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MIDWESTERN BUSINESS AND ECONOMIC REVIEW
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Table of Contents

Re-examining Intra-Industry Information Transfers: Did "Bad News" for Nortel Networks Corportation Imply Bad News for Other Canadian Technology Firms?

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Introduction

This paper revisits the common stock market wisdom that the financial performance of key stocks is an important early barometer of the future stock market performance of their respective industry sectors. It is generally accepted by the popular financial press, investment analysts and portfolio managers, that the performance of key industry players foretells the stock market performance of the other stocks in that industry sector. Is this common wisdom always correct? We investigated the stock market impact of Nortel's earnings announcement on October 24, 2000. Nortel announced quarterly earnings that were less than those expected. Since that time, there has been a recession. Nortel has had major losses and massive layoffs. How did the stocks within the technology industry sector react to Nortel's bad news and what are the implications for portfolio managers?

In this paper, we focus exclusively on earnings-related announcements as a mechanism for information dissemination and on one earnings announcement in particular. Foster (1981) classifies the following information as determinants of a firm's earnings: (1) general economic information, (2) industry-wide information, and (3) firm-specific information. In general, many firms' earnings announcements contain only firm-specific information and reveal little or no information generalizable to the industry sector. However, when the large industry players, such as Microsoft, IBM, Nortel, Intel, Motorola, Nokia, Ericsson, Marconi, General Motors, Citibank, etc., release information about their operations or financial statements, both the industry and firm-specific types of information might be present in their announcements.

Information announcements from large industry players could affect the market reaction of their industry sector in two different and opposite directions. If the announcement is believed to reflect general industry information, then one would expect the other industry players to be similarly affected and for their stock prices to reflect a contagion effect. If on the other hand, the announcement is believed to reflect firm-specific information, then one would expect the other competing industry players to be affected in the opposite manner, demonstrating a competition effect. A large industry player reporting major production difficulties would strongly suggest increased sales and improved stock prices for their competitors. In addition to affecting their specific industry sectors, large industry players may also affect entire financial markets, causing substantial impacts on economic and financial indicators.[1]

Nortel was (and still may be) a major player in the technology sector, and the financial media provided ample coverage of its daily operations. Furthermore, the financial gurus on Bay Street, as well as the average investors, perceived Nortel's financial performance as the barometer of technology sector to judge future business prospects.[2] Nortel's quarterly earnings announcement on October 24, 2000 came at a time of economic uncertainty when analysts were trying to determine where the economies in Canada and the US were heading after

having the longest economic expansions to date. The day after Nortel's announcement, October 25, 2000, the TSE 300 index fell 840 points, the largest daily point loss in the Toronto stock exchange history. The financial media reported the news with big headlines indicating a common belief that Nortel's bad news was also bad news for the entire technology sector. We investigated the validity of the prevailing belief among money and portfolio managers in Canada that Nortel represented the health and direction of the industry.[3]

This paper investigates the fundamental concept of intra-industry information transfers within the methodological context of Seemingly Unrelated Regressions (SUR). Our objective was to document stock price reaction among competitors to the specific event analyzed. Although a variety of intra-industry information transfers have been investigated within the finance literature, we have found no studies of earnings announcements. The finance literature reports studies on intra-industry information transfers within the areas of mergers and acquisitions, market structure and competition, regulatory changes and dividend announcements. Examples of such studies include those by Akhigbe and Madura (1999), Eckbo (1985), and Saunders and Smirlock (1987) on mergers and acquisitions; Laux et al. (1998), Slovin et al. (1991), and Szewczyk (1992) on market structure and competition; Madeo and Pincus (1985), Asness and Smirlock (1991), and Schipper and Thompson (1983) on regulatory changes.[4]

Our study is methodologically similar to that of Saunders and Smirlock who analyze the takeover of a securities firm by a bank and its effects on other firms in the same industry. Saunders and Smirlock analyzed a single announcement that originated from a single firm within the industry by employing the methodology of Seemingly Unrelated Regressions (SUR). This paper also focuses on a large industry leader, Nortel Networks Corp., and the spillover effects of the earnings announcement on the other firms in the technology sector in Canada.

In Section II, we present our methodology and explain the functions of our system restrictions on the coefficient estimates for the event parameters in a generalized regression system. In section III, we explain our empirical findings and discuss the implications in the context of intra-industry contagion effects. Finally, Section IV presents the summary and conclusions.

Data and Methodology

We investigate Nortel and 25 other Canadian technology firms included in the S&P/TSE CDN Info Tech Index.[5] The daily stock prices of the firms in the index were obtained from Yahoo Inc. for a period of 120 trading days that extends from July 26, 2000 to January 19, 2001.[6]

According to the Fama et al. (1969) and Brown and Warner (1985), the traditional event study methods based on abnormal returns are not appropriate for the analysis of intra-industry information transfers because the residuals are expected to be contemporaneously correlated. The reason for this assessment is that firms receive information common to all firms in the industry at the same time.[7] Therefore, we used Seemingly Unrelated Regressions (SUR) as it had also been applied to event studies of this nature in Asness and Smirlock (1991), Saunders and Smirlock (1987), and Schipper and Thomson (1983).[8] The SUR method overcomes contemporaneous correlations in residuals by estimating equations jointly as a generalized regression. We used the following system of equations to obtain our results:

$$R_{1t}=\alpha_1+\beta_1 R_{Mt}+\beta'_1 R_{Mt-1}+\beta''_1 R_{Mt+1}+\gamma D_t+\lambda P_t R_{Mt}+e_{1t}$$
$$R_{2t}=\alpha_2+\beta_2 R_{Mt}+\beta'_2 R_{Mt-}+\beta''_2 R_{Mt+1}+\delta_2 D_t+\Omega_2 P_t R_{Mt}+e_{2t}$$
$$\cdots$$
$$R_{26t}=\alpha_{26}+\beta_{26} R_{Mt}+\beta'_{26} R_{Mt-1}+\beta''_{26} R_{Mt+1}+\delta_{26} D_t+\Omega_{26} P_t R_{Mt}+e_{26t}$$

In this system of equations, R_{it} represents the return on the stock of firm i on day t, and R_{Mt} represents the return on the Toronto Stock Exchange (TSE 300) index in Canada. Two additional control variables, R_{Mt-1} and R_{Mt+1} (the stock market return of the TSE 300 index on the day before and the day after day t), are also used in the model to avoid nonsychronous trading effects as it is shown in Scholes and Williams (1977). D_t is a dummy variable and takes a value of 1 on the announcement date and 0 otherwise. P_t is also a dummy variable that

takes the value of 1 for the event day and for the entire post-event period, and 0 otherwise. There are 26 return generating equations in the system with the first equation representing Nortel's return, and the following equations from 2nd to 26th representing the remaining 25 firms in our sample.[9] Every equation is composed of two components, a control and an event component. A market model, $R_{it}=\alpha_i+\beta_i R_{Mt}+\beta'_i R_{Mt-1}+\beta''_i R_{Mt+1}$, which includes contemporaneous, lagged, and lead returns from the market index, establishes the control component of the system of equations.

The second component of the equation includes event study parameters, $(\gamma D_t+\lambda P_t+R_{Mt-1})$ for Nortel and $(\delta D_t + \Omega P_t+R_{Mt-1})$ for the other 25 firms. The parameters, δ and Ω, capture event day effects on the other 25 firms as a group. These two coefficients provide information on intra-industry information. A statistically significant estimation for δ implies that Nortel's announcement has resulted in an intra-industry information transfer (from Nortel to the other firms) that is return related. A significant coefficient estimate for Ω indicates that the announcement has affected the level of uncertainty about (variability in) stock prices within the industry. Specifically, there has been an intra-industry information transfers (from Nortel to other firms) of systematic risk. If the hypothesis of "bad news" to Nortel is also bad news to other firms in the industry, then one would expect lower average returns in the industry (indicated by $\delta > 0$) and higher average systematic risk (higher variability in stock prices) in the industry (indicated by $\Omega > 0$).

We organized our event study into two sections. In the first section, we run a system of equations for Nortel and for the remaining 25 firms with the restrictions of $(\delta_2 = \ldots = \delta_{26})$ and $(\Omega_2 = \ldots = \Omega_{26})$. The restriction on coefficient estimations in the group forces the event parameters to take the same value and, therefore provide an average group reaction estimate to Nortel's announcement rather than reflect each individual firm's reaction. Nortel's own event parameters are left without group restrictions ($\gamma \neq \delta$ and $\lambda \neq \Omega$), so that γ and λ measure only Nortel's reaction to the announcement. If Nortel's announcement releases news on lower profitability and lower total sales than the initially expected forecasts, we should expect negative reactions from investors and find $\gamma < 0$. Also, if we find $\lambda > 0$, it implies an increase in Nortel's systematic risk.

In the second section, we divide all firms into two groups, technology-hardware and technology-software to establish groups with a more homogeneous line of business. Our goal is to investigate whether intra-industry firm differences, namely hardware versus software product lines, are significant factors for the information transfers. Since Nortel could be classified within hardware group, the announcement effects of Nortel should be more strongly felt in the hardware group (subscripts 2 through 16) more than the software group (subscripts 17 through 26). We establish the following restrictions on coefficients to force the firms within either the hardware or software industry groups to take the same coefficient estimates, thus providing average group reactions to the earnings announcement being analyzed. Thus, we run a system of equations with the restrictions of $(\delta_2 = \ldots = \delta_{16})$, $(\delta_{17} = \ldots = \delta_{26})$, $(\Omega_2 = \ldots = \Omega_{16})$, and $(\Omega_{17} = \ldots = \Omega_{26})$. The first group of restrictions, $(\delta_2 = \ldots = \delta_{16})$ and $(\delta_{17} = \ldots = \delta_{26})$, ensure that event day coefficient estimates are to be the same across firms within each group. The second set of restrictions, $(\Omega_2 = \ldots = \Omega_{16})$ and $(\Omega_{17} = \ldots = \Omega_{26})$ ensures that the coefficient estimates for systematic risk to be the same across firms within each group.

Empirical Results

The empirical findings from the SUR equation system are reported in Tables 1 and 2. Table 1 presents the coefficient estimates for the contemporaneous, lagged, and lead variables representing the TSE 300 index returns. The summation of these coefficients provides the overall systematic risk measure for the firms. The mean of contemporaneous systematic risk estimates for the hardware and software groups are 1.31 and 0.95 respectively, implying a higher systematic risk factor for the hardware firms on the average.

Table 2 reports the event study parameter estimates for Nortel, all firms together, and the hardware and soft-

Table 1
Firm-Specific Parameter Estimates of Control Variables for the SUR Equation System At the Event Date: October 24, 2000[a]

Firm No.	α_i	β_I	β_i'	β_i''
Tech-Hardware				
1	-0.0009	2.5295**	-0.2006	-0.1397
2	-0.0015	0.4183*	-0.1212	0.2210
3	0.0073	0.8254**	0.0995	0.0975
4	0.0025	2.0700**	0.6108	0.1215
5	0.0049	1.3801**	0.2236	0.1003
6	0.0025	1.4637**	0.3509*	0.2374
7	0.0060	2.5603**	0.2031	0.2457
8	0.0005	0.2985	-0.0082	0.2833
9	-0.0007	0.6802*	0.1331	0.4939
10	0.0028	1.1680**	0.7026**	0.4455
11	0.0018	0.7324**	0.1882	-0.0518
12	0.0077	2.6133**	-0.0989	-0.3263
13	0.0029	1.2160**	0.1775	-0.0406
14	0.0022	0.8743**	0.2930	-0.3243
15	0.0033	0.7036**	0.7257**	0.5124*
16	-0.0105	1.4177**	-0.2773	0.0731
MEAN	0.0019	1.3095	0.1876	0.1218
Tech-Software				
17	0.0049	0.6537	0.1381	0.7615
18	0.0037	0.7554**	-0.0205	0.0447
19	-0.0004	0.9600**	-0.0787	0.1117
20	0.0037	2.2046**	0.0043	0.0475
21	0.0020	0.2046	0.4175	0.4501
22	0.0017	0.3358	-0.1481	-0.1981
23	-0.0019	1.1111**	-0.1331	0.1519
24	0.0054	0.8666**	0.0936	0.1477
25	0.0036	1.4242**	0.6433*	0.7154*
26	0.0037	0.9410*	0.5972	-0.2220
MEAN	0.0026	0.9457	0.1514	0.2010

[a] The above coefficient estimates are obtained from a market model representing the control component, $R_{it} = \alpha_i + \beta_i R_{Mt} + \beta_i' R_{Mt-1} + \beta_i'' R_{Mt+1}$ with contemporaneous, lagged, and lead returns of TSE 300 index.

*Estimated coefficient is significant at the 5 percent level (two-tailed test).

**Estimated coefficient is significant at the 1 percent level (two-tailed test).

Table 2
Event Study Parameter Estimates for the SUR Equation System[a,b]

	γ	λ	δ	Ω
Nortel Networks	-0.0406* (-2.04)	0.3959* (2.05)	---	---
All Firms	---	---	0.0300* (2.20)	0.4185* (3.16)
Hardware	---	---	0.0303* (2.10)	0.4521** (3.22)
Software	---	---	0.0291 (1.54)	0.3264 (1.78)

[a] The above event parameter estimates are obtained from a model for Nortel, $\gamma D_t + \lambda P_t R_{Mt}$, and for the other remaining firms, $(\delta D_t + \Omega P_t R_{Mt})$. The γ coefficient shows the announcement effect on Nortel's own common stock returns, and λ measures if Nortel's risk has also been affected by the announcement. In contrast, δ measures the other firms' return reactions as a group, and Ω measures the average systematic risk changes in the industry.
[b] t-statistics are below the coefficient estimates.
*Estimated coefficient is significant at the 5 percent level (two-tailed test).
**Estimated coefficient is significant at the 1 percent level (two-tailed test).

ware groups separately. Our empirical findings suggest that Nortel had experienced a 4.06 % reduction in its common stock valuation on the event day. Furthermore, the systematic risk factor for Nortel stock has increased from 2.53 to 2.93 (2.53 + 0.40).

Contrary to the hypothesis that Nortel's "bad news" is bad news to others, we found 3.00 % increase in the overall portfolio value representing the remaining 25 firms in the industry.[10] The intra-industry effect is the opposite of the commonly believed "Nortel is the industry" motto. The reason for this overall portfolio value increase for firms other than Nortel could be explained in two ways. First, Nortel could have dragged the TSE300 down disproportionably with its heavy weighting in the TSE300 index, thus causing other firms in the industry to realize relative gains due to the distortion created in the market index.[11] Second, other news releases in the industry might cause the remaining firms to realize price advances.[12] Although the first form of intra-industry information transfers did not occur, there were not lower average returns for the industry, the second form of intra-industry information transfers from Nortel to the other firms did occur, the average systematic risk in the industry increased from 1.31 to 1.73 (1.31 + 0.42). This increase in systematic risk (defined as an increase in variability in stock prices) reflects increasing levels of uncertainty.

We investigated intra-industry firm differences by dividing firms into hardware and software groups.[13] The results show that Nortel's announcement did not affect software firms' common stock returns and systematic risk factor as a single group. In contrast, the hardware firms' portfolio value as a single group has been increased by 3.03 %. Furthermore, the systematic risk in hardware group has been also increased by a factor of 0.4521.[14]

In order to reflect business risks effectively, other risk measures have also been proposed in the literature as complements to the standard systematic risk measure obtained from a market model. James (1984) and Asness and Smirlock (1991) use the variance of total stock returns as a measure of bankruptcy risk. We applied this measure to our study and present the results in Table 3. In order to find the bankruptcy risk measure, we calculated two variances of stock returns; the first was for a period of 60-trading days prior to the event, and the second was for a period of 60-trading days following the event. Then, we summed up the variances for the pre-event and post-event periods across the firms and calculated the group averages. The F-tests for Nortel and other groups are all statistically significant at the 1 percent level, implying higher bankruptcy risk for the industry after the announcement. This finding is consistent with our results of increasing systematic risk in the hardware group after the announcement.

In Table 4, we examined the existence of information leakages and market efficiency surrounding the announcement date by using six additional dummies corresponding to three days preceding the event, and the three days following the event. The coefficient estimates for the dummies and their corresponding standard deviations are added up over three-day periods, and the figures in Table 4 are obtained. None of the coefficient estimates corresponding to the three-day dummies preceding the event are statistically significant, thus implying that no information leakages occurred before the announcement. In contrast, the coefficient estimates for the three dummies following the event are all statistically significant, except for Nortel's, implying inefficiencies in the financial markets for the three-day post-event period. Nortel's announcement came on October 24, 2000, late in the late afternoon. Nortel's stock continued to trade the following day until trading was halted at midday due to the enormous quantity of sell orders. Therefore, the announcement effects have been studied over three-day periods.[15] The existence of market inefficiencies in the trading of Nortel's shares due to a mismatch of supply and demand, during the three-day period after the announcement, does not provide any support for the hypothesis of "bad news" to Nortel is bad news to other Canadian technology firms.

Summary and Conclusions

This study has examined the evidence for the accepted stock market wisdom that the stock market performance of key stocks is an important early barometer of the stock market performance of their respective industry sectors. We have found that in the case of Nortel's earnings announcement of October 20, 2000, the evidence does not support the commonly accepted wisdom, . We found significant negative common stock return reaction for Nortel, but failed to find negative returns for a portfolio of the remaining 25 firms in the industry. However, there were intra-industry effects in the form of higher systematic risk in the industry indicating higher levels of economic uncertainty as reflected by higher variability in stock prices of firms within the technology hardware group.

These results suggest a re-examination of the common wisdom about stock market leaders is necessary; these stocks do not always affect technology sector stock prices in a predictable manner. The model of how intra-industry information transfers affect industry sector stock prices requires additional complexity. This paper provides a specific example in Nortel that documents a two dimensional intra-industry effect in which the characteristics of changes in stock market values (means) are absent and changes in systematic risk (variance) are present.

We acknowledge that our study has the limitations of examining one earnings announcement, of one company,

in one environment. However, it must be borne in mind that Nortel was a key technology sector company that had the reputation of being well managed and having a technologically sophisticated portfolio of products. If there was no industry effect at this time, then when could one expect such an effect?

These findings raise questions about the validity of the common belief of key industry players foretelling the stock market reaction of the industry sector. Further research remains to be done. First, this study should be duplicated to determine whether this phenomenon occurs frequently or is peculiar to Canada. Second, there is the issue of time frame. Is the failure to achieve statistically significant abnormal returns an anomalous result of the time horizon. Third, the study focused on stock market returns, not accounting income. In between the reporting of financial accounting performance and stock market results, there is the intervening step of investor perceptions and the little understood role of mass psychology and behavioral finance. We did not investigate what occurred to accounting earnings, we focused exclusively on stock market returns.

Table 3
Average Variance Before and After the Event Date[a]

	Average Variance 60-Days Before Y	Average Variance 60-Days After	F-test
Nortel Networks	0.1640	0.4235	2.58**
All Firms	0.2019	0.4688	2.32**
Hardware	0.1785	0.4645	2.60**
Software	0.2395	0.4857	2.03**

[a]Variance multiplied by 100.
*Estimated coefficient is significant at the 5 percent level (two-tailed test).
**Estimated coefficient is significant at the 1 percent level (two-tailed test).

Table 4
Information Leakages and Market Efficiency Surrounding the Event Date[a]

	3-Day Period Before the Event Y	3-Day Period After the Event
Nortel Networks	-0.0003 (-0.05)	-0.0506 (-0.85)
All Firms	0.0101 (0.29)	0.1262** (3.36)
Hardware	0.0246 (0.65)	0.1032* (2.55)
Software	-0.0258 (-0.52)	0.1832** (3.46)

[a] t-statistics are below the coefficient estimates.
*Estimated coefficient is significant at the 5 percent level (two-tailed test).
**Estimated coefficient is significant at the 1 percent level (two-tailed test).

Table 5
Firms in S&P/TSE CDN Info Tech Index[a]

Firm No.	Firm Name	Ticker Symbol	Revenues (000)	Total Assets ($000)
Tech-Hardware				
1	Nortel Networks Corp.	NT.TO	31,401,000	42,227,000
2	ATI Technologies	ATY.TO	1,387,268	1,015,011
3	COM DEV International	CDV.TO	209,022	243,739
4	Certicom Corp.	CIC.TO	12,040	40,533
5	Celestica Inc.	CLS.TO	9,788,825	5,937,985
6	C-Mac Industries	CMS.TO	2,575,508	3,029,968
7	EXFO Electro-Optical Engineering	EXF.TO	73,119	219,723
8	Leitch Technology	LTV.TO	163,953	231,419
9	Mitel Corp.	MLT.TO	686,700	835,600
10	MOSAID Technologies	MSD.TO	48,109	74,283
11	Onex Corporation	OCX.TO	24,917,000	19,719,000
12	Research In Motion	RIM.TO	244,248	970,063
13	Sierra Wireless	SW.TO	57,450	136,815
14	360networks	TSX.TO	568,000	5,602,000
15	Tundra Semiconductor	TUN.TO	42,298	58,167
16	Wi-Lan Inc.	WIN.TO	66,370	136,191
Tech-Software				
17	Corel	COR.TO	172,072	218,587
18	Creo Products	CRE.TO	453,625	953,200
19	Cognos Inc.	CSN.TO	508,038	393,094
20	Descartes Systems	DSG.TO	75,754	413,119
21	CGI Group	GIBA.TO	1,439,906	920,873
22	Hummingbird Ltd.	HUM.TO	238,024	372,791
23	BCE Emergis	IFM.TO	473,560	1,316,310
24	Open Text	OTC.TO	119,338	192,818
25	724 Solutions	SVN.TO	33,775	287,316
26	Zi Corp.	ZIC.TO	8,516	62,853

[a] Financial figures (total assets and revenues) are obtained from Globe and Mail based on September 30, 2000 estimates, and all figures are in Canadian dollars.

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Notes

[1] For example, After Marconi's profit warning in the U.K., FTSE 100 index fell sharply, and Burns reported in *The Investment Dealer's Digest* on July 9, 2001 that "While the European market has had its fair share of profit warnings in recent weeks, this is the most shocking yet, wiping some £3.5 billion, or 54% of the total value of Marconi shares, in what traders say is the worst one-day fall in the history of FTSE 100 index." Also, after Nortel's earnings announcement, Browning reported in *The Wall Street Journal* on October 26, 2000 that Nasdaq Composite Index fell 5.56% and was "knocked down by a stock that isn't even part of the index." Browning also reported a year earlier in *The Wall Street Journal* on October 22, 1999 to illustrate IBM's effect on the market with a headline "IBM Pulls Down Blue-Chip Index." Dignan reports on *CNET News.com* on June 12, 2001 that "technology stocks shake off the effects of a Nokia-inspired sell-off." Barret also reports on *CNET News.com* on February 16, 2001 that "The effects of Nortel's pre-announcement spilled across the tech sector Friday, sending networking and fiber-optic stocks tumbling." Klayman reports on *Reuters* on July 8, 2001 that "Motorola a tech barometer - Motorola is a bellwether stock for the technology industry because of its broad array of products." *BBC News Online* reports on April 18, 2001 that "Intel, which is seen as a key market barometer..." Carrick reports on *Globe and Mail* on August 26, 2000 that "Live by Nortel, die by Nortel."

[2] For example, Chapman from Westminster Securities Inc. reports on June 18, 2001 that "But for some reason or other we seem to have an over fixation on Nortel as some sort of measurement of the health of the Canadian economy." Also, Porter from BMO Nesbitt Burns describes Nortel as "Canada's technology bellwether" on February 19, 2001.

[3] For example, Franklin Templeton Investment Corp. reports in the Quarterly Market Recaps-Canadian Equity section of Second Quarter of 2001 that "The nemesis, as usual, is the technology sector, which to many Canadian investors means Nortel." Also, Richard Croft, the president of R.N. Croft Financial Group reports on Quicken.ca on February 19, 2000 that "Like or not, the Canadian economy is inexorably tied to the fortunes of Nortel...That the market valued Nortel as the main engine in the Canadian economy was, rightly or wrongly, the best unbiased view we have of what the company was really worth. And more importantly, it was an unbiased opinion as to what was driving the Canadian economy." Furthermore Coomber and Lazarus reports on the All Canadian Mutual Fund Guide Online on Winter 2000 issue that "However, Andrew Smith, an investment analyst with Spectrum United Funds in Toronto points out that selling off Nortel is also a bet against the market."

[4] Binder (1985) provides why the application of a multivariate regression model in event studies is more appropriate method than the traditional event study methods.

[5] All the firms in S&P/TSE CDN Info Tech Index are also included in the TSE technology-hardware and software sub indices except Onex Corporation. We examined firms' product line and found that it is a better match in technology-hardware classification.

[6] Two additional trading days were also added to compensate the variables in the market model for the time periods of t-1 and t+1.

[7] See also Brown Warner (1980), Dale (1981), Dodd (1980), and Firth (1976) and (1996) for the further treatment of traditional event study methods.

[8] Greene (1990) explains the Seemingly Unrelated Regressions (SUR) in the framework of the Generalised Least Squares. The equation system, $y=X\beta+\varepsilon$, represents our 26 equations in a compact form, and the following matrix provides how each equation is presented in a Generalised Least Squares framework:

$$\begin{bmatrix} y_1 \\ y_2 \\ . \\ y_{26} \end{bmatrix} = \begin{bmatrix} X_1 & 0 & . & 0 \\ 0 & X_2 & . & 0 \\ . & . & . & . \\ 0 & 0 & . & X_{26} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ . \\ \beta_{26} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ . \\ \varepsilon_{26} \end{bmatrix}$$

For example, $\mathbf{X}_1$ from the above matrix includes the independent variables in the market model as a part of the overall equation system, and represents the determinants of Nortel's returns. The is for the first firm (Nortel) in the overall system, and has 120 observations (trading days) in its time dimension. The remaining $\mathbf{X}_t$'s corresponds the same return generation process in the market model for the remaining 25 firms. The variance-covariance matrix of the equation system,

$$\Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & . & \sigma_{126} \\ \sigma_{21} & \sigma_{22} & . & \sigma_{226} \\ . & . & . & . \\ \sigma_{261} & \sigma_{262} & . & \sigma_{266} \end{bmatrix}$$

could be also written with identity matrix as the following:

$$E(\varepsilon\varepsilon') = V = \sum \otimes I = \begin{bmatrix} \sigma_{11}I & \sigma_{12}I & . & \sigma_{126}I \\ \sigma_{21}I & \sigma_{22}I & . & \sigma_{226}I \\ . & . & . & . \\ \sigma_{261}I & \sigma_{262}I & . & \sigma_{266}I \end{bmatrix}$$

Furthermore, the inverse of the Vmatrix can be used to derive ß estimation, and provides efficiency gains exploited from the correlations of error terms:

The ß estimation depends on $\sum$ but since it is unknown in empirical studies, it is estimated from the least squares regression residuals, and used to find an estimation for ß. This initial process is called Feasible Generalised Least Squares estimation.

[9] Table 5 presents the firms included in our study from 1 to 26 and their revenues and assets figures for the year 2000.

[10] The large change in TSE 300 was due to Nortel's heavy weighting in the TSE 300 index calculation. Not surprisingly, we found a high correlation coefficient of 0.91 for the Nortel's common stock returns and the TSE 300 index returns (significant at 1 percent level) for our sample period

[11] Simon reported in *The New York Times* on July 26, 2001 that Nortel's index weighting has reached to more than 36% of TSE300 at the peek of its prices between June-August 2000. Also, Heinzl and Cherney reported in *The Wall Street Journal* on August 30, 2000 indicating a 35 percent of Nortel's share in the index and defined the Canadian TSE by writing, "Canada's stock market among the most lopsided in the word due to the impact of a single company."

[12] Serant reports in *Electronic Buyer's News* on October 30. 2000 that price gains among the other semiconductor firms in the industry was due to positive results from many chip makers.

[13] We also separated 26 firms into two groups by revenue

and total assets of firms. There were 11 large firms with either revenues or total assets larger than $500 million, and 15 small firms below this figure. The empirical findings from the SUR regressions with small and large group coefficient restrictions showed that the small and large firm group reactions were not statistically different from each other.

[14] Foster (1981) also finds a similar result for the impact of the earnings releases on the other firms in industry. He iterates that "The magnitude of this impact is more significant for a sample of firms which have a larger percentage of their revenues in the same line of business as the earnings release firm vis-à-vis a sample with a lower percentage of their revenues from the same line of business."

[15] Karmin and Cherney reported in *The Wall Street Journal* on October 26, 2000 that "Trading in Nortel,..., had to be halted at midday after a bombardment of sell orders overwhelmed the Toronto exchange's trading system."

The Impact of Advanced Manufacturing Technology on Job Satisfaction and Work Design

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Introduction

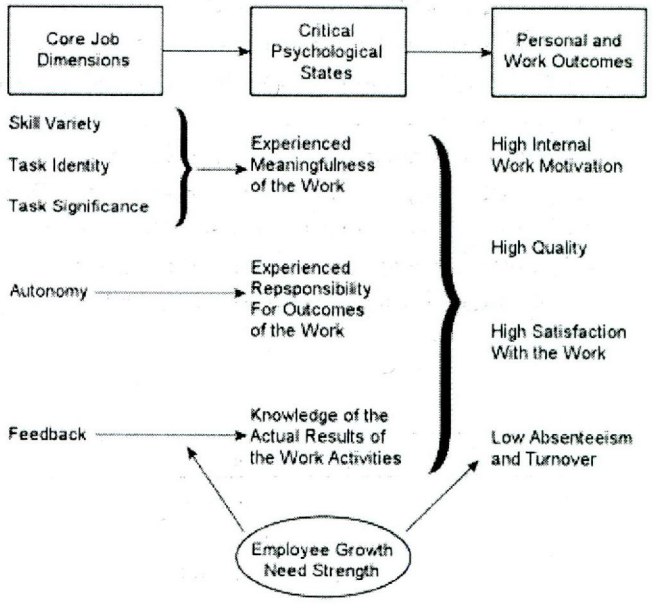
One of the most important issues currently facing manufacturing organizations is the exploitation of recent developments in computer-based production technology or advanced manufacturing technology (AMT). Wall, Clegg, and Kemp (1987) describe the core technologies of AMT as ranging from standalone computer numerically controlled (CNC) machines and robotic installations to larger scale flexible manufacturing systems (FMS) and fully computer-integrated manufacturing (CIM). Common to all forms of AMT is computerized control over the production process. The rapid development and implementation of AMT is revolutionizing manufacturing work and has important implications for job design and job satisfaction (Forester, 1985; Wall, Corbett, Clegg, Jackson, and Martin, 1990a).

Theoretical Background

Job Characteristics Model

The dominant model of job design is the Job Characteristics Model (JCM: Hackman and Oldham, 1975). According to the JCM, shown in Figure 1, high levels of five core job characteristics (skill variety, task identity, task significance, autonomy, and feedback) lead to three critical psychological states (meaningfulness, responsibility, and knowledge of results) which, in turn, lead to positive work outcomes, like higher motivation, performance, satisfaction. All the linkages in the JCM are moderated by growth need strength—the strength of one's desire for self-improvement and growth in the workplace (Hackman and Oldham, 1976).

Figure 1



Unfortunately, Tabor and Taylor's (1990) review of over 200 studies involving the JCM revealed that the five core job dimensions of the JCM do not "span the range of conceptual categories workers actually use when thinking about their jobs" (p. 492). They recognized the need to investigate alternative job characteristics not included in the JCM. Nowhere is this need more apparent than in the emergence of advanced manufacturing technology. According to Wall et al. (1990a), the AMT environment calls for the recognition of several important job characteristics that have received little attention among

organizational researchers. They developed a model consisting of four AMT job characteristics (control, cognitive demand, responsibility, and social interaction) that impact the psychological well-being of AMT workers. The present study examines the extent to which these AMT job characteristics account for differences in job satisfaction among shopfloor workers in a variety of jobs in an AMT plant.

Advanced Manufacturing Technology (AMT) Model

Research into the effects of AMT on employee psychological well-being is sorely lacking in the literature. A notable exception is a stream of research conducted by the Social and Applied Psychology Unit of the University of Sheffield in Great Britain. This group of researchers conducted several key field investigations in AMT plants. Findings from these studies provided considerable insight into the unique characteristics of AMT jobs and their effects on psychological well-being, particularly job satisfaction (Corbett, 1987; Martin and Jackson, 1988; Corbett, Martin, Wall, Clegg, 1989; Wall, Corbett, Clegg, Jackson, and Martin, 1990a; Wall, Corbett, Martin, Clegg, and Jackson, 1990b).

Noting a lack of theoretical integration in the AMT literature, Wall et al. (1990a) developed a theoretical framework to guide research into the psychological effects of AMT on shopfloor operators. Their model, which is the AMT equivalent of the Job Characteristics Model (JCM), identifies four key job characteristics which are relevant to AMT work and predicts how these characteristics differentially impact performance, job-related strain, and job satisfaction. The AMT job characteristics, shown in Table 1, include control, cognitive demand, responsibility, and social interaction.

The most common concern regarding the job content implications of AMT is the extent to which the operator has control over the work. The fact that AMT has the potential to reduce operator control is well documented (Sinclair, 1986; Perrow, 1983; Blumberg and Gerwin, 1984). The AMT model specifies three aspects of control: timing control, method control, and boundary control. Timing control is similar to the notion of machine-pacing. The negative effects of timing control are well documented in research on repetitive work and

Table 1

Category	Characteristic	Definition
Control	Timing Control	Extent to which the individual can decide when to carry out given tasks, rather than having to respond when the technology requires.
	Method Control	Extent to which the individual can carry out the work in his or her own way, rather than work being externally prescribed by the technology or procedures.
	Boundry Control	Extent to which the individual, rather than others, has responsibility for secondary activities completed in support of the primary operating tasks.
Cognitive Demand	Monitoring Demand	Extent to which the individual is required to pay close and constant attention to work processes or activities.
	Problem-Solving Demand	Extent to which the individual is required to diagnose and solve problems.
Responsibility	Production Responsibility	Extent to which errors by the individual may result in serious damage to production equipment or considerable loss of output.
Social Interaction	Social Contact	Extent to which the individual has opportunity for social contact with others, rather than working in isolation from others.
	Social Support	Extent to which the individual has opportunity to build quality relationships with others.

Source: Wall, Corbett, Clegg, Jackson, and Martin, 1990

machine pacing (e.g., Blauner, 1964; Hurrell 1981). It varies widely across the spectrum of AMT technology and is not addressed by the JCM (Wall et al., 1990a). Method control refers to individual choice in how to complete given tasks. It is generally related to concept of autonomy in the JCM and varies according to the particular AMT technology used and the organization of the job. Finally, boundary control refers to operator responsibility for secondary activities, such as machine maintenance, modifying programs, ordering supplies, inspection, and quality control (Wall et al., 1990a). It is not addressed by the JCM, but may impact task identity and skill variety in the JCM.

Cognitive demand refers to the need for mental rather than physical activity (Wall et al., 1990a). The most frequently mentioned aspect of cognitive demand is monitoring or attentional demand. Van Cott (1985) argues that AMT has changed the role of the operator from an "active element to one of passive monitoring" (p. 48). Monitoring demand varies considerably across AMT applications (Wall et al., 1990a). A second aspect of cognitive demand, problem-solving demand, refers to the need to prevent or address errors. Problem-solving demand also varies according to the AMT job design. Neither characteristic is addressed in the JCM.

Production responsibility refers to the extent to which errors by an operator result in serious damage to production equipment or considerable loss of output (Wall et al., 1990a). It is often high in AMT systems due the extreme cost of computer-controlled production equipment and the serious consequences of operator errors and downtime (Wall et al., 1990a). This conception of production responsibility is not addressed in the JCM. It differs considerably from the notion of autonomy in the JCM, which emphasizes freedom, independence, and discretion in carrying out work tasks (cf. Hackman and Oldham, 1975).

The final AMT job characteristic is social interaction. Social interaction is the most neglected of the four AMT job characteristics (Wall et al., 1990a). Social contact refers to the amount of social contact operators experience at work. Social contact was originally included in Turner and Lawrence's (1965) Requisite Task Attributes scale as a determinant of satisfaction. This relationship was confirmed by Hackman and Lawler (1971), but social contact was not included as a core job dimension in the JCM. Highly automated AMT systems which place operators in relative isolation from one another, applications with high monitoring demands, and those which require operators to tend multiple machines severely limit social contact. Social support refers to the quality of social interaction which can also be limited by AMT technology (Wall et al., 1990a). Neither social contact nor social support is included in the core job dimensions of the JCM.

According to Wall et al. (1990a), the AMT job characteristics affect job satisfaction in a relatively straightforward manner. They propose that job satisfaction in AMT work increases as an additive function of greater timing, method, and boundary control, lower monitoring demand, higher problem-solving demand, cost responsibility, social contact, and social support. Thus, the theoretical model of AMT job characteristics identifies key characteristics of AMT work and offers testable propositions as to how each characteristic impacts job satisfaction. Wall et al. (1990a) admit, however, that the model is far from complete and in need of empirical testing.

Purpose of The Study

By and large, the AMT model of job characteristics remains untested. No large-scale test of the model in an AMT plant has been documented to date. Wall et al. (1990a) state that the model can be applied across a wide range of shopfloor jobs and production technologies. This study provides a preliminary test of the AMT model among a relatively large sample of shopfloor employees working in a wide variety of jobs in an AMT plant. Jobs were classified according to Blauner's (1964) four distinct forms of production technology to yield four distinct job types (process control, machine tending, assembly/packaging, and maintenance or craft). Job satisfaction among shopfloor workers in each of these distinct job types was assessed to determine whether job satisfaction differs by job type and to determine whether these differences are consistent with the predictions of

the AMT model. Specifically, three hypotheses were tested:

Hypothesis 1: Job type will emerge as the most important predictor of job satisfaction.
Hypothesis 2: Job type will explain significant variance in job satisfaction scores beyond the variance explained by key demographic factors.
Hypothesis 3: Intrinsic job satisfaction will differ significantly among the four job types. Differences will be consistent with the predictions of the AMT model. Jobs rated lowest in motivating potential based on the AMT job characteristics will be the least satisfying and those rated highest in motivating potential based on the AMT job characteristics will be the most satisfying.

Methods

Site and Respondents

The study was conducted among shopfloor employees in a large manufacturing plant located in the southern United States that is involved in the production of glass fibers. Plant operations are centered around three basic forms of AMT. Computer integrated manufacturing (CIM) is used to control glass furnaces and specialized equipment used to extrude glass fibers from molten glass. A large number of standalone computer-controlled machines are used for drying, winding, and chopping glass fibers. Finally, automated conveyor systems, robots, and automated packaging equipment are used in assembling, accumulating, and packaging the finished product.

A total of 642 shopfloor employees were directly involved in operating and supporting the manufacturing operation. A total of 525 shopfloor employees attended paid pre-shift meetings during which participation in the study was encouraged but not required. A total of 50 surveys were excluded from the study due to errors or incomplete responses, leaving 475 usable surveys for a net response rate of 74 percent.

Demographic analysis of respondents revealed that the workforce is largely male (72 percent) and under 40 years of age (76 percent). Most of the respondents had a high school diploma (82 percent) and 40 percent had completed some college courses. Plant tenure was bimodal with two distinct groups--one concentrated in the 4 to 6 year range and another concentrated at the 10 to 15 year range. Nearly half of the respondents were machine operators (48 percent) while the balance were involved in process control (16 percent), assembly/packaging (18 percent), and maintenance (18 percent).

Measures

The complete Job Descriptive Index (Smith, Kendall, and Hulin, 1969, 1985; Balzer and Smith, 1990) was used to assess job satisfaction. The Job Descriptive Index (JDI) is the most popular and carefully developed measure of job satisfaction in use today (Locke, 1988; DeMeuse, 1986; Zedeck, 1987). It was selected for use in the current study due to its high reliability, low reading level, ease of administration, and its ability to measure several distinct facets of satisfaction. The JDI is comprised of six scales designed to measure satisfaction with the Work Itself, Present Pay, Opportunities for Promotion, Supervision, Coworkers, and Job in General (JIG). Because the current investigation is concerned with the effects of job design on intrinsic job satisfaction, the Work Itself (Work) scale and the Job in General (JIG) scale are the primary focus of the study.

The Work scale, which measures satisfaction with intrinsic qualities of the work itself, is by definition a relevant measure of intrinsic job satisfaction. The JIG scale, which measures general, non-specific perceptions of job satisfaction, is often highly correlated with the Work scale (cf. Mathieu and Zajac, 1990) and also serves as a useful measure of intrinsic job satisfaction. The remaining scales of the JDI, which measure satisfaction with various extrinsic facets of satisfaction (e.g., pay, promotional opportunities, supervision, and coworkers), are not directly related to job design, but are included in the study to provide a more complete picture of employee job satisfaction.

Procedure

Classification of Jobs

Jobs in the plant were organized around the operation of a large number of computer-controlled machines. The plant operated primarily under specialist control (Wall et al., 1990b) which restricts machine operator activities to basic machine tending and assigns responsibility for maintenance, reprogramming, and resolution of operating problems to support personnel. Jobs were classified according to Blauner's (1964) four distinct forms of production technology to yield four distinct job types (process control, machine tending, assembly/packaging, and maintenance or craft). This job classification scheme and the primary activities associated with each of the four job types is outlined Table 2.

Job Ratings

The four distinct job types were evaluated in terms of Wall et al.'s (1990a) AMT job characteristics. Each job type was rated on the AMT job characteristics to yield a motivating potential score, just as is done in the JCM. Because the instrumentation to measure AMT job characteristics has not yet been developed, the researcher, who was familiar with the activities of shopfloor employees, worked closely with company engineers and supervisors to produce ratings of each job type. General ratings were provided to indicate low (1), medium (2), or high (3) levels of each AMT job characteristic for each job type. These ratings were not intended to be highly precise or scientific. Rather, they reflect a general evaluation of objective characteristics of the work performed by those in each job type. These ratings are presented in Table 3. Ratings for monitoring demand were reverse scored because the AMT model predicts a negative relationship between monitoring demand and job satisfaction. In keeping with Wall et al.'s (1990a) recommendation, an additive motivating potential score for each job type was computed. First, an average score for each job characteristic category was computed by averaging ratings for its subcomponents (e.g., timing control, method control, and boundary control). Then, the average scores for each category were totaled to yield the motivating potential score. Motivating potential scores may range from a minimum of 4 to a maximum of 12.

Maintenance and process control jobs were rated highest in AMT motivating potential followed by assembly/packaging and machine tending jobs. Therefore, based on Hypothesis 3, maintenance and process control jobs should stand out as the most satisfying jobs and machine tending jobs should stand out as the least satisfying jobs, particularly on the two measures of intrinsic job satisfaction--the Work and JIG scales.

Table 2: Job Classification Scheme

Job Type	Primary Activities Involved
Process Control	All technical support required to monitor and control automated machines. Includes troubleshooting, testing, setup, and reprogramming.
Machine Tending	All machine tending and monitoring activities required during the regular production cycle of the machine.
Assembly/Packaginig	All activities required for final preparation, accumulation, and packaging of finished goods.
Maintenance	All mechanical and electrical repairs and preventive maintenance required to maintain machine operation.

Analysis

Analysis of the data proceeded in three phases. First, a correlation matrix was constructed to examine relationships between demographic variables and scores on the six JDI scales. Then, an unbalanced ANOVA procedure was performed to determine the relative importance of demographic variables and job type (Hypothesis 1). Next, multiple linear regression with dummy variable coding was used to partial out the effects of key demographic variables to determine whether job type explained significant variance beyond that accounted for by variables, like age and education (Hypothesis 2). Finally, multiple comparison tests were conducted to determine whether intrinsic job satisfaction was, in fact, significantly higher or lower in certain job types as predicted by the AMT model (Hypothesis 3).

Results

Pearson product-moment correlations presented in Table 4 reveal significant relationships between age and most job satisfaction scales. This is expected as overall job satisfaction typically rises with age (Locke, 1988). Plant tenure is strongly correlated with age and moderately correlated with the Work and Job in General scales. The strong correlation between age and plant tenure is expected since long-tenured employees, by definition, are older. Weaker, yet significant, correlations, were also found between education and the Work and Promotion scales. Higher educated employees are less satisfied with the work and promotional opportunities. Age, education, and plant tenure are the most important demographic variables affecting job satisfaction. Moderate intercorrelation between the JDI scales was also evident in Table 4. The strong correlation (.71) between the Work scale and the Job in General scale is consistent with findings in Mathieu and Zajac's (1990) extensive meta-analysis and supports the notion that both the Work and JIG scales measure related constructs, namely intrinsic job satisfaction.

Hypothesis 1 was tested using a specialized unbalanced ANOVA procedure because the analysis involved several categorical variables (gender, education, and job type) with unequal group size. Analysis of variance results presented in Table 5 clearly indicate the importance of job type as a predictor of job satisfaction. Significant main effects ($p<.01$) were obtained for the relationship between job type and all job satisfaction scales, except promotion. Few demographic factors had significant main effects. Two exceptions were significant relationships between gender and both pay ($p<.05$) and pro-

Table 3: Ratings of Job Types on the AMT Job Characteristics

		Job Type			
Category	Characteristic	Process Control	Machine Tending	Assembly/Packaging	Maintenance
Control	Timing Control	3	1	2	3
	Method Control	2	1	2	3
	Boundry Control	2	1	2	3
Cognitive Demand	Monitoring Demand (R)	2	1	2	3
	Problem-Solving Demand	3	1	2	3
Responsibility	Production Responsibility	3	2	1	3
Social Interaction	Social Contact	3	1	2	3
	Social Support	3	1	2	3
	Motivating Potential	10.8	5.0	7.0	12

Rating Scores: 1 = Low; 2 = Moderate; 3 = High
(R) denotes reverse scoring
Motivating Potential Score is the sum of the average score for all items in each of the four categories.

motion ($p<.01$) and between education and both work ($p<.01$) and promotion ($p<.01$). With the exception of the promotion scale, job type was the dominant predictor of all satisfaction scales offering strong support for Hypothesis 1.

As stated previously, correlation analysis revealed that education, age, and tenure were key demographic variables affecting job satisfaction. The strong correlation between age and plant tenure is expected since long-tenured employees are, by definition, older. To avoid redundancy, only the more influential age variable was retained in regression analyses used to test Hypothesis 2. The purpose of this analysis is to determine whether job type explains variance in job satisfaction above and beyond the effects of the key demographic factors of age and education. Therefore, the effects of age and education were partialled in the analysis. Since education and job type are categorical variables, they were represented as indicator or dummy variables. Results of the analysis in Table 6 reveal significant effects for job type ($p<.01$) among all job satisfaction scales, except promotion. Effect size (R2) was moderate for intrinsic job satisfaction scales, like the Work and Job in General scales, but weaker for pay, supervision, and coworkers. The fact that

Table 4: Correlation Matrix and Reliabilities[a]

Variable	Mean[b]	SD	1	2	3	4	5	6	7	8	9	10
1. Age	35.8	8.9	--									
2. Gender[c]	1.26	.44	.15 **	--								
3. Education[d]	2.36	.85	.04	-.18 **	--							
4. Plant Tenure	7.33	3.46	.46 **	.09	.06	--						
5. Work	22.22	11.63	.24 **	.02	-.14 **	.27 **	.85					
6. Pay	29.68	14.69	.05	.02	.02	.02	.33 **	.82				
7. Promotion	10.85	12.46	.08	-.07	-.19 **	.06	.41 **	.22 **	.86			
8. Supervision	30.19	14.56	.13 **	.03	-.06	.04	.40 **	.21 **	.28 **	.82		
9. Coworkers	29.92	14.66	.19 **	.00	.00	.06	.41 **	.27 **	.30 **	.46 **	.83	
10. Job in General	31.37	13.10	.24 **	.05	-.05	.20 **	.71 **	.35 **	.35 **	.41 **	.46 **	.87

[a] Reliabilities are presented on the diagonal [b]N = 475 [c]Male = 1; Female = 2
[d] 1 = no hs diploma; 2 = hs diploma; 3 = some college; 4 = bachelor's; 5 = master's
* $p < .05$; ** $p<.01$ (2-tailed)

Table 5: Unbalanced Analysis of Variance - Main Effects

	Work Itself		Pay		Promotion		Supervision		Coworkers		Job in General	
Source	F	p	F	p	F	p	F	p	F	p	F	p
Age	.901	.655	.815	.795	.804	.812	1.056	.380	1.221	.166	.888	.677
Gender[a]	.203	.653	6.465	.011 **	12.513	.000 ***	.165	.685	.053	.818	.001	.976
Education[b]	4.367	.002 **	.725	.575	5.901	.000 ***	1.382	.239	.299	.879	2.081	.082
Plant Tenure	.740	.724	.955	.495	.891	.562	1.078	.377	1.493	.116	.873	.582
Job Type[c]	21.910	.000 ***	10.287	.000 ***	2.414	.066	4.603	.004 **	8.751	.000 ***	11.938	.000 ***

[a] Male = 1; Female = 2;
[b]1 = no hs diploma; 2 = hs diploma; 3 = some college; 4 = bachelor's; 5 = master's
[c]1=process control, 2=machine tending, 3=assembly/packaging, 4=maintenance
* $p < .05$ ** $p < .01$ *** $p < .001$ (2-tailed)

job type affects satisfaction with pay is not surprising, because pay levels differ among the job types. What is surprising, however, is the effect of job type on satisfaction with supervision and coworkers. This implies that the unique nature of the production technology among the four job types impacts employee interaction with their supervisor and their coworkers. Overall, these findings offer clear support for Hypothesis 2.

The final phase of data analysis involved multiple comparisons to determine which specific job types are significantly different in terms of job satisfaction (Hypothesis 3). Differences in job satisfaction among the four job types is graphically depicted in Figures 2 through 7. Machine tending jobs have the lowest levels of job satisfaction on five of the six scales while maintenance and process control jobs have the highest levels of job satisfaction on all scales, except the promotion scale. Satisfaction with promotion was low for all job types, indicating that most employees see little opportunity for promotion. Overall, graphical analysis clearly supports Hypothesis 3. Job satisfaction clearly differs by job type with higher scores among workers in jobs with the highest AMT motivating potential (maintenance) and lower scores among those in jobs with the lowest AMT motivating potential (machine tending).

Despite, the clarity of the graphical analysis, one must determine whether differences in satisfaction scores among job types is statistically significant. This requires multiple comparison tests of mean differences between satisfaction scores among the job types. Dunett's T3 multiple comparison test was chosen for this analysis because it does not assume equal group size as do more popular multiple comparison tests, like Tukey HSD. Group size varies considerably among job types from only 78 employees in process control jobs to 227 employees in machine tending jobs. Since, intrinsic job satisfaction was of interest in Hypothesis 3, multiple comparisons were performed for only the Work and Job in General scales. Significant p-values ($p<.01$) were found for all comparisons involving machine tending jobs. No other comparisons emerged as significant. Therefore, only machine tending jobs stand out as having statistically different job satisfaction scores. Higher scores on maintenance jobs are overshadowed by dramatically lower machine tending scores. This analysis offers partial support for Hypothesis 3. Jobs that were rated lowest in AMT motivating potential in Table 3 (machine tending jobs) are, in fact, the least satisfying jobs. Higher satisfaction scores among those rated highest in AMT motivating potential (maintenance jobs) did not reach statistical significance.

Discussion

The purpose of this study was to provide a preliminary test of the AMT model proposed by Wall et al. (1990a)

Table 6: Regression Statistics for Job Type Controlling for Age and Education

JDI Scale	Job Type							
	Process Control (N=78)	Machine Tending (N=227)	Assembly/ Packaging (N=85)	Maintenance (N=85)	F	R^2	R	P
Work	28.9	16.9	24.9	27.6	30.232	.149	.386	.000 ***
Pay	30.3	28.6	25.9	35.8	6.902	.042	.205	.000 ***
Promotion	12.5	9.7	13.5	9.8	0.804	.005	.071	.102
Supervisors	29.1	28.3	31.6	34.9	3.899	.024	.155	.009 **
Coworkers	31.7	26.5	31.3	36.0	6.026	.036	.190	.000 ***
Job in General	37.3	26.5	34.6	35.6	15.736	.086	.293	.000 ***

* $p < .05$ ** $p < .01$ *** $p < .001$ (2-tailed)

Figure 2
Satisfaction with The Work Itself
(Mean and 95% Confidence Interval)

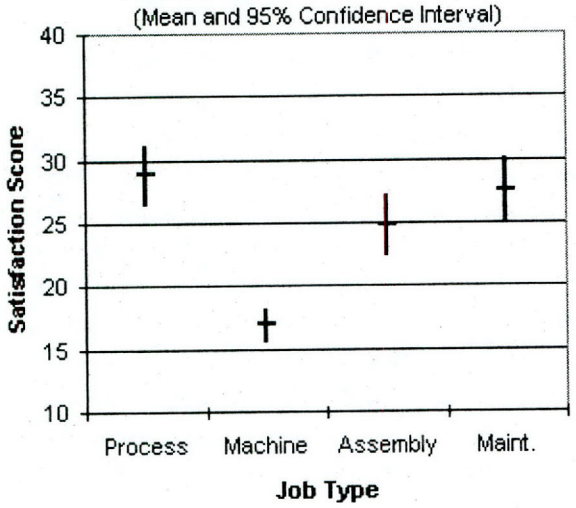


Figure 3
Satisfaction with Pay
(Mean and 95% Confidence Interval)

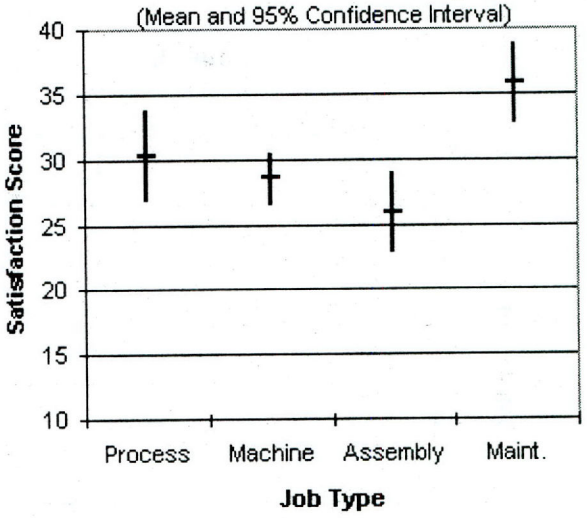


Figure 4
Satisfaction with Promotion
(Mean and 95% Confidence Interval)

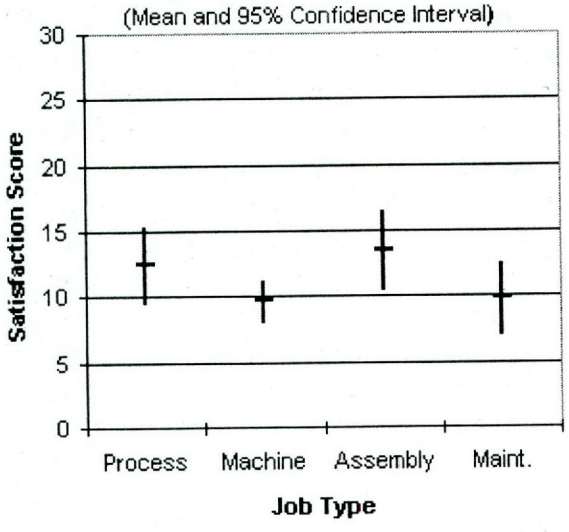
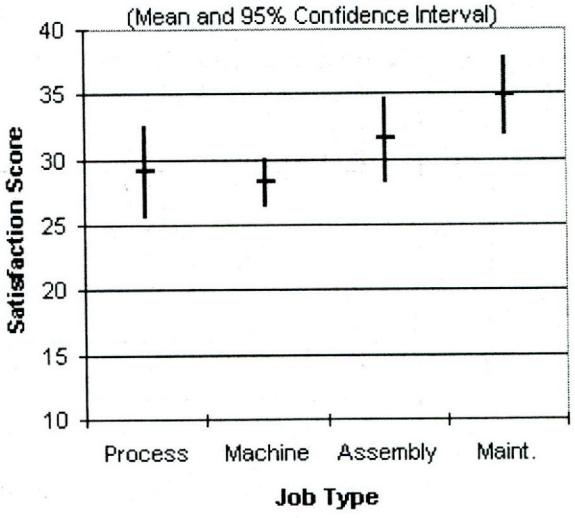
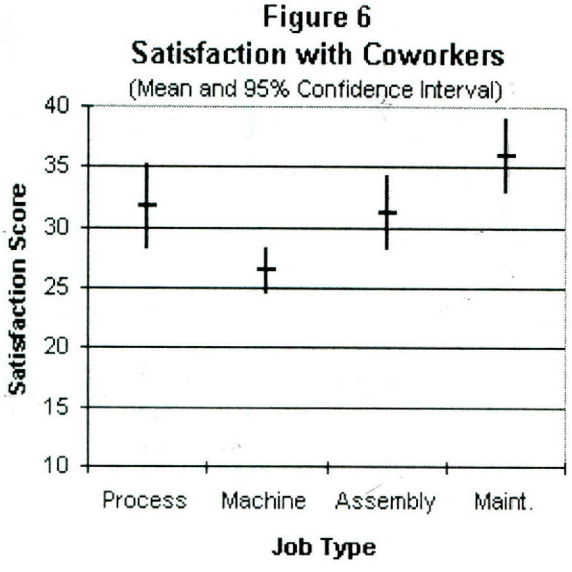
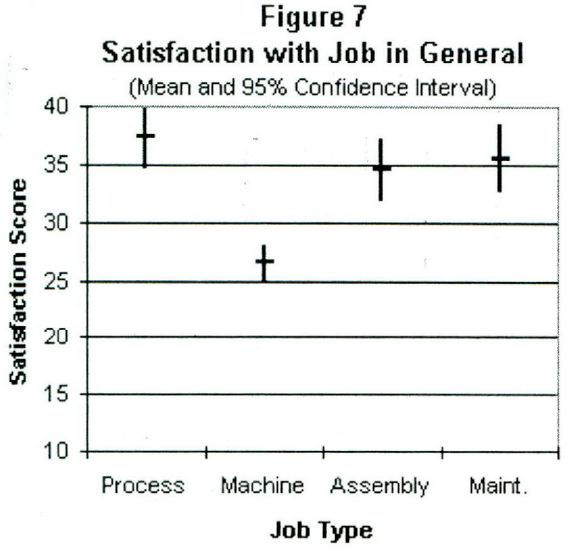


Figure 5
Satisfaction with Supervision
(Mean and 95% Confidence Interval)







among a large sample of shopfloor employees working in variety of jobs in an AMT plant. Specifically, the study was designed to determine whether job satisfaction differed significantly among four distinct types of factory jobs and to determine whether differences in intrinsic job satisfaction among these job types was consistent with predictions of the AMT model. Overall, findings in this study demonstrated that job satisfaction differs greatly among the four types of factory jobs, accounting for significant variance beyond the effects of demographic factors. Significant differences in mean levels of intrinsic job satisfaction reflected in the JDI Work and Job in General scales were consistent with the predictions of the AMT model. Workers in machine tending jobs, which had the lowest AMT motivating potential ratings, had, by far, the lowest satisfaction scores.

The primary implication of this study is that it confirms the major propositions of Wall et al.'s (1990a) AMT model which proposes that intrinsic job satisfaction increases or decreases in AMT work as an additive function of the AMT job characteristics. Findings confirm that AMT jobs with little control over timing, methods, and boundary conditions, high monitoring demands, low problem-solving demands, low levels of cost responsibility, little opportunity for social contact, and low levels of social support are clearly the least satisfying jobs on the shopfloor. Jobs with the most satisfying levels of the AMT job characteristics, on the other hand, did not stand out in multiple comparisons. This implies that there may be threshold levels of AMT job characteristics that must be met to avoid dissatisfaction among shopfloor employees. Failure to meet threshold levels of these job characteristics leads to dissatisfaction while efforts to exceed threshold levels may yield only modest increases in intrinsic job satisfaction. Thus, the greatest benefit of the AMT model may rest in its potential for identifying dissatisfying work designs in AMT systems.

Dissatisfaction among machine operators in the present study highlights the need for effective job design in AMT systems. The same technology can be used to enrich or to de-skill jobs depending on the tasks included in the AMT operator's job (Martin and Jackson, 1988). Machine operator dissatisfaction in this study may arise

from the firm's heavy reliance on specialist control. Specialist control restricts machine operators to the mundane rigor of basic machine tending duties leaving responsibility for problem solving, reprogramming, and repair in the hands of specialists. Specialist control is associated with the most dissatisfying levels of the AMT job characteristics (Wall et al., 1990a) and the lowest levels of intrinsic job satisfaction (Wall et al., 1990b). This study demonstrates the potential usefulness of the AMT model in job redesign. Findings in this study indicate that machine operators are in need of some combination of enhanced control over the process, reduced demand for machine monitoring, and increased opportunity for problem solving, responsibility, and social interaction. Movement from the present reliance on specialist control to operator control as described by Wall et al. (1990b) would certainly be a step in the right direction.

This study represents a first step toward using the AMT model to evaluate job design. The technique used to evaluate, score, and derive AMT motivating potential scores for the jobs in this study may be applied to a variety of AMT jobs. The greatest limitation of this study, however, is the lack of objective or perceived measures of the AMT job characteristics. While assessment of these job characteristics is relatively straightforward, the quality of researcher ratings is dependent on the experience, knowledge, and judgment of the rater. The researcher and company officials in the present study were very familiar with the manufacturing processes and the design of the various shopfloor jobs. Ratings of the AMT job characteristics were used only to rank the motivating potential of each job type for the purpose of predicting the most and least satisfying job types. No attempt was made to assess the direct relationship between individual AMT job characteristics and job satisfaction based on these ratings. Such assessments should not be attempted until standardized procedures are developed to measure objective or perceived AMT job characteristics. Development of reliable measures of the AMT job characteristics is perhaps the greatest priority for future work in this stream of research.

This study confirms Blauner's (1964) argument that the nature of the production technology employed on the job greatly influences the work environment and employee reactions to it. Moreover, this study offers preliminary evidence that the AMT job characteristics proposed by Wall et al. (1990a) are useful in predicting work attitudes in today's advanced factories. This suggests a need to update the Job Characteristics Model (Hackman and Oldham, 1975) in favor of an integrative model that incorporates new job characteristics that are more relevant to the advanced, computer-controlled factory of the 21st century. Future research should seek to develop valid measures of the AMT job characteristics proposed by Wall et al. (1990a) which will enable researchers to begin the process of developing and testing an integrative model of job design.

In summary, the present study provides preliminary support for the AMT model in a large-scale study of shopfloor employees in an AMT plant. Correspondence between satisfaction scores and ratings of AMT motivating potential demonstrate the potential usefulness of these job characteristics in designing AMT jobs. The relatively low satisfaction scores of a large group of AMT machine operators in the present study indicates that problems with AMT job design may be widespread. These factors coupled with the rapid proliferation of AMT systems in manufacturing testify to the enormous potential of this stream of research. Hopefully, this study will spark renewed interest in the AMT model that will lead to the development of reliable measures of AMT job characteristics which, in turn, will facilitate further theoretical development and application of the model to effective AMT job design.

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Covenants Not to Compete: Louisiana vs. Texas

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Introduction

In many businesses, employers and employees enter into covenants not to compete; this is not a new concept. However, covenants not to compete continue to pose legal obstacles to the parties. An employer has an interest in protecting the significant value of proprietary and confidential information. He does not want an employee to take this information and compete against him. On the other hand, it is part of the American dream in our free-enterprise economic system for an employee to be able to walk away from his employer and start his own business. How does the legal system strike a fair balance between the two competing interests?

In 1989, both the Louisiana Legislature and the Texas Legislature made significant changes in their respective statuses pertaining to covenants not to compete. This paper will compare how Louisiana differs from Texas in its attempt to strike a balance between the competing interests of an employer and employee. The paper is limited to a discussion of an employee/employer relationship, not to the circumstances surrounding the sale of a business and an agreement not to compete executed along with the sale. Both statutory and common-law differences among the states will be analyzed. Remedies available under Texas and Louisiana statutes also are examined and compared. Current statutory law is presented with noted case law interpretation an insight.

The Texas Approach

Before 1989, Texas statutory law and case law were confused as to the validity and purpose of employment covenants not to compete. In an effort to stay the confusion, the Texas Legislature passed the 1989 Covenant Not to Compete Act, a bill adding Sections 15.50 and 15.51 to the Texas Business and Commerce Code.[1] In 1993, the Texas Legislature amended Section 15.51 to apply to employment at will. It also added to the act Section 15.52, making it clear that the Covenant Not To Compete Act supplanted the Texas common law relating to covenants not to compete and that the act was to be applied retroactively.[2] Section 15.50 of Subchapter E Covenants Not To Compete of the Texas Business and Commerce Code provides in pertinent part:

> (a) Notwithstanding Section 15.06 of this code, and subject to any applicable provision of Subsection (b), a covenant not to compete is enforceable if it is ancillary to or part of an otherwise enforceable agreement at the time the agreement is made to the extent that it is ancillary to or part of an otherwise enforceable agreement at the time the agreement is made to the extent that it contains limitations as to time, geographical area, and scope of activity to be restrained that are reasonable and do not impose a greater restraint that is necessary to protect the goodwill or other business interest of the promisee.

The Louisiana Approach

In reaction to the Louisiana courts' restrictive interpretation of the covenants not to compete statutes, the Louisiana Legislature completely redrafted the state's non-competition statute in July 1989. Change proponents

of the changes argued that the amendments were needed to rectify the court's flawed interpretation of La. R.S. 23: 921. The new statute consists of a general prohibition of all non-competitive agreements. The general prohibition is followed by four specific exceptions under which non-competing agreements are enforceable. Additionally, the statute sets forth the relief available for the breach of such an agreement. The current statute provides in pertinent part:

> A. Every contract or agreement, or provision thereof, by which anyone is restrained from exercising a lawful profession, trade or business of any kind, except as provided in this Section, shall be null and void.
>
> . . .
>
> C. Any person, including a corporation and the individual shareholders of such corporation, who is employed as an agent, servant, or employee may agree with his employer to refrain from carrying on or engaging in a business similar to that of the employer and/or from soliciting customers of the employer within a specific parish or parishes, municipality or municipalities, or parts thereof, so long as the employer carries on a like business therein, not to exceed a period of two years from termination of employment. An independent contractor, whose work is performed pursuant to a written contract, may enter into an agreement to refrain from carrying on or engaging in a business similar to the business of the person with whom the independent contractor were an employee, for a period not to exceed two years from the date of the last work performed under the written contract.
>
> D. Upon or in anticipation of a dissolution of the partnership, the partnership and the individual partners, including a corporation and the individual shareholders if the corporation is a partner, may agree that one of the partners will carry on a similar business within the same parish or parishes, municipality or municipalities, or within specified parts thereof, where the partnership business has been transacted, not to exceed a period of two years from the date of dissolution.
>
> . . .
>
> G. Any agreement covered by Subsection B, C, D, E, or G of this Section shall be considered an obligation not to do, and failure to perform may entitle the oblige to recover damages for the loss sustained and the profit of which has been deprived. In addition, upon proof of the obligor's failure to perform, and without the necessity of proving irreparable injury, a court of competent jurisdiction shall order injunctive relief enforcing the terms of the agreement.[3]

The new statute vastly expands the scope of the legislative prohibition of non-competition agreements. Unlike the former statute, which prohibited only non-competition agreements between an employer and an employee, Subsection A of the new statute prohibits "every contract or agreement" that restrains competition except those specifically provided for in subsections B, C, D and E. The statute the exempts from this prohibition only those non-competition agreements that are made by an employer and employee, a buyer and seller of a business' goodwill, and the members of a partnership.[4]

A 1993 amendment to this statute added independent contractors to the list of exceptions, and a 1995 amendment added computer programmers. All other non-competition agreements are prohibited by the statute.[5]

Time Geographical Area and Scope of Activity Limitation

It has long been the common law in both Texas and Louisiana that covenants not to compete must contain reasonable limitations as to time, geographical area, and scope of activity. However, the Louisiana Legislature specifically has stated limitations as to time and geographic area in the statute itself.[6] Texas, on the other hand, simply requires that the particular limitation "not impose a greater restraint than is necessary to protect the goodwill or other business interest of the promise."[7]

Time

Texas courts usually have upheld time restrictions of one or two years.[8] In making such a determination, the main factor considered is whether the covenant imposes upon the employee a greater constraint than is necessary to protect the business and goodwill of the employer.[9] In Investors Diversified Services v. McElroy[10], the court upheld a covenant not to compete by selling securities for one year that was limited to current company customers.[11] Also upheld in Travel Masters v. Star Tours,[12] a covenant not to compete in the travel agency industry for two years that was limited to the travel agency's clients and customers list.[13] Regardless of the industry, the time restraint must be specific. In Emergicare Systems Corp. v. Bourbon,[14] a covenant not to compete for one year was not enforced because of an indefinite starting time.[15] Therefore, with respect to time, the Texas courts determine on a case-by-case basis whether the agreement not to compete constitutes a reasonable restraint of trade.

The Louisiana Legislature specifically placed a maximum time limit of two years in the statute.[16] Contracts seeking to extend non-competition agreements beyond the two-year statutory limit are null and void.[17] The two-year limitation begins to run immediately upon the termination of employment.[18] Unlike their counterparts in Texas, Louisiana judges do not have the discretion to determine whether a covenant not to compete for a period greater than two years is reasonable. The Louisiana Legislature has clearly stated any covenant not to compete in excess of two years is illegal.[19]

Geographical Area

As with time restriction, Texas and Louisiana law differ regarding geographical limitation. The Texas Legislature adopted the general language that geographical limitations are valid as long as the covenant not to compete does not impose upon the employee a geographical restraint greater than what is reasonably necessary to protect the business and goodwill of the employer. As with other elements of the covenant, the determination of reasonableness is decided on a case-by-case basis. For example, the limitation of a twelve-mile radius of an animal hospital in Irving, Texas, was found to be unreasonable and unnecessary; evidence was introduced that showing pet owner's travel, on average, two miles for pet care in the Irving area.[20] An example of a geographical area that was deemed reasonable by the Texas courts was a fifty-mile radius in Houston, Texas when the covenant concerned an automobile muffler franchise.[21]

The Louisiana Legislature, on the other hand, specifically mentions in its statute that an employee may agree to restrain from carrying on like a business within a specified parish or parishes, municipality or municipalities, or parts thereof.[22] It is well settled in the Louisiana First, Second, Fourth, and Fifth Circuit Courts of Appeal, that non-competition agreements that fail to specify "parish or parishes, municipality or municipalities, or parts thereof in which the employer carries on a similar business" are unenforceable.[23]

The Louisiana courts' interpretation is so restrictive that savings clauses in non-competition agreements have been declared invalid and unenforceable. For example, in one case, a geographical area encompassed within a non-competition agreement covering seventy-five mile radius of Shreveport or Bossier City made the employment agreement overly broad; the agreement could not rewritten to limit it to the geographical area allowed by statute.[24] Furthermore, in Comet Industries, Inc.,[25] the Louisiana Second Circuit Court of Appeals held that a lack of geographical restriction in an employee's non-competition agreement with an employer was not remedied by an employment agreement's "savings clause." The clause provided that if any provision in a non-competition paragraph was "excessively broad," it would be limited and reduced to make it compatible with applicable law.

Only the Louisiana Third Circuit Court of Appeals has maintained a broad interpretation of enforcement of non-competition agreements. The court held an agreement does not have to specify the parishes of applicability if they are identifiable.[26] The discrepancy among the circuit courts will remain until the Louisiana Supreme Court rules on the issue.

Scope of Activity

Generally two types of scope-of-activity limitations exist: those that prohibit the employee from soliciting the employer's customers and those that prohibit the employee from engaging in any competitive business. Texas and Louisiana common law are similar when it comes to scope of activity.

Texas courts have ruled that "reasonable" limitations on customer solicitation are valid and enforceable.[27] However, the Texas courts have limited their view on what is considered to be solicitation. Accordingly, the courts consider covenants that bar all types of solicitation to be overbroad and unreasonable.[28] To be considered reasonable, the limitation must be based on " a connection between the personal involvement of the former firm member and the client."[29] Covenants against solicitation should be limited to customers with whom the employee had contact during the employment. If the covenant is not limited in this way, the Texas courts will find it overbroad.

In dealing with the limitations that prohibit any competitive activity, the Texas courts generally uphold the limitations when the employer is engaged in a single type of business.[30] When the employer is engaged in multiple business types, the limitation is unreasonable unless it is limited to the specific type of business in which the employee worked for the employer at the time.[31] In one Texas case, a recruiter specialized in placing only data processors Her covenant not to compete provided that she could not work for any other placement agency within a fifty-mile radius of any city in which the firm operated an office. After she was terminated, she went to work for another placement agency but recruited only employees for underwriting positions with insurance companies. The court held that the scope-of-activity limitation in her covenant was overbroad and unreasonable.[32]

Similar to Texas, Louisiana courts have upheld non-solicitation agreements as long as they were limited to the customers for items the employees sold.[33] Otherwise, the agreements would be deemed overbroad and unenforceable.

In dealing with limitations that prohibit any competitive activity, Louisiana courts have differing views. In one case, a production manager for a construction company signed an agreement not to directly or indirectly engage in competition with the employer. Within one year of the agreement, the employee resigned and accepted a job with a competitor. The court held that the non-competition provision in the former employee's contract was overbroad under the non-competition statute and thus unenforceable.[34] In another Louisiana case, the court upheld that a covenant not to compete can be prohibited by non-competition agreement regardless of whether it is the employee's own business or whether the employee works for another.[35]

Enforcement

Both Texas and Louisiana law allow for injunctive relief, damages, or both. Texas law states that under a covenant not to compete, a court may award the promisee damages, injunctive relief, or for a covenant breach by the promisor.[36] Although the Louisiana statute does not specify injunctive relief, it does allow it. The legislature designated non-competition agreements as obligations not to do so.[37] This designation brings such agreements within the realm of Louisiana Civil Code Article 1987, which has been held to allow injunctive relief without the usual requirement of proving irreparable harm.

The Texas Legislature allows a court to reform a covenant not to compete that is deemed overbroad as t time, geographical area, or scope of activity that is not greater than necessary to protect the goodwill or other business interest of the promisee.[38] The Louisiana Legislature does not mention reformation in the statute.[39] A review of jurisprudence since 1989 shows that Louisiana courts have been reluctant to reform covenant not to compete agreements.

Conclusion

It is interesting to observe how state governments differ in addressing a common issue such as covenants not to compete. The approaches taken by the Texas Legislature and Louisiana Legislature to satisfy competing interests

of employers and employees demonstrates the problem's complexity. The Texas approach allows courts more flexibility to determine whether a covenant not to compete should be enforced, reformed, or judged invalid. Texas courts have the freedom to reform an overbroad covenant not to compete and to make it reasonable as it relates to time, area, and scope of activity.

The Louisiana Legislature has approached the issue differently. The state's statute is more restrictive that is Texas'. Louisiana courts do not have the flexibility that Texas courts do. While Texas law states a reasonable restraint as to time and geographic area, Louisiana specifically limits its covenants to a maximum of two years and requires an enumeration of the geographical area. Both states' courts treat the scope of activity requirements similarly.

The enforcement provisions of the respective statutes also differ. Although the two states allow for injunctive relief, damages, or both, Texas okays reformation while Louisiana is silent on the matter. Again, the approach by Texas allows its courts greater flexibility than Louisiana's are given.

Notes

[1] Tex. Bus. & Com. Code Ann. 15.50-.52 (Vernon Supp. 2000)
[2] Id. At 15.51-.52
[3] La. Rev. Stat. Ann. 23:921 (West Supp. 2000)
[4] Id.
[5] Id.
[6] Id.
[7] Tex. Bus. Comm. Code Ann. 15.50 (Vernon Supp. 2000)
[8] Investors diversified Services V. McElroy, 645 S.W. 2d 338, 339 (Tex. App. – Corpus Christi 1982, no writ); Travel Masters V. Star Tours, 742 S.W. 2d 837, 840 (Tex. App. –Dallas 1987, writ dism'd w.o.j); Property Tax ass'n V. staffeldt, 800 S.W. 2d 349, 350 (Tex. App. –El Paso 1990, writ denied)
[9] Wabash Life V. Garner, 732 F. Supp. 692 (N.D. Texas 1989)
[10] 645 S.W. 2d 338 (Tex. App. – Corpus Christi 1982, no writ)
[11] Id at 339
[12] 742 S.W. 2d. 837, (Tex. App. Dallas 1987, writ dism'd w.o.j.)
[13] Id. At 840
[14] 942 S.W. 2d 201 (Tex. App. –Eastland 1997, n writ)
[15] Id. At 203
[16] See supra note 3
[17] Cellular One, Inc V. Boyd, 653 So 2d 30 (La. App. 1cir 1995)
[18] Allied Bruce Terminex Companies, Inc. V. Ferries, 634 So 2d 44 (La. App. 1cir 1994)
[19] See supra note 3
[20] Cukjarti V. Burkett, 772 S.W. 2d 215, 217 (Tex. App. – Dallas 1989 no writ)
[21] Meineke Discount Muffler V. Jaynes, 999 F. 2d 120, 123 (5th Cir. 1993)
[22] See supra note 3
[23] Sentilles Optical Services V. Phillips, 651 So 2d 395 (La. App. 2nd Cir., 1995); Medivision V. Germer, 617 So 2d 69 (La. App. 4th Cir. 1993); Daiguiri's III On Bourbon, Ltd. V. Wandflush, 608 So 2d 222 (La. App. 5th Cir. 1992); Lafourche Speech & Language Services, Inc. V. Juckett, 652 So 2d 679 (La. App. 1st Cir. 1995)
[24] Amcon of Louisiana, Inc. V. Battson 666 So 2d 1227 (La. App. 2nd Cir. 1996)
[25] Comet Industries, Inc. V. Colvin, 600 So 2d 89 (La. App. 2nd Cir. 1996)
[26] PHI, Inc. V. Untereker, 731 So 2d 965 (La. App. 3rd Cir. 1999)
[27] Ruscitto V. Merrill Lynch, 777 F. supp. 1349 (N.D. Tex. 1991)
[28] Peat Marwick V. Haas, 818 S.W. 2d 381, 387 (Tex. 1991)
[29] Id. At 338
[30] Property Tax Ass'n, Supra note 8
[31] Diversified Human Resources V. Levinson-Polakoff, 752 S.W. 2d 8 (Tex. App. – Dallas 1988, no writ)
[32] Id. At 11
[33] Soriano Bros., Inc. V. Sullivan 719 So 2d 131 (La. App. 4th Cir. 1998)
[34] Swat 24 Shreveport Bossier, Inc. V. Bond, 759 So 2d 1047 (La. App. 2nd Cir. 2000)
[35] Sariano Bros., Inc. Supra note 33
[36] Tex. Bus. & Comm. Code Ann 15.51 (Vernon Supp.)
[37] See supra note 3

[38] See supra note 36
[39] See supra note 3

Is Economic Freedom Good or Bad for the Economy

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Introduction

Economists have long argued that the freedom to own property, trade, and earn a profit are essential ingredients for economic progress. Indeed, a number of recent empirical studies have found a positive relationship between economic freedom and growth (see, e.g., Barro 1991; Barro 1994; Scully and Slottje, 1991; Vanssay and Spindler, 1994; Torstensson, 1994). It seems that economic freedom generates the proper incentives for entrepreneurial activity, hard work, and the efficient use of resources. On the other hand, it is generally believed that the efficiency and wealth created by the free market system comes at the expense of other social goals, such as economic equality and a clean environment. The purpose of this study is to investigate the second concern. Specifically, a cross-country analysis is used to determine the effect of various types of economic freedom on per capita CO_2 emissions. Since the greenhouse effect and global warming are major environmental concerns and since economic freedom is considered vital for economic growth, the link between the two is of great importance.

The paper is organized as follows. The second section provides some theoretical considerations on the relationship between economic freedom and the environment. The data are presented next, followed by the estimation results. The paper ends with a brief summary of the main points.

Some Theoretical Considerations

The relationship between economic freedom and the environment is complex. CO_2 is a global pollutant. As such, there is a free-rider problem that complicates the reduction of emissions. In addition, there are several components of economic freedom that may be important for environmental quality. Three simplified hypotheses may help in our understanding of the issue.

First, a quadratic, or inverted U-shaped, relationship may exist between CO_2 emissions and government intervention in the economy. In countries with little government involvement, increases in public expenditures are likely to focus on industry and infrastructure development. Naturally, these projects will involve an increase in environmental degradation. At higher levels of government intervention, however, the public sector takes on a greater role as a redistributive agent, which results in increased income equality. This, in turn, has a positive effect on the demand for environmental quality (Magnani, 2000). Also, to the extent that a clean environment is a luxury good, it is likely that this good will only be demanded when the demand for other public goods has been satisfied. This is most likely to occur at high levels of government intervention.

Second, lower inflation rates and a stable macroeconomic environment lead to more efficient investment decisions and encourage long-term investments. Lack of price stability is a serious problem for development since investment declines when price signals are not clear. Most

environmental investments involve long time horizons and will not be made without a belief that the economy will be stable until the payoffs are received. As a result, a stable macroeconomic environment can have a positive effect on the environment.

A third component of economic freedom that is likely to impact CO_2 emissions is the extent to which environmental regulations are imposed on industry. These regulations may take the form of direct control of pollution by the state or indirect control through a system of tax incentives. In either case, greater regulatory burdens on business are expected to reduce CO_2 emissions.

The Data

The data, except for the freedom measures, come from *World Development Report 2000/2001*. CO_2 emissions, measured in metric tons per capita, are emissions stemming from the burning of fossil fuels and the manufacture of cement. They include contributions to the carbon dioxide flux from solid fuels, liquid fuels, gas fuels, and gas flaring. The GDP per capita data is converted into international dollars using purchasing power parity.

The data on economic freedom are obtained from the Heritage Foundation's *Index of Economic Freedom*. To measure economic freedom and rate each country, the authors of the *Index* study 50 independent economic variables. These variables fall into 10 broad categories, or factors, of economic freedom: trade policy, taxation, government intervention in the economy, monetary policy, capital flows and foreign investment, banking, wage and price controls, property rights, regulation, and black market. Each country is rated for every category on a scale between one and five. Three of the categories are used to test the hypotheses described in section 2: government intervention in the economy, monetary policy, and regulation. A brief description of these categories is given in Table 1.

The sample includes 135 countries and all data are reported for the year 1999. Descriptive statistics are presented in Table 2 and the correlation matrix is presented in Table 3. Note that all variables except *Government Intervention* are positively correlated with CO_2 and all of the freedom variables are positively correlated with *Per Capita GDP*.

Empirical Analysis

In an effort to answer the question how economic freedom relates to the environment, a linear regression model is used. CO_2 emissions are assumed to be a function of

Table 1: Description of Freedom Categories

Category	Description
Government Intervention	• Government consumption as a percentage of the economy • Government ownership of businesses and industries • Share of government revenues from state-owned enterprices and government ownership of property • Economic output produced by the government
Monetary Policy	• Average inflation rate from 1991 to 1999
Regulation	• Licensing requirements to operate a business • Ease of obtaining a business license • Corruption withing the bureaucracy • Labor regulations • Environmental, consumer safety, and worker health regulations • Regulations that impose a burden on businesses

Table 2: Descriptive Statistics

	Mean	Std. Deviation	Minimum	Maximum
CO_2	1.38	2.31	0	22.05
Per Capita GDP	7477.68	8242.29	414	38247
Government Interention	3.27	0.87	1	5
Monetary Policy	2.91	1.54	1	5
Regulation	2.58	0.92	1	5

Table 3: Correlation Matrix

	CO_2	Per Capita GDP	Government Interention	Monetary Policy	Regulation
CO_2	1				
Per Capita GDP	.795**	1			
Government Interention	-0.079	.185*	1		
Monetary Policy	.314**	.587*	0.101	1	
Regulation	.345**	.663**	.323**	.528**	1

Table 4: Results of Regression Analysis

Variable	Coefficient
Per Capita GDP	.0821
	(10.940)***
Government Intervention	0.407
	(1.668)*
(Government Intervention)^2	-0.454
	(-1.641)*
Monetary Policy	-0.189
	(-2.984)***
Regulation	0.136
	(1.939)**
N = 135	
R^2 = 0.667	
Adjusted R^2 = .0654	
F-test 52.004	

Notes:
t-values are reported in parenthesis
*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant atthe 0.10 level

per capita GDP and the various measures of economic freedom. The squared term of the variable *Government Intervention* is included in the model to test the possibility of a quadratic relationship.

Table 4 presents the results of the regression model. Consistent with other studies, the model indicates a positive relationship between Per Capita GDP and CO_2 emissions. The estimated coefficients for the *Government Intervention* variables imply an inverted U-shaped relationship between the freedom variable and CO_2 emissions, with a turning point at an index value of 3.1. Consequently, in economies with relatively low levels of government intervention, an increase in freedom (less government intervention) reduces emissions, while the opposite is true at high levels of government intervention.

Regarding the other economic freedom variables, the estimated coefficients support the original hypotheses. Price stability has a negative impact on CO_2 emissions. This is consistent with an earlier finding by Munasinghe and Cruz (1995) that removal of price distortions contributes to both economic and environmental gains. Furthermore, CO_2 emissions are an increasing function of regulatory freedom. In countries that impose fewer business regulations, CO_2 emissions tend to be higher.

Conclusions

The results in the previous section should be interpreted with some care. Economic freedom is difficult to quantify. The *Index of Economic Freedom* used in this study, while consistent with other measures of economic freedom, may be conceptually flawed. Moreover, it is not possible to directly relate the economic freedom indices to the hypotheses described in section 2. As is often the case, it is difficult to know exactly what drives the results. Still, there are some interesting findings.

The study predicts a positive relationship between CO_2 emissions and per capita GDP, which supports earlier studies. Increased economic freedom, in the form of less government intervention, decreases CO_2 emissions when the level of government intervention is low but increases emissions when intervention is high. Increased price stability and greater environmental regulation reduces CO_2 emissions. Hence, the relationship between economic freedom and the environment is complex. Depending on the type of freedom and the extent to which that freedom is guaranteed the effect may be positive or negative.

It would be desirable to extend this analysis to other types of environmental measures and to compare the results using alternative indices of economic freedom. But these are tasks for the future.

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