An Analysis of International Linkages in Strike Activity

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The international pattern of strike activity has been a source of interest to both policy makers and researchers. The worldwide decline in strike activity over the last decade or two has prompted researchers to explore, among other things, the extent to which international changes in strike activity have been mirrored locally. While different researchers have taken different views on the importance of international influences on local activity, little has been done to explore the individual linkages between countries within a VAR (vector autoregression) framework. This article attempts this.

We address the issue of interdependence in quarterly strike activity for eight OECD countries (Australia, USA, UK, NZ, France, Japan, Italy and Canada) by firstly reporting simple correlation coefficients for strike rate variables for the period 1960-98. We note the preponderance of positive correlation coefficients between the various countries.

Second, we test for bivariate Granger-causality, finding a considerable degree of interdependence – though these findings may be affected by the assumptions made about lag lengths (a not uncommon finding associated with this methodology).

Thirdly, and perhaps most importantly, we examine the cointegration characteristics of an 8-country (8-variable) VAR system using the Johansen approach for identifying the number of cointegrating equations (vectors) amongst the variables in the system. The results of this exercise suggest the presence of a small number of cointegrating vectors within the system. This in turn suggests that the system has a tendency to 'wander' from some potential steady

state equilibrium value. However, it is found that when global labour-market 'agitation factors' (the estimated OECD unemployment rate and nominal GDP growth rate) are included in the system, a greater degree of relationship binding is in evidence. This finding is consistent with a view that global labour-market agitation factors are a major driving force in explaining 'global' patterns of strike activity.

Next, we employ a generalised impulse response analysis to gauge the expected effect on 'global' strike activity of changes is the labour-market agitation factors. Finally, some concluding thoughts are proffered.

1. INTRODUCTION

This article explores international linkages in strike activity. It attempts to measure the extent of interdependence in strike activity among eight OECD economies, namely Australia, New Zealand, the USA, Canada, the UK, France, Italy and Japan. It also attempts to gauge the influence of global labour-market 'agitators' on strike activity. These agitators, proxied by *nominal* OECD big-seven GDP growth and the average OECD big-seven unemployment rate, are analysed to see the extent to which they influence strike activity worldwide.

The issue of the extent to which strike activity is an international phenomenon is, arguably, of interest to policy makers. This is because evidence that suggests international influences drive domestic strike activity implies a limited capacity for domestic policy makers to influence local outcomes.

The remaining sections of this article are structured as follows. In section 2 we review the research literature on the role of international influences on strike activity. In section 3 we identify our intended point of departure from earlier research and introduce some preliminary tests of interdependence – namely cross correlation analysis and Granger-causality analysis. In section 4 we test for evidence of cointegration between worldwide strike activity variables and two 'global agitation' indices, while in section 5 we apply a

generalised impulse response analysis to the model developed in section 4. Finally, some concluding thoughts are offered in section 6.

2. LITERATURE REVIEW

The study of economic and other determinants of strike activity has a considerable history. Many Australian studies have been at the forefront of this endeavour. Studies by Oxnam (1953, 1975) and Bentley and Hughes (1971) emphasised the impact of domestic economic influences, in particular the state of the labour market as reflected in the unemployment rate or some similar business-cycle proxies, as a determinant of strike activity. Subsequent studies by, for example, Phipps (1977) and Perry (1980) drew attention to the roles of inflation and wage indexation, as well as other influences, on strike activity. With the introduction of the Accord between the union movement and the Labor government as a foundation for industrial relations management, research was subsequently directed towards the effect of the Accord on strike activity. The work of Beggs and Chapman (1987a, b, c) and Chapman and Gruen (1991) initiated this round of research, which was subsequently followed up by Morris and Wilson (1994, 1995, 1999, 2000) and Perry and Wilson (2001).

Attempts to specifically measure the influence of international forces on strike activity were first made in Beggs and Chapman (1987a, c) and updated in Chapman and Gruen (1991). These studies proved to be influential, and arguably set the direction of applied research on strike activity for the subsequent decade or more. Their results suggested that apparent local determinants of strike activity dominated international influences. Given the influential role that these studies had on subsequent research and economic policy deliberations, it is appropriate to review them in some detail.

We commence with Beggs and Chapman (1987a). This study looks at the relationship between Australian strike activity and strike activity in twelve (at times thirteen) other OECD countries. Though their chart of aggregate OECD strike activity shows some suggestive similarities to Australian strike activity (see p. 143), they instead emphasise the

apparent impact of the Accord in reducing strike activity more dramatically in Australia than elsewhere. They then estimate an *Australian* annual strike activity equation with the following explanatory variables: inflation, the unemployment rate, a time dummy and a dummy shift variable for the period (1983-85) of the Accord between the Australian government and the Australian Council of Trade Unions. The estimated coefficients attached to the explanatory variables for the Australian equation are then applied to twelve OECD countries. In other words, the Australian coefficients for inflation, the unemployment rate and a time dummy (but not the Accord dummy) are applied to the other OECD countries. They argue that '... the method is to estimate an Australian strike equation and use it to predict other countries' disputation on the basis of the latter's macroeconomic experience. If predicted strike activity exceeds that actually experienced, this suggests that imposing the Australian industrial relations environment would have increased industrial disputation in the country concerned, the opposite being the case if predicted outcomes are less than actual' (p. 144).

They find that '... by this test the Australian Industrial relations environment delivers lower strike activity than the other (mainly) English-speaking countries, the USA, the UK, Canada and Ireland and the two Southern European Countries (Italy and Spain). Greater strike activity is predicted in the Northern European countries and Japan' (pp. 145-146).

The methodology employed in this study is interesting and adventurous. However, there is no attempt to look at linkages or inter-relationships between strike activity in various countries. This is more directly tackled in another later paper - Beggs and Chapman (1987c).

A slightly later study by Beggs and Chapman (1987c) attempts to address the issue of the role of international influences on local (Australian) strike activity in a somewhat more direct fashion than the previous study discussed. Thus it sets out to test, among other things, the proposition that '... there is a transmission of industrial restiveness between countries (p. 330)'. To test this, the study analyses data for Australia, the USA, the UK and Canada. It models annual strike activity for each of the four countries as a function of inflation,

unemployment, time and an Accord dummy. The Accord dummy variable (for 1983-85) is significant only for Australia. Beggs and Chapman (1987c) observe that:

> 'The 'international phenomenon' perspective implies that levels of disputes are *determined by political and sociological factors which are transmitted among countries by the media.* These unmeasured determinants of strike activity, if they exist, will be manifested in the disturbance terms of the regression model. The proposition that these factors move collectively internationally can be tested through an investigation of the extent of cross-country correlations among individual country regression disturbances over the entire 1964-1985 period (pp. 334-335, italics added)'.

They find next to no evidence of cross-country correlation in the residuals of their strike activity equations for their four countries. They thus conclude that:

> 'The results are unambiguous: in an international context the Australian diminution of strike activities after the beginning of the Accord was most unusual, and there is no evidence of a general worldwide transmission of industrial disputation (p. 330)'.

Two criticisms can be levelled against the methodology employed in Beggs and Chapman (1987c). First, confining international interdependence to a test of the similarities in the (white-noise?) 'pattern' of the residuals of the various equations, locks out of the analysis the international transmission of information generated by worldwide comparable experiences of inflation and unemployment. During the 1970s and early 1980s unemployment and inflation simultaneously rose for most OECD economies. It can be argued that these worldwide changes in inflation and unemployment were, in turn, themselves largely generated by a nexus of interdependent worldwide forces. The worldwide changes in inflation and unemployment affected, in one way or another, worldwide strike activity. The focus

on *'political and sociological factors transmitted through the media'* is, arguably, too restricting. A methodology that presumes the effect of unemployment and inflation on strike activity is of a uniquely domestic origin, understates the international influences at play in the generation of domestic strike activity.

A second criticism of the methodology employed in Beggs and Chapmans (1987c) is that, even if we accept for the sake of argument the notion that each country can independently determine its own inflation and unemployment rate, other perceived individual causal factors (such as union density, profit proxies and so forth) as well as more complicated lag structures associated with the relation between strike activity and various explanatory variables, may be of importance. In other words, the individual country equations may be mis-specified. Given that the quarterly model of strike activity developed by Beggs and Chapman (1987b) has a considerably larger number of explanatory variables than the annual-data based models of Beggs and Chapman (1987a, c) and Chapman and Gruen (1991), it can be argued that there is some degree of inconsistency in the various studies.

Finally we review Chapman and Gruen (1991). This study more or less updates the Beggs and Chapman (1987a, c) studies. It tests strike activity as a function of inflation, the unemployment rate, time and a dummy variable for the Accord period of 1983-87. They use Zellner's seemingly unrelated regression method to assess the effects of inflation and the unemployment rate on strike activity for all thirteen OECD countries in the study. They find, among other things, that:

> '... differently to Beggs and Chapman (1987c) result for 1964-85, where it was apparently the case that the Australian experience after 1982 was unique, there is now evidence that decreases in strike activity are a worldwide phenomenon for the 1983-87 period, as has been argued by some critics. But while the fall for the rest of the world is about 40 per cent, the Australian diminution in strike activity, at around 70 per cent, is clearly much greater than this' (p. 477-8).

These findings suggest that, by extending the period of the study, the underlying influence of worldwide factors has found expression. However, it can be further argued that the extent of international interdependence is still understated by this methodology. This is because of the focus on the period of the Accord and the implicit downgrading of other periods when interdependence was present.

3. A POINT OF DEPARTURE AND SOME PRELIMINARY TESTS

The methodology employed in this study of international strike activity departs from the methodology employed in the studies discussed in the previous section of this article. First, in this study we do not confine our interdependence to an individual country's strike activity *not* explained by variations in unemployment and inflation. Instead, we allow for the possibility that international forces affect individual countries' experience of unemployment and inflation. Second, we do not confine our study of interdependence to (say) the period of the Accord. Instead, we allow for the possibility of interdependence throughout the period (1960-1998) of the study. Third, we explore measures of interdependence in strike activity using a range of techniques developed for that purpose, including simple cross correlation analysis, Granger bivariate causality analysis, and cointegration tests within a VAR (vector autoregression) framework. And finally, we explore the possibility that a set of 'prime movers' or 'drivers' have been important factors influencing strike activity for the countries studied

The Data

We look at international interdependence for eight OECD economies for which quarterly data on strike activity are available. These countries are The USA, Japan, France, Italy, the UK, Canada, Australia and New Zealand. We did not include countries for which quarterly data was unavailable for the entire period of the study.

The strike activity variable chosen is the natural log of the number of working days lost due to stoppages per 10 000 employees. Refer to Table 2 for the algebraic symbols employed for the log of strike activity for each of the eight countries examined. One modification is made to the raw data. That modification is made to USA data, which is adjusted, to allow for the major change that occurred in the collection of USA strikes data in 1982. As from the first quarter 1982 the definition of strike activity in the USA changed from work stoppages involving six workers to work stoppages involving 1000 workers. This effectively meant the number of reported working days lost due to stoppages fell by an estimated 38 per cent from 1982 onwards. Based on the ratio of the average value of the old-definition data to the new-definition data for the five years immediately preceding the year (1982) when the new definition took over from the old definition, we magnified the data for the later period so as to give an estimated or synthetic series somewhat more harmonised with the original series in place prior to the change in definition[1].

Correlation and Granger Causality Analysis

Table 1a: International Strike Activity – Correlations Between Countries

	LAU	LCA	LFR	LIT	LJA	LNZ	LUK	LUS
LAU	1	0.664705	0.361096	0.541023	0.405347	0.506866	0.633863	0.551049
LCA		1	0.279921	0.423995	0.318704	0.372715	0.491195	0.54897
LFR			1	0.608816	0.651669	0.354949	0.491181	0.473532
LIT				1	0.650263	0.452666	0.623428	0.579018
LJA					1	0.192515	0.441635	0.65104
LNZ						1	0.562802	0.276154
LUK							1	0.580354
LUS								1

** 'L' refers to 'log'. Thus LUS refers to the natural log of working days lost due to strikes per 10 000 workers in the USA etc. See Table 3 for full explanation of symbols.*

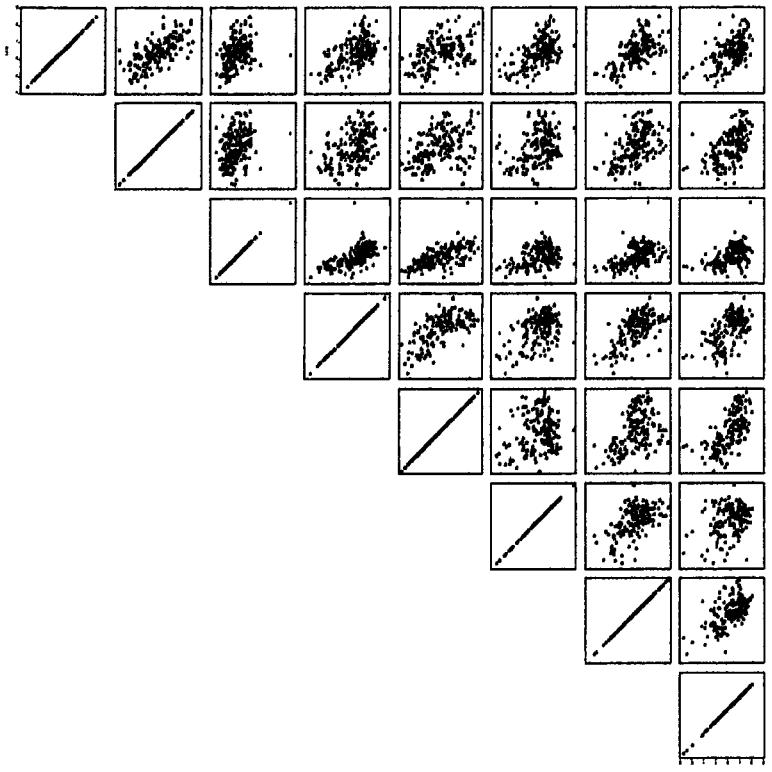
To provide preliminary information of possible interlinkages in world strike activity, we undertake conventional correlation and Granger-causality analyses. Table 1a shows that correlation coefficients range from a low of 0.19 between New Zealand and Japan to a high of 0.66 between Australia and Canada. In fact Australia had relatively high correlations with all countries in the system. Note that the correlation matrix measures the cross correlations for the *natural log* of strikes (as defined). The correlations are not as strongly positive when the raw data are employed.

Table 1b: Significance of the Correlation Coefficients

	LAU	LCA	LFR	LIT	LJA	LNZ	LUK	LUS
LAU		10.89664	4.742489	7.878821	5.430623	7.197607	10.03716	8.087673
LCA			3.571076	5.733751	4.118047	4.919267	6.906479	8.043964
LFR				9.399146	10.52242	4.650006	6.906222	6.584595
LIT					10.48305	6.217472	9.765424	8.697851
LJA						2.402768	6.028678	10.50478
LNZ							8.338928	3.519018
LUK								8.728099
LUS								

Significance at the 5% level = 1.96

Figure 1: Scatter Matrix*



* *Note, the order of the countries is the same as for the correlation table – Table 1*

Table 1b shows that all correlations were significant at the 5 per cent level. The scatter matrix diagrams in Figure 1 present a visual impression of the interlinkages that appear to exist in international strike activity. The spike in strike activity caused by the student unrest in France in 1968 is clearly visible in row three of the 'scatmat'[2].

Table 2: Granger Causality Tests

Null Hypothesis:	F-Statistic	Probability
LCA does not Granger Cause LAU	2.84	0.03
LAU does not Granger Cause LCA	2.58	0.04
LFR does not Granger Cause LAU	2.43	0.05
LIT does not Granger Cause LAU	2.46	0.05
LAU does not Granger Cause LNZ	4.48	0.00
LUK does not Granger Cause LAU	3.14	0.02
LAU does not Granger Cause LUK	2.83	0.03
LUS does not Granger Cause LAU	3.12	0.02
LFR does not Granger Cause LCA	3.73	0.01
LCA does not Granger Cause LIT	2.40	0.05
LJA does not Granger Cause LCA	4.14	0.00
LCA does not Granger Cause LNZ	3.57	0.01
LUK does not Granger Cause LCA	3.27	0.01
LUS does not Granger Cause LCA	3.06	0.02
LIT does not Granger Cause LFR	6.58	0.00
LJA does not Granger Cause LFR	9.77	0.00
LNZ does not Granger Cause LFR	2.65	0.04
LFR does not Granger Cause LNZ	3.59	0.01
LFR does not Granger Cause LUK	2.48	0.05
LUS does not Granger Cause LFR	3.98	0.00
LFR does not Granger Cause LUS	4.05	0.00
LJA does not Granger Cause LIT	10.52	0.00
LNZ does not Granger Cause LIT	2.63	0.04
LIT does not Granger Cause LNZ	4.77	0.00
LIT does not Granger Cause LUK	2.73	0.03
LUS does not Granger Cause LIT	4.29	0.00
LIT does not Granger Cause LUS	5.27	0.00
LJA does not Granger Cause LNZ	3.41	0.01
LJA does not Granger Cause LUK	2.50	0.05
LJA does not Granger Cause LUS	6.90	0.00
LUK does not Granger Cause LNZ	5.05	0.00
LUS does not Granger Cause LNZ	4.80	0.00
LUS does not Granger Cause LUK	3.36	0.01

See Table 3 for the meaning of symbols.

Correlation analyses and scatter diagrams, of course, provide only limited support of possible international linkages. A Granger Causality test, on the other hand, provides evidence (or lack of it) for information flows between variables. Table 2 shows the outcome from a conventional Granger causality test between all countries. The lag used is an important consideration since this determines how much past information appears to be important in determining information flows between variables. For reasons explained later (see footnote 6) we use four lags and, from an intuitive point of view, it would appear reasonable to believe that twelve months is a 'fair' period over which past information on strike activity is likely to play a part in current strike activity. To contain the size of the table we have only included those results that show significant Granger causality (information flow) at the 5 per cent level. It is clear from Table 2 that, while no one country is linked to all other countries in terms of Granger causality, all countries do enter the system as being linked to one or more other countries – a clearly important outcome.

4. CO-INTEGRATION EVIDENCE

Table 3: Unit Root Tests on Log of Original Series

Country	Symbol*	Levels	Differences
US	LUS	-3.18	-7.72
Australia	LAU	-1.53	-7.31
New Zealand	LNZ	-1.50	-9.02
Canada	LCA	-3.06	-7.34
Japan	LJA	-3.11	-6.65
UK	LUK	-2.21	-8.10
France	LFR	-3.22	-7.08
Italy	LIT	-3.39	-8.03
'Global' Nominal GDP Growth	YWA	-2.41	-8.61
'Global' Unemployment rate	UW	-2.24	-4.55
Critical Values		**Levels**	**Differences**
1% Critical Value		-4.02	-2.58
5% Critical Value		-3.44	-1.94
10% Critical Value		-3.14	-1.61

* *'L' refers to 'log'. Thus LUS refers to the natural log of working days lost due to strikes per 10 000 workers in the USA etc.*

Given the correlation and Granger-causality evidence of interdependence in strike activity, a next step is to test for evidence of cointegration[3]. Initially we examine the stationarity properties of the strike activity series. Table 3 indicates that each of the series is I(1), i.e. each of the series is non-stationary in log-levels, but stationary in terms of first differences. Note also the tests on the stationarity of nominal GDP and unemployment; these variables will be discussed in more detail later in the article.

Given the evidence of Granger causality in table 3, a standard Johansen (1991, 1995) cointegration test can be conducted. The general autoregressive representation for the vector Y, which contains v variables (series), all of which are I(1)[4], can be expressed as:

$$Y_t = c + \sum_{i=1}^{k} \pi_i Y_{t-i} + \varepsilon_i \qquad (1)$$

where c is a constant term and π is a v x v matrix of parameters. The maximum lag of the system, k, is chosen so as to ensure that the residuals, ε, are white noise. This vector autoregression system may also be re-arranged to yield an error correction model (ECM) representation:

$$\Delta Y_t = c + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-k} + \varepsilon_i \qquad (2)$$

with $\Gamma_j = -(I - \sum_{i=1}^{j} \pi_i)$ and $\Pi = -(I - \sum_{i=1}^{k} \pi_i)$

where I is the identity matrix, Π is known as the long-run matrix while Γ provides short-run dynamics. Since the variables ΔY_t and ΔY_{t-1} are I(0), while the Y_{t-k} variables are I(1), the system has the same degree of integration on both sides of the equality only if: (i) $\Pi=0$, in which case

the Y variables are not cointegrated as there is no long-run equilibrium relationship between them; or (ii) if the parameters of Π are such that ΠY_{t-k} is also I(0). This latter case applies when the Y variables are cointegrated and, in turn, implies that the rank, r, of the matrix Π *should* be less than the number of variables, v, in the vector Y (i.e. the matrix Π should not be full rank, $0<r<v$). The rank r is also known as the order of cointegration and is equal to the number of distinct cointegration vectors (cointegrating equations) linking the variables in Y. In fact, in a VAR model with v variables there can at most be $r = v-1$ cointegrating vectors. If $0<r<v$ then Π has rank deficiency and can be decomposed as $\Pi=\alpha\beta'$, where α and β are $(v \times r)$ parameter matrices. The matrix β contains the r cointegrating relations, with matrix α containing parameters measuring the speed of adjustment from long-run equilibrium.

The cointegrating rank is also important in identifying the number of stochastic processes that exist within the cointegrating system. Stock and Watson (1988) illustrate that cointegrated variables share common stochastic trends and if the cointegrating rank of a system is $r = v-1$, then there is a single common trend (i.e. $v - r = 1$) driving all v series[5]. In economic terms, the existence of such a single common trend would imply that individual country strategies on (say) the management of strike activity (for instance the policy of the Accord in Australia) are limited in their outcome over the long-run as each series (country) would not follow divergent strike activity paths. Conversely, the larger the number of stochastic processes within the system (i.e. the smaller the number of cointegrating vectors) the greater the opportunity for tailored strategies by individual countries to reduce strike activity in the long run.

Viewed another way, Dickey, Jansen and Thornton (1991) point out that cointegrating vectors can be thought of as representing constraints that an economic system imposes on the movements of variables within the system over the long run. In essence, the more cointegrating vectors there are, so the more 'stable' the system, i.e. the less it can wander from its steady-state equilibrium value. So, for instance, if there is one common trend and $v-1$ cointegrating vectors then the $v-1$ variables must be solved for in terms of the v^{th} variable. There is only

one direction in which the system can wander (i.e. there is only one direction in which the variance is infinite). By way of contrast, if there is only one cointegrating vector, then the v^{th} variable must be solved for in terms of the other v-1 variables and hence there are v-1 independent directions in which the system can wonder – it is stable in only one direction. So, the fewer the number of cointegrating vectors, the less constrained is the long-run relationship and the more directions in which the system can wander from its steady state equilibrium value.

Table 4: Johansen Trace Tests

	All countries		*All countries + agitation indices*	
r	λ_{Trace}	*5% critical value*	λ_{Trace}	*5% critical value*
$r=0$	211.05	156.0	336.57	233.13
$r\leq1$	155.12	124.2	265.37	192.89
$r\leq2$	105.39	94.2	202.49	156.00
$r\leq3$	67.90	68.5	147.63	124.24
$r\leq4$	38.52	47.2	107.75	94.15
$r\leq5$	19.94	29.7	74.93	68.52
$r\leq6$	8.21	15.4	49.47	47.21
$r\leq7$	0.11	3.8	28.91	29.68
$r\leq8$			9.55	15.41
$r\leq9$			1.86	3.76

Starting with the strike activity of the set of eight countries, the first three columns in Table 4 show the number of cointegrating equations present within the system (before the introduction of selected global agitation indices to be discussed below). Trace test statistics are presented, along with the 5 per cent critical values for the rejection of the null hypothesis of there being r or less cointegrating equations. The trace statistics are calculated as:

$$\lambda_{Trace}\ (r) = -T \sum_{i=r+1}^{n} \log(1 - \lambda_i) \tag{3}$$

where λ_i is the i^{th} largest eigenvalue. The lag length of the Johansen procedure was determined by the Schwarz Information Criterion (SIC) on the undifferenced VAR (See Schwarz, 1978) while ensuring all residual series from the VAR were uncorrelated. From this, four lags were considered optimal for minimising the SIC and guaranteeing no autocorrelation problems[6]. The table indicates that, at the 5 per cent level of significance, there were three cointegrating equations (increasing to four cointegrating equations at the 10 per cent level).

So far there are two conclusions that can be drawn from this analysis *viz* (i) there appear to be multiple equilibria amongst international labour markets; and (ii) while this may indicate a potential to reach individual equilibria, it also indicates that there may be a constraining influence on individual countries as they pursue such separate equilibria. With three cointegrating vectors, long-run relationships appear to be of at least intermediate strength and certainly provide evidence of integration among international labour markets.

Now let us superimpose on the thus-far-developed system what might be thought of as labour-market agitation indices. The agitation indices we propose and employ are two in number. The first is 'global' *nominal* GDP growth as measured by the weighted average annual growth of nominal GDP for the OECD's big seven, namely the USA, Japan, Germany, France, Italy, the UK and Canada. The second agitation index is the 'global' unemployment rate as measured by the weighted average quarterly unemployment rate for the OECD's big seven.

We now briefly discuss these indices. 'Global' nominal GDP growth is an indicator of nominal aggregate demand growth, which works its way through the economy to the labour market. Nominal GDP growth can, of course, be decomposed into real GDP growth and inflation. We have chosen, however, not to decompose nominal GDP growth.

Instead, we have opted for a parsimonious, though constrained, measure of the simultaneous impact of real GDP growth and inflation on strike activity. This arrangement has the advantage of focussing changes in aggregate demand into a single encapsulating measure. It might be viewed as being loosely analogous to the way in which economists construct a 'misery' index, which is the simple sum of the inflation rate and the unemployment rate.[7] Our particular index, however, is not a 'misery' index; it is an agitation index capturing the simultaneous effect of global changes in inflation and real GDP growth on strike activity.

We hypothesise that rapid growth in nominal GDP, brought about by a combination of real GDP growth and inflation, acts to destabilise labour markets and labour market relations. Higher real GDP growth is, in isolation, typically associated with higher profits and higher demand in product and labour markets. This in turn is likely to engender in employees and unions a stronger propensity to strike in support of improved conditions.

Higher inflation, on the other hand, is also likely to be associated with a higher level of employee and union militancy and thus higher strike activity. Inflation, in the absence of immediate compensating nominal wage changes, imposes on employees a decline in real wages. This is likely to lead to a higher level of employee and union agitation to restore real wage conditions.

The second agitation index employed in this article is the 'global' unemployment rate. It is argued that a rise in the unemployment rate tends to produce a moderation in strike activity. This is because the unemployed can act (to a greater or lesser extent) to compete for the jobs of the employed. Thus the employed are likely to moderate their aspirations and agitation for change in the face of a higher unemployment rate. In the longer term, the impact of a high unemployment rate on strike activity, might be expected to be attenuated if the unemployed are not in a position to compete for the jobs of the employed. However in the short to medium term, this attenuating effect is likely to be less powerful.

It may be worth emphasising that we are introducing into the system *global* agitation indices and not country-specific agitation

indices. We are positing that the global economic environment is influencing strike activity in each individual country. We are thus hypothesising that these global forces act as over-arching influences on all individual labour markets. The individual labour markets of individual countries may be submerged by the weight of global influences or, more likely perhaps, they may themselves be largely mirroring the impact of these pervasive global forces.

The fourth and fifth columns of Table 4 show that when these agitation indices enter the system the number of cointegrating equations increases to seven at the 5 per cent level (and eight at the 10 per cent level). The introduction of these additional variables reduces the number of common stochastic trends to three at the 5 per cent level and to two at the 10 per cent level. This is, arguably, an important outcome because it suggests that global agitation indices provide a robust linking or binding force amongst the different strike rates under review. The results also suggest that the particular labour market policies pursued by individual countries in an attempt to 'manage' strike activity may have a limited long-run impact. This is because there appears to be a relatively small number of common factors driving all the individual labour markets.

Table 5: Sequential Restriction Tests for Exclusion

	All countries		All countries plus Agitation indices	
Country	$\chi^2(3)$ statistic	*P*-value	$\chi^2(7)$ statistic	*P*-value
US	12.83	0.0050	23.57	0.0014
Australia	10.91	0.0122	36.00	0.0000
New Zealand	20.48	0.0001	25.65	0.0006
Canada	6.86	0.0767	17.01	0.0173
Japan	4.47	0.2129	24.68	0.0009
UK	23.52	0.0000	37.77	0.0000
France	16.27	0.0010	32.22	0.0000
Italy	7.04	0.0707	21.46	0.0031

The exclusion tests were based on there being r-cointegrating equations, determined by the Johansen trace test at the 5 per cent significance level.

Of course not all countries in our system may be part of the cointegrating space. This is because a sub-set of markets may not all be represented within the cointegrating equation set, indicating they are independent of the other markets. One way to test this is to perform a bi-variate cointegrating analysis for each pair of series and build up to the multivariate scenario. However, this can become cumbersome with a large number of series. An alternative approach does exist which is to check the significance of the weighting from each series within the cointegrating equations. Table 5 provides sequential restriction test statistics to determine whether each labour market is represented within the cointegrating vector. If it is not, then it will be independent of any cointegrating links placed on the other markets. The exclusion tests operate on the matrix β from the decomposition of Π above. The null hypothesis being tested is a test of the form $\beta_i=0$ for each $i=1...v$ series in β. This imposes linear restrictions by sequentially restricting variables from appearing in the cointegrating space. Johansen (1991, 1995) shows that the restrictions may be tested by a likelihood ratio test and the test statistic is distributed as χ^2 with the degrees of freedom determined by the number of cointegrating vectors in the initial system. From the restriction tests it is noticeable that Japan is clearly not part of the cointegrating space, while Canada and Italy can only be included at the 10 per cent critical level.

The result for Japan is, at first glance, curious because strike activity in Japan, as with other countries in (and out of) the system, has declined significantly during the 1980s and 1990s. Given this similarity, we might reasonably consider it to be an integral part of the system. We suggest the answer lies in the fact that the decline in strike activity in Japan was particularly acute during the 1980s and 1990s compared to the other countries in the system. Thus, while most economies in the system experienced roughly half the level of strike activity during the 1980s compared to the 1970s, in the case of Japan, the decline in strike activity was in the vicinity of 90 per cent.

However, as the two right-hand columns in table 5 indicate, all of the country-strike activity variables (including Japan) appear to be

significant integral parts of the system when the two global agitation indices are incorporated into the system. This finding reinforces the view that the agitation indices play an important binding role in the system. Thus not only does the inclusion of the agitation indices contribute to a tighter linking of the variables in the system, the inclusion also strengthens the role of all the variables within the system.

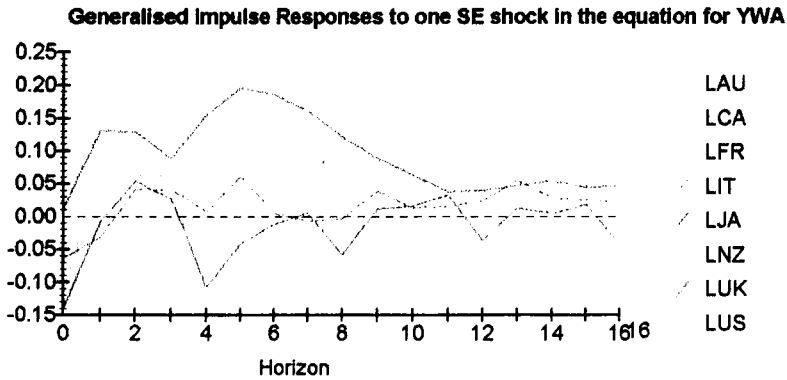
All in all, these findings are consistent with the findings of many past studies that have found strike activity to be linked to inflation, unemployment and (at times) GDP growth[8]. However a crucial distinction between this study and earlier studies is that in this study the agitation indices are 'global' indices, in the sense that they reflect overall levels of OECD agitation. Another distinction, is that this study makes international interdependence part-and-parcel of the framework of relationships between variables, rather than making international links a somewhat secondary appendage to a framework that focuses on apparent mainly-local variables.

5. ECONOMIC DRIVERS AND IMPULSE RESPONSE

Since Tables 4 and 5 suggest that world global agitation indices form an important and linking part of a cointegrated system, it may be useful to analyse the extent to which shocks in agitation indices impact upon strike activity. One way to do this is to employ impulse response functions in a vector autoregression (VAR) model or error correction model (ECM) framework. Impulse response functions allow an understanding of the possible dynamics of interaction within the system since an impulse response function measures the time profile of the effect of shocks at a given point in time on the (expected) future values of variables in the system. Until recently, the interpretation of the outcome of such impulse response functions within either a VAR or ECM framework has not been straightforward. This is because the error terms (innovations) are usually correlated, so that they have a common component, which cannot be associated with a specific variable (market). Econometricians generally dealt with this issue in a

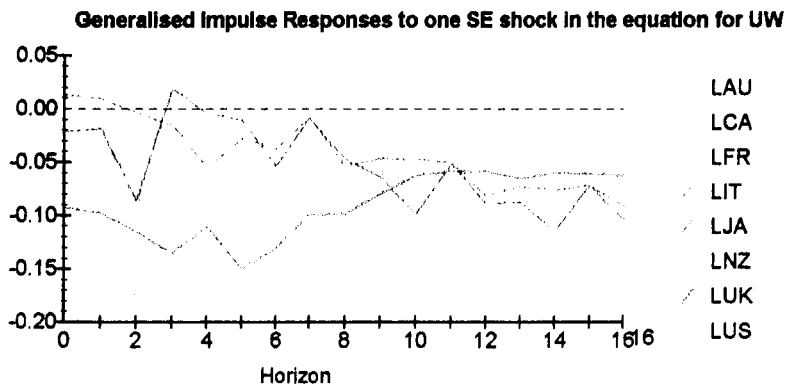
somewhat arbitrary fashion by attributing all of the effect of any common component to the variable that comes first in the VAR system. If we do not have a pre-determined structural model within which we are operating, this may be an unsatisfactory method, as merely changing the order of variables will change the outcome of the impulse response. Pesaran and Shin (1998) have recently developed a procedure that does not rely on the ordering of the variables in a VAR model. These authors refer to their approach as a generalised impulse response analysis. Pesaran and Shin show that their procedure for generalised impulse responses is unique and takes full account of the historical patterns of the correlations observed amongst the different shocks. In the present analysis we are only interested in observing the time profile of a shock in the two global agitation indices on other variables in the system. The most appropriate way to assess the time profile is graphically and the profiles for each country are shown in Figures 2 and 3.

Figure 2



See Table 3 for series definitions

Figure 3



See Table 3 for series definitions

Shocks to each of the agitation indices generally bring the sort of responses we might expect from the various strike activity variables in the system. In Figure 2, for example, we can see that a one standard error shock to nominal income will result in an increase in strike activity in practically all countries. In some countries, for instance Australia, there appears to be an initial fall in strike activity. This may not be unusual in that increased economic activity and improved incomes may generate an initial sense of exuberance and thus reluctance to strike for better conditions. However, over the ensuing quarters, it may be the case that the upsurge in economic activity may well generate increased inflation and a fear of a fall in living standards, which may then provoke an upsurge in strike activity designed to resist any erosion of real wage rate levels.

The pattern of Japan's impulse responses to nominal GDP changes appears the most aberrant. Its strike activity is initially negative then positive then negative and then 'settles' somewhat more quickly than other countries towards zero. This might be explained (or, less flatteringly, be rationalised) as being a response to Japan's idiosyncratic labour market practices plus its somewhat aberrant economy during the 1990s. During this time its economy declined while the most of the

rest of the OECD expanded. Another factor may have been Japan's exceptionally low level of disputation, particularly during the 1980s and 1990s. During these periods, Japan's level of strike activity was negligible, measuring around 5 per cent of the level of disputation in the USA.

For most countries the memory of the shock remains in the system for an extended period resulting in only a gradual decrease in strikes towards some 'equilibrium' in the range 0 per cent to about 2 per cent or 3 per cent from about the tenth quarter after the shock.

Figure 3 illustrates the impulse response to a one-off increase in the global unemployment rate. The (predominantly) negative response is what we may expect *a priori*. However, the lingering negative effect makes little sense, as it would be expected that the effect of a one-off shock would eventually dissipate.

6. CONCLUDING THOUGHTS

In this article we have sought to explore aspects of international interdependence in worldwide strike activity. The work of earlier researchers has been extended in at least two regards. First, we have extended the period of the analysis, by incorporating late 1980s and 1990s data. Second, we have employed a number of techniques that allow a more direct testing of international linkages. The techniques employed in this endeavour are: (i) correlation analysis, (ii) Granger-causality analysis and (iii) VAR analysis in conjunction with impulse response analysis.

All in all the evidence suggests a strong degree of worldwide interdependence and an important role for what we have described to be 'agitation' indices. These indices – global unemployment and nominal GDP growth – are seen to be significant variables within the system of interdependency to the extent that their presence strengthens the linkages within the system.

While our findings suggest that there is a high degree of interdependence, the results do not indicate that the variables within the system are *completely* bound to one another. In other words, the

variables within the system are *not* so strongly mutually interdependent, that there is no scope for variables within the system to 'wander'. Whether this indicates that there is scope for effective policy manipulation, by policy makers in individual countries pursuing their own strategies to 'manage' strike activity, is unclear. While such a possibility cannot be excluded, it seems likely that the effectiveness, of an individual country's independent policy manipulation, would be very much tempered by worldwide systemic influences.

DATA SOURCES

The strike rate is defined as the number of working days lost due to strikes per 10 000 employees. Nominal GDP growth is the (annual) percentage change from the same quarter of the previous year. The unemployment rate data are quarterly observations for OECD standardised data. Sources: OECD, *Main Economic Indicators Historical Statistics* and *Economic Outlook*. Certain refinements and updates were communicated directly to the authors via direct correspondence with respective national statistical collection agencies. Employee series were centred and smoothed. Where employee series were incomplete, interpolations and or estimates based on labour force estimates were employed.

NOTES

1. The US Department of Labor backdated the new-definition data on an annual basis (though not a quarterly basis) for the period 1947 to 1981. Thus comparisons can be made between old-definition and new-definition data for the overlap period, 1947 to 1981. The correlation coefficient for the two quite volatile series was 0.98. Given the strength of the correlation between the old-definition and new-definition data, the grossing up of the new-definition data from 1982 onwards by a constant proportion seems to be reasonable procedure.
2. During the second quarter of 1968, the rebellious activities of French students and others produced an exceptional level of recorded disputes.

For that particular quarter (1968:2), more than twice as many strikes occurred in France as occurred in *total* for all other quarter between 1960 and 1998. It is not unreasonable to treat this event as a one-off outlier. We have elected, however, to leave this in as an integral part of the model, on the grounds that to exclude this extraordinary event may result in important information being absent from the system.

3. Briefly, when estimating the relationship between variables, spurious results can be generated if the data series are non-stationary. By non-stationary, we mean basically that the mean value and the variance of the series increase (for example) over time. A stationary series, on the other hand, has a stable mean and stable variance over time, which permits more confidence in the use of the series when regression analysis is employed (stationarity is an assumption for hypothesis testing in classical regression). Thus, an index of nominal GDP, for example, that rises exponentially over time will be non-stationary as its mean and variance increase with the passage of time. By differencing a non-stationary variable (looking at the period-by-period change) we can often transform a non-stationary series into a stationary one. Such differencing however may mean that long-term equilibrium relations between non-stationary variables go undetected. Cointegration analysis, developed by Engel and Granger (1987), addresses this problem by testing to see if (say) two variables are stationary in combination. What this boils down to, in a simple two-variable regression analysis, is a test to see if the residual term is stationary.
4. Cf. Muscatelli and Hurn (1995).
5. Stock and Watson (1988a, pp 150-151) explain a stochastic trend (as opposed to a deterministic trend) as follows. A variable trend is modelled as increasing in each period by some fixed amount (say, 1%) on average; however, in any given period the change in the trend will deviate from its average by some unforecastable random number. Because it has this unpredictable random component this formulation of a variable trend is referred to as a stochastic trend. This notion of a stochastic trend corresponds to the notion of random walk with drift in the stock market literature
6. If using EVIEWS, for example, this would represent three lags on the differenced VAR. Note also that four lags for the (un-differenced) strike activity variables have been applied to the Granger-causality analysis on the basis of the results generated here.
7. See for example Dornbusch et al. (1995).
8. One possible explanatory variable missing from the system is the influence of changing trade union density. It is widely recognised that union density

has declined over the last couple of decades. Moreover, a number of studies have illustrated a link between union density and strike activity, for example, Perry (1980) and Morris and Wilson (2000). We have *not* included a global union density variable in this study, firstly because there is no such index readily available and secondly because, when these data are collected, it is typically on a non-quarterly basis. One way of capturing the possible influence of declining trade union density on the VAR system is to allow for a time trend variable in the cointegrating space. When this was incorporated in our VAR system we found that, in the absence of the global agitation indices, the number of cointegrating variables did not change. When the global agitation indices were included in the system, the number of cointegrating equations was six (one less than when the trend variable is absent in Table 4). We conclude from this that our result of a binding role associated with the presence of the global agitation indices stands – though in a slightly attenuated form.

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