1478	0.148	0.1257	0.0671	0.1042		
	Post	0.4976	0.3567	0.3479	0.3079	0.2552	0.2269	0.1411	0.077	12	
39	Pre	0.3982	0.5457	0.3656	0.4843	0.2533	0.7306	0.1497	0.2096		
	Post	0.3516	0.2301	0.1121	0.0402	−0.008	0.0659	−0.013	−0.112		

of total labour input adjustment than earlier. Moreover, 3 months on, the ratio remains higher in all but two industries. Six months on it is higher in all but six. A dramatic change has occurred in the composition of the labour input response to a shock in output, becoming more intensive in the form of hours at the expense of employment adjustments (see Table 4).[1] In sharp contrast, two representative cases are Textiles (22), a non-durable, and Primary Metals (33), a durable goods industry. Both have relatively large shares of manufacturing's employment (and industry value-added as a share of total production) but are experiencing the largest drops in the relative share of overall manufacturing employment. Both Textiles and Primary Metals experience declines in employment adjustment and increases in hours adjustment, thus dominating the anomalous responses observed in Printing/Publishing (27) and Miscellaneous Manufacturing (39).

6.3 Asymmetries over the cycle

The type of asymmetry examined here is the dissimilar size of responses to shocks between the expansion and contraction stages. Direct comparisons of expansion against recession periods in the subperiod cannot be conducted because the latter lack sufficient sample size. If there is a significant difference uncovered for impulse responses between the total period and exclusively expansion period, then it is assumed there must be a significant discrepancy between expansions and contractions. Whether the size of this asymmetry remained the same or varied between the subperiods is examined next. In TM, the hours response appears to be somewhat lower in expansionary periods, relative to downturn periods. Moreover, this asymmetric response is more of a post- than pre-period phenomenon (because the asymmetry gap is significant for three of the periods following a shock in the post-1979 period, as opposed to only one in the pre-1979 period). In the durables sector, hours responses in the pre-period were somewhat lower during expansion periods, for up to 10 periods. However, in the post-period, the asymmetry diminishes somewhat, not displaying a significant difference in the period following the shock, nor after the 7th month.

The employment response, however, displays a more vivid contrast across time periods. In TM, the employment response is and remains significantly smaller during expansion relative to contraction periods. Moreover, it appears that in both proportionate and absolute terms, the declining relative size of the employment impulse response during expansions became more pronounced in the post-1979 period (although this is not tested formally). For example, the employment response in the very first period following a shock diminished to only 0.12 in post-period expansions, whereas it fell only to 0.31 in pre-period expansions. The asymmetries for employment responses are most pronounced in the DM industries.

In addition, the magnitude of employment responses during expansion times are considerably smaller in the post-1979 era. Moreover, employment takes a longer lag time to adjust to its peak, in 6 rather than 3 months, during post-period expansions. In

[1] When the VAR system is re-estimated with periods of recession excluded, results are similar. This discounts the possibility that the weakening employment response is an artifact of an asymmetry in the data themselves. The changes observed between the two periods are probably not attributable to either the number or length of business cycle recessions or expansions in the two subperiods within the series. A possibility remains, however, that larger average firm size in the later period or certain industries has reduced the size of the employment adjustment response and increased the hours (see Lever, 1996).

the non-durables sector, there is also evidence of an asymmetric cyclical response of employment, but the relatively smaller employment response during expansion periods is much less pronounced, in both subperiods. The source of the relatively lower responsiveness observed in the non-durables sector apparently lies in expansion periods. Thus, while there are differences in the degree of responsiveness between the durables and non-durables sectors, there appears to be uniformity in the changes in the impulse responses between the two, and much of the change across time appears to take place in expansion periods. The observed reduction in the employment impulse response in the post-period is thus largely due to the changing nature of expansions since the pre-1979 period. Output demand increases tend to create fewer jobs than previously, with the magnitude of this shift particularly large in the durables sector.

Figures 5 and 6 illustrate the change in responses within expansion periods in the durables manufacturing sector. In both the pre- and post-1979 periods, the employment gain following a positive shock was only half as strong during expansion periods. However, the key difference is that expansions in the pre-1979 period exhibit a larger employment increase in the months immediately following the positive output shock. In post-period expansions, hiring responses are much more lagged, taking a year to climb gradually to its peak response. The discrepancy in the hours responses in expansions before and after 1979 is consistent with this change. In post-period expansions, there is a proportionally much greater jump in hours in the very first month following the positive shock to output. This suggests that employers now tend to rely more on longer hours, concentrated in the immediate period following a positive shock, and more slowly respond to shocks via hiring.

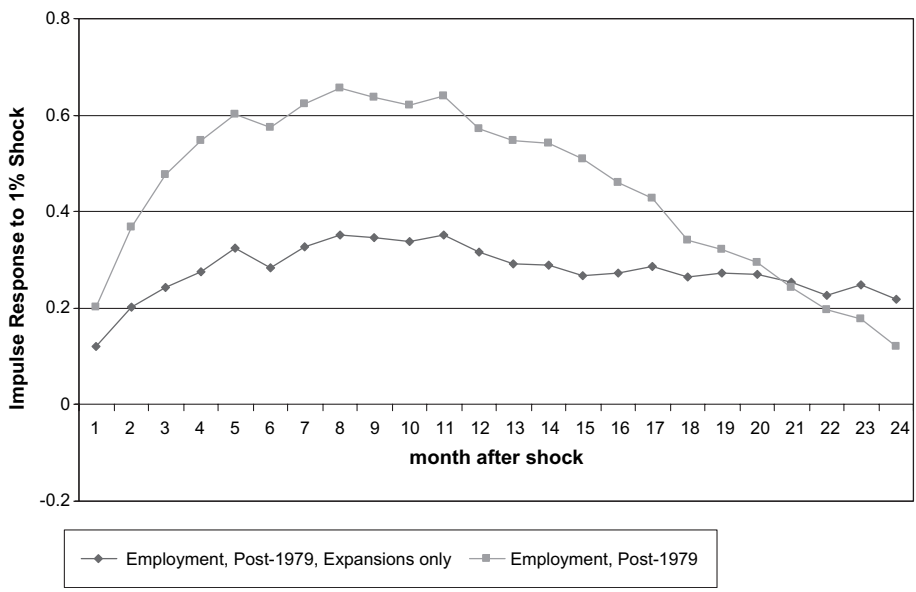

Fig. 5. *Durables manufacturing, asymmetry in the employment response, post-1979. Source: US Department of Labor, Bureau of Labor Statistics, Current Employment Statistics series, monthly survey of establishment, for average weekly hours and overtime hours, production and non-supervisory and average weekly earnings. Federal Reserve Board's monthly Industrial Production Index for output.*

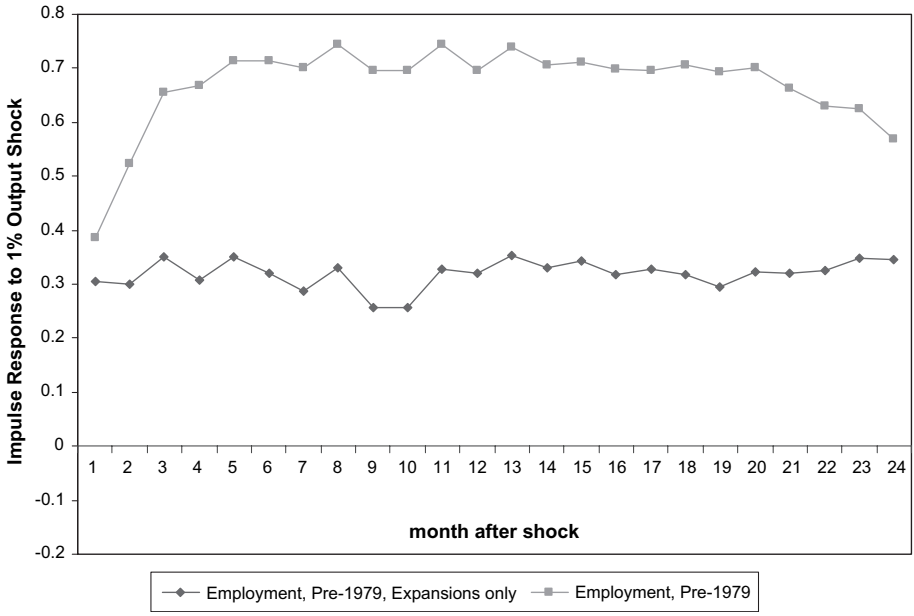

Fig. 6. *Durables manufacturing, asymmetry in the employment response, pre-1979. Source: US Department of Labor, Bureau of Labor Statistics, Current Employment Statistics series, monthly survey of establishment, for average weekly hours and overtime hours, production and non-supervisory and average weekly earnings. Federal Reserve Board's monthly Industrial Production Index for output.*

By detailed industry, a pattern of asymmetry is evident as well, particularly in employment adjustment. The empirical patterns of asymmetric adjustment responses are presented in Table 3. In only three of the 15 detailed industries examined, was there symmetry in adjustment across stages of the cycle, in both the pre- and post-periods. In 10 the 15 total industries, during the post-1979 era the employment response is relatively smaller during periods of expansion. In addition, this asymmetry has become more common, since only seven of the 15 industries exhibited such asymmetry in the earlier, pre-period. Findings are similar although far less noteworthy for hours responses. Six of 15 industries exhibit a relatively smaller hours response in expansions, in the post-period, more than the three industries observed in the pre-period. Not one industry exhibited stronger adjustment responses of employment or hours during expansion periods. Thus, labour input is less responsive in upturns than downturns, particularly employment, and becoming even less so. Food Processing (20) is an example of an industry displaying symmetry in impulse responses over opposing stages of the cycle, for both hours and employment. In contrast, Stone/Clay/Glass (32) exhibits asymmetry, in both hours and employment adjustment. Although the relative intensity of hours adjustment in Food (20) is no greater in the post-period, its hours response during expansions became relatively weaker in the post-period, despite no such differences over cyclical stages in the pre-period. The employment response in Stone/Clay/Glass (32) also displays no asymmetry in the pre-period but a significantly lower response during the post-1979 years. This is a common case where not only did the employment response decline in the post-period, but the

Table 3. *Asymmetric responses of employment and hours, post-1979 vs. pre-1979*

	Employment *and* hours responses weaker in expansions in post-period only	Responses weaker in expansions, hours in post-period and employment in both periods	Employment *and* hours responses weaker in expansions, both periods	Employment and hours responses weaker, pre-period only	Employment response weaker in expansion, hours symmetric	Employment and hours responses symmetirc
SIC #	25, 32, 33, 35	24, 26 (durables)	22, 34	23	24, 28, 37 (non-durables)	20, 21, 39
Total $n = 15$	4	2	2	1	3	3

observed asymmetries in adjustment reveal that the employment response has weakened, particularly following growth in output demand. Such is the case for industries 22, 25, 26, 28, 32, 33, 34, 35 and 37.

In sum, the impulse response estimates yield three main findings.

1. Out of 15 total two-digit SIC industries with available data, all but one exhibited either a significant decline in the employment response or increase in the hours response since 1979, with Printing and Publishing (27) being the lone exception. Eight industries (SIC 20, 21, 22, 26, 28, 33, 34 and 35) experienced *both* a significant decline in employment and rise in hours adjustment since the earlier time period. Only one industry underwent an increase in employment flexibility, although another four experienced this additional flexibility eventually after first undergoing significant reduction in employment flexibility.[1]
2. The relative hours response intensity, the share of hours in total labour input adjustment in the period following an output demand shock, has increased greatly in magnitude in the post-1979 period, rising in 13 of 15 industries. Thus, there is solid evidence that hours flexibility has increased somewhat whereas employment flexibility is abating in manufacturing employers' immediate responses to temporary shocks in demand.
3. Asymmetries exist at the opposing stages of the business cycle. Employment, and to an extent hours, adjust relatively less during expansions than in contractions. In addition, the asymmetry appears to be growing for employment since 1979. In particular, durables industries now exhibit more rapid adjustment in hours and more delayed responses of employment, during expansions.

[1] Miscellaneous manufacturing (39) as the exceptional case is not overly emphasised. Table 4 shows that it accounts for the lowest share of employment of all two-digit industries in both the pre- and post-1979 periods (around 2%), with the exception of Tobacco (21), and lowest share of value added in 1991 (1.5%). Moreover, miscellaneous manufacturing is a hotchpotch of industries producing a wide variety of output such as advertising signs, pens and pencils, toys and costume jewellery, unclassifiable elsewhere.

Table 4. *Relative importance of each SIC industry, in manufacturing employment and output*

		Industry employment % share of total employment		Industry value added as % share of industrial production	
SIC No.	Industry name	1977	1987	1977	1987
20	Food	8.9	8.8	8.0	8.8
21	Tobacco	0.6	0.3	0.6	1.0
22	Textiles	6.3	4.9	2.3	1.9
23	Apparel	8.5	7.2	2.8	2.3
24	Lumber	4.5	4.5	2.3	2.1
25	Furniture	2.5	2.9	1.3	1.5
26	Paper	3.7	3.9	3.1	3.6
27	Printing	4.6	6.0	4.5	6.5
28	Chemicals	4.2	4.5	8.1	8.9
29	Petroleum	1.0	0.9	2.4	1.3
30	Rubber	3.1	4.9	2.8	3.2
31	Leather	2.1	1.1	0.5	0.3
32	Stone/clay/glass	3.6	3.3	2.7	2.4
33	Primary metals	7.2	4.9	5.3	3.3
34	Fabricated metals	8.0	8.1	6.5	5.4
35	Machinery	9.0	10.0	9.5	8.5
36	Electric machinery			7.2	6.9
37	Transportation equip	9.3	9.2	9.1	9.3
38	Instruments			2.7	5.1
39	Miscellaneous mfg	2.4	2.1	1.5	1.3

7. Implications for investigating causes behind the rising intensity of hours adjustment

The results provide useful signposts to direct future empirical research on labour market flexibility. The impulse response magnitudes and asymmetries suggest that a leading candidate for the underlying cause of the observed changes is the upgrading of jobs' skill requirements. Escalating hiring and training costs borne by employers associated with skill upgrading and technological advances would tend to make employers generally more reluctant to hire *and* to fire.[1] Skill upgrading that raises employers' fixed employment costs would weaken and delay the employment adjustment response to a given shock to output demand, in either direction of the cycle. This in turn may both heighten and shorten the lag in hours adjustment responses to a shock.[2] Thus, the relative size of the hours response vis-à-vis employment should be greater in time periods and industries with rising hiring and employer-financed training costs. In addition, there is no reason to observe any asymmetries in the direction or magnitude of these adjustments during opposing

[1] Skill levels (proxies) are generally acknowledged to be rising in the US (e.g., Howell and Wolff, 1992; Sachs and Schatz, 1993; Bernard and Jensen, 1997, van Reenen, 1997; Bartel and Sicherman, 1999) and in the UK (e.g., Machin, 1994). Flexible specialisation and other work reorganisation innovations have raised skill requirements and the importance of numerical flexibility (see Capelli, 1993).

[2] Hours in durable and non-durable manufacturing panel data are acyclical, but procyclical for 'higher quality' (college educated) workers (Keane and Prasad, 1993).

stages of the business cycle should the source of the change be hiring and training costs being borne by firms.[1]

The impetus behind increasing employer concern over their fixed labour costs may have stemmed from the intensifying international competition. In the early-1980s, US manufacturers had to contend with the sustained effects of a relative stronger dollar and more contestable, global markets. Many manufacturing firms may have focused their energies on labour cost restraint, by redesigning the structure of production or reducing internal, X–inefficiencies (mounting costs traced to an absence of effective competition in the market for their products). If firms switched strategically towards efficiency, even at the expense of flexibility, industries would exhibit both a decline in their employment response and an absolute decline in their employment level. This can be viewed indirectly through the industry's employment as a share of total manufacturing employment, at selected dates in the pre- and post-periods. Table 4 compares 1977 and 1987. Six of the eleven detailed industries experiencing a decline in employment responsiveness indeed underwent a decline in their employment level relative to other industries in the manufacturing sector (20, 21, 22, 32, 33, 37). However, five industries (25, 26, 28, 34 and 35) saw their employment share rise.[2]

8. Summary and implications for policy

This paper applies VAR analysis as one way of illustrating the degree of flexibility to which labour input responds to variation in output. The key finding is that in the last two decades in the US, the proportional response of employment to changes in output has decreased considerably relative to the response of hours than it did in the prior two decades. The response of hours to a given shock in output relative to the response of employment rose in the period since 1979 in all but two of the 15 industries in our sample. In 11 industries, the standardised employment response either declined or remained the same, while in 10 industries the hours response increased or remained the same. Thus, the relative importance of hours adjustment in total labour input adjustment increased. In addition, the lag time of the employment response has

[1] The other source of higher fixed labour costs, i.e., employee benefits expenses, would also diminish and delay the employment response, at least during expansion phases of the cycle. However, during contraction periods, growing benefit expenses would actually magnify and hasten the employment (layoff) adjustment response. Moreover, higher benefit costs would increase and hasten hours adjustment during expansions and stultify and delay it during contractions. Thus, greater benefit costs in a period or industry would produce an asymmetrical enhancement of the size of the relative hours response during expansion phases and a diminution during contraction periods. They suppress the employment response in expansions *only* and have the opposite effect during contractions, and should heighten the hours response during expansions but stifle the hours response during contractions. The results thus point more to hiring and training than to benefit expenses as the potential source of the intensification of hours adjustment. A role also may also be attributable to institutional changes. For example, six of the eight industries experiencing de-unionisation in the 1983-88 period (Food, Tobacco, Apparel, Lumber, Stone/Clay/Glass, Primary and Fabricated Metals, and Miscellaneous Manufacturing) also had an intensified relative use of hours adjustment.

[2] The growing intensity of trade may play an added role. Trade imbalances heighten the elasticity of labour demand for non-production more than production workers (Slaughter, 1997). Differing employment responses to trade pressures are shown by the non-uniform responses of industry employment levels to exchange rate shocks (Burgess and Knetter, 1998). The US *Annual Survey of Manufacturers* for 1991 and 1978 contain both the imports to shipments and exports to shipments ratios for all 15 of the detailed industries. The bigger increases between 1978 and 1991 occurred in the same industries exhibiting the largest significant declines in the size of their employment responses.

lengthened, while the hours response has become even more concentrated immediately following shocks. Moreover, asymmetric effects over stages of the business cycle display a diminishing size of the employment response during cyclical expansion periods. The dissimilar behaviour over time periods corroborate and extend into the 1990s the findings of Hamermesh (1993). They challenge labour demand studies claiming that (overtime) hours adjust similarly over time, are synchronized across industries or fluctuate cyclically around a stationary trend equilibrium. Rather, a substitution within labour utilisation strategies appears to be occurring, increasingly favoring worktime over employment flexibility, rather than an increase in external, numerical flexibility (among regular workers) in general.

The results suggest that the US economy will tend to respond more slowly to economic rebounds than they did in the past, where gains in average weekly hours more slowly translate into employment gains. Indeed, this happened in the anomalous 'jobless recovery' or productivity-led recovery experienced by the US from the early to mid-1990s.[1] The findings also suggest layoffs may be increasingly buffered at early stages of a downturn by reductions in overtime hours, as has been occurring in 2000–01. Another implication is that the 'flexible firm' is not evident in the aggregate US manufacturing sector, indeed labour input has become, on balance, less responsive, although working hours adjustment has increased in many industries. The findings also imply that the causes behind the reduced role of employment in labour input adjustment include structural developments external to firms, not just the organizational, internal decisions of firms.[2] The changing pattern and asymmetries in hours and employment adjustment suggest that one of these structural developments is skill upgrading of many manufacturing jobs that require more employer-financed training or firm-specific knowledge. This in turn suggests that public policies that defray the growing expenses associated with hiring and training employees would avoid future 'jobless recoveries', facilitate more robust job creation during expansions and stabilise volatility in hours.

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[1] See Perry and Schultze (1993) and Gordon (1993) for the former and Moore (1995) for the latter.
[2] Haskell *et al.* (1997).

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Appendix

The ordering used in the Choleski decomposition of the system described in equation (1A), below, is the same justified by the recursive ordering in equation (1).

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_{13} y_{t-13} + u_t \qquad \text{(A1)}$$

where y_t is (4×1), $y'_t = (Q_t, H_t, E_t, W_t)$, Φ_i is a (4×4) matrix $[i = 1, 2, \ldots 13]$, and $u_t \sim$ i.i.d. $N(0, \sigma_u{}^2)$.