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Editorial Note

The November 2018 issue of the *Journal of International Business Disciplines (JIBD)* has been the result of a rigorous process in two stages:

- Stage 1: all papers that were submitted to 2018 IABD conference went through blind reviews, and high quality papers were accepted for presentation at the conference.
- Stage 2: approximately ten percent of the accepted articles and two invited manuscripts were selected for possible publication in *JIBD*. The respective authors were contacted and asked to resubmit their papers for a second round of reviews. These manuscripts went through a blind review process. In the end, four articles were recommended for publication in the November 2018 issue of *JIBD*.

JIBD is committed to maintaining high standards of quality in all of its publications.

Ahmad Tootoonchi, Chief Editor
Journal of International Business Disciplines

SUBINSTITUTIONAL ENVIRONMENT AND EXPROPRIATION OF MINORITY SHAREHOLDERS IN CHINA

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ABSTRACT

This study examines how the subinstitutional environment impacts the incentive of controlling shareholders to expropriate minority shareholders and how the coercive pressure from increased government regulation interacts with the subinstitutional environment to alter the practices of financial tunneling by controlling shareholders. With a sample of Chinese public firms, we find that subinstitutional environments with more developed legal and market institutions alleviate minority shareholder expropriation. When a regulatory agency illegalizes the use of intercorporate loans, controlling shareholders turn to transfer pricing for expropriation and transfer pricing is more severe in subinstitutional environments with highly developed legal and market institutions. Our findings highlight both the strong incentive of controlling shareholders to expropriate at differing levels of subinstitutional environment, and the challenges confronting regulatory agency in emerging economies where external mechanisms for firm control is far from being developed.

INTRODUCTION

Agency theory, focusing on conflicting interests of principals and agents, is derived from and more applied to developed economies (Jensen & Meckling, 1976; Young et al, 2008). Agency problem in transition economies has manifested itself more in principal-principal conflict, which refers to minority shareholders expropriating or tunneling (Dharwadkar, George & Brandes, 2000; Johnson, La Porta, Lopez-de-Silanes, & Shleifer, 2000). Controlling shareholders realize the control right using pyramidal ownership structure or cross-holdings (Claessens, Djankov & Lang, 2000; Lins, 2003). Faced with low cash flow rights, controlling shareholders have the incentive and ability to divert resources from controlled companies at the expense of other large shareholders (Lemmon & Lins, 2003). As shown by Shleifer and Vishny (1997), controlling shareholders can employ different means to expropriate such as “outright theft, dilution of outside investors through share issue to insiders, excessive salaries, asset sales to themselves or other corporations they control at favorable prices, or transfer pricing with entities they control" (c.f. Lemmon & Lins, 2003).

The expropriation problem is attributed to the lack of legal institutions and inadequate enforcement of laws, and the underdevelopment of financial markets, such as lack of takeovers (La Porta, Lopez-de-Silanes, Shleifer & Vishny, 1998, 2000). Existing research focuses on the effect of institutional environments in developing economies on the behavior of controlling shareholders (La Porta et al, 1998), and the effect of expropriation on firm valuation (Lemmon & Lins, 2003; Claessens et al., 2002). Overall, the institutional environment is an antecedent (Young et al, 2008). Prior literature on corporate governance treats institutional environment as a given and static, emphasizing the deterministic nature of institutional environment on corporate governance in emerging economies, and measuring it at the national level. Dichotomizing the institutional environment along the spectrum from weak to strong at the national level could lead to ignoring the differing effects on expropriation behavior of controlling shareholders of subinstitutional environments within the territory of one country.

Further, considering that institutional environments are changing due to the introduction of new regulations on corporate governance in transition economies, the corresponding changes of expropriation behavior from controlling shareholders could not be captured when a homogeneous institutional environment is assumed at a national aggregate level. In sum, such treatment of the institutional environment is inadequate to capture the dynamics of corporate governance evolution within one country. Homogeneous institutional environment is far from being a realistic picture of corporate governance in emerging economies.

Many important research questions remain unanswered. Drawing on agency theory and institutional theory, our research attempts to resolve three research questions. (1) Does institutional heterogeneity within one country moderate the relationship between controlling shareholding and expropriation of minority shareholders? (2) Does the increased regulatory pressure mitigate the expropriation problem in a transition economy? (3) How does expropriation of minority shareholders evolve over time within one transition economy?

We choose to test our theory using publicly traded firms in China for three reasons. First, as an emerging economy, China is characterized by unbalanced development of legal and market institutions across its territory. Its coastal areas have the most dynamic economy, and the protection of property rights and investors is highest according to the composite marketization index compiled by Fan, Wang and Zhang (2010), followed by middle and western areas with lower marketization indices, respectively. This feature of heterogeneous institutional environments enables us to find the effect of institutional heterogeneity on expropriation. Previous research has afforded us the preliminary evidence to examine differential effect of subinstitutional environments on firm behavior in China. Wang, Wong, & Xia (2008) find that in areas with less developed legal and market institutions, publicly listed state owned enterprises (SOEs) are more likely to hire small local auditors, which suggests there are incentives for local SOEs to collude. Luo and Tang (2007) find that market environment, characterized by less government intervention and more developed financial markets, mitigates the tunneling behavior of controlling shareholders.

Second, by the end of 2005, China Securities Regulatory Commission, with the coordinated efforts of State Council of China, explicitly declared the use of intercorporate loans by controlling shareholder as illegal. Before 2005, it was prevalent for controlling shareholders to borrow large sum of funds from listed companies they controlled and never pay back. An intercorporate loan was a dominant tunneling strategy before 2005. This exogenous change from regulatory agency in 2005 largely resolves the endogeneity issue arising from each set of specific industry characteristics. The quasi-experimental context allows us to better delineate the effect of regulatory pressure on change of expropriation behavior after the regulation. Extant research on expropriation has limited their timeframe of samples in China to 2005 due to the change in regulatory policy. It is imperative to find whether increased regulatory pressure mitigates the principal-principal conflict or forces controlling shareholders to adopt an alternative expropriation strategy after 2004. This finding will have important policy implications.

Third, investigating expropriation of minority shareholders *over time* can provide us a more realistic and dynamic picture of the problem. Given the large population of developing economies such as China, addressing the expropriation issue can enhance the quality of economic development, benefiting the largest share of the underprivileged population. The significance of studying expropriation problem cannot be overestimated.

Our research contributes to the literature in two respects. First, our research extends institutional theory by showing that the effect of coercive pressure by controlling shareholders on expropriation behavior is dependent on the subinstitutional environment where the focal public firm is headquartered. The extent to which legal and market environment develops impacts the incentive and subsequent expropriation strategy of controlling shareholders. Our results suggest that before year 2005, when intercorporate loans are legal, the more developed the legal and market institutions are in a certain province of China, the less the expropriation of minority shareholders are measured by intercorporate loans. When expropriation by financial tunneling is declared illegal and the law is enforced strictly, the use of intercorporate loans is almost extinct after 2005. However, in provinces where legal and market institutions are more developed, controlling shareholders are more likely to employ transfer pricing to expropriate minority shareholders compared to provinces where legal and market institutions are less developed. We define the differences in development of legal and market institutions across the regional areas as institutional heterogeneity.

Contending that the effect of coercive isomorphic influence derived from regulatory agencies differs across subinstitutional environments, we enrich the neoinstitutional theory. Prior research using institutional theory emphasizes the effect of institutional change on organizational behavior (e.g., Marquis& Huang, 2009). Scholars either assume that the institutional environment is stable and undifferentiated across geographical regions or they ignore the regional differences in institutional environments. With a few exceptions (Tolbert & Zucker, 1983; Jiang et al, 2010), the effect of non-synchronous change of institutions goes unnoticed. We contend that examining the differing impacts of non-synchronous institutional changes within one country would give us a more realistic picture of the dynamics of corporate governance change, such as principal-principal (P-P) conflicts.

Second, our research contributes to agency theory by highlighting that expropriation strategy by controlling shareholders changes over time. Expropriation of minority shareholders is a dominant manifestation of principal-principal conflict in emerging economies. Originating from Anglo-Saxon cultures and applied to developed economies mainly characterized by principal-agent conflict, agency theory can be enriched by examining the principal-principal relations in an institutional environment characterized by weak rule of law and prevalence of expropriation of minority shareholders (c.f. Young et al, 2008). The P-P conflict is well examined in the U.S. context. Hoskisson, Hitt, Johnson, and Grossman (2009) found the differing impacts of heterogeneous institutional investors on firm innovation strategies. Our research also answers the call by Young et al (2008) to examine the P-P conflicts in emerging economies. As pointed out by Fiss (2008), transition economies offer promising areas to study how corporate governance systems and practices change and become persistent. In our study, we find that expropriation of minority shareholders are not only prevalent in China, but also increased regulatory efforts forcing controlling shareholders to adopt expropriation strategies, which are less able to be detected, thereby not eliminating the problem. So our research demonstrates the dilemma that confronts a regulatory agency: by eliminating one form of expropriation of minority shareholders, new forms of expropriation are devised to evade regulatory pressure. In the discussion section, we will propose the remedies to the expropriation problem.

THEORY AND HYPOTHESES

Institutional theory highlights the institutional pressure on organizations. Organizations obtain legitimacy and resources by conforming to three types of isomorphism namely coercive, normative and mimetic (Meyer and Rowan, 1977; DiMaggio and Powell, 1984). Institutions consisting of regulative, normative and cultural-cognitive pillars exert effects on organizations and individuals through three corresponding mechanisms: coercive, normative and mimetic (North, 1990; Scott, 2001). We contend that the regulatory process, through laws and regulations with sanctioning activities, impact the incentives of organizations and individuals and their subsequent behavior. The incentive to conform is contingent on the extent of the law or regulation enforcement. We also argue that institutional environment within one country is not only an antecedent of organizational behavior, but also moderates the relationship of incentive and behavior.

Extant literature investigates the deterministic effects of institutional environment on organizational behavior or the adaptive behavior of organizations under coercive, normative or mimetic pressures (Tober & Zucker, 1983; Haveman, 1993; Kostova & Roth, 2002). The main thread is that institutional environment is an antecedent (Young et al, 2008). Comparative institutional research across countries usually aggregates institutional characteristics at the national level. While characterization of institutional environment at the national level shed much light on the institutional differences across countries, its assumption that institutions within one national territory are changing at the same pace and in the same direction is inadequate in deepening our understanding of the interaction between institutional change and corporate governance within a particular country. First, many developing countries have such a large geographical area that institutional development in the process of globalization is not synchronous. The legal and market institutions are developing in an unbalanced manner. Metropolitan cities in developing countries are more subject to the influence of multinational corporations based in these cities. Legal and market institutions are more developed in the metropolitan areas. The rule of law may play a more significant role in these areas than in other less-developed regions of the same country.

Second, the notion of a homogeneous institutional environment fails to capture the differences of organizational behavior and individual incentives within the territory of one country. While the expropriation of minority shareholders by controlling shareholders in emerging and transition economies is well documented in finance, management and economics literature (e.g. La Porta, Lopez-de-Silanes & Shleifer, 1997; La Porta, Lopez-de-Silanes, Shleifer & Vishny, 2000; Jiang, Lee, &Yue, 2010), how the subinstitutional environment impacts the incentive-behavior relationship *over time* remains unexplored. Overall, the treatment of institutional environment as a homogeneous system hinders the understanding of evolution of corporate governance in developing countries.

Luo and Tang (2007) and Wang et al (2007) have examined the moderating effect of subinstitutional environments using a sample of firms between 2001 and 2003. Our research differs from theirs in two ways. First, we integrate agency theory and institutional theory to explicate the mechanism of how subinstitutional environment changes the incentives of controlling shareholders to expropriate. Second, with new data from 2003 to 2007, we further investigate how the expropriation behavior under coercive pressure changes in differing subinstitutional environments *over time*.

Subinstitutional Environment

To capture the regional differences across 30 provinces in China, the construct of subinstitutional environment has four theoretical dimensions: the government-market relations, the factor market development, the product market development, and the legal environment (Luo & Tang, 2007; Wang et al, 2007; Fan et al, 2010).

One feature of the China economy is that the intervening hand of government is visible in the economy. Quite a number of firms listed on the stock exchanges are state owned enterprises (SOEs). State ownership results in inefficiency and minority shareholder expropriation (Shleifer & Vishny, 1997; Luo & Tang, 2007). Moreover, when central or local government has vested interests in firms they control, issues concerning minority shareholder expropriation would be hard to resolve. The jurisdictional convention in China decides that local courts where the focal firms are registered and headquartered have the jurisdiction authority to resolve the suits filed by minority shareholders against controlling shareholders (refer to the case in the Appendix). Therefore, government-market relations not only affect minority shareholder expropriation, but also the enforcement of contracts. When a decentralized government refrains from getting much involved in the economy, its courts are more likely to be impartial in judging economic cases. A decentralized government is conducive to minority shareholders forming a coalition to protect their legal rights.

Since the factor market overall is not competitive in China, the related party transactions have potential benefits of lowing productions costs if controlling shareholders intend to do so. When factor market is not competitive buying instead of making reduces the transaction costs (Williamson, 1979). Additionally, empirical evidence shows that when public firms have ST status, controlling shareholders in a pyramidal ownership structure prop up resources into the controlled firms (Riyanto &Toolsema, 2004). Thus, the extent to which factor market develops has effect on expropriation behavior.

The related party transaction also includes related party sales. The law and contract enforcement is the fourth essential component of subinstitutional environment. The effect of laws and legal environment on financial tunneling is well documented by La Porta et al. (2003) and Djankov et al. (2008). The prominent role of legal environment makes it a primary component of subinstitutional environment.

Agency problem arises when goals of agents (managers) are incongruent with those of principals (investors). Without effective monitoring, managers would behave in an opportunistic way to maximize their own benefits (Jensen and Meckling, 1976). The principal-agent conflict is more applied to the developed economies with good rule of law than to developing economies with inadequate law enforcement or institutional void (Peng, 2002). As suggested by Eisenhardt (1989), agency theory can be enriched when complemented by other theories and examined in appropriate contexts. The characteristics of institutional environment of emerging economies can make such contribution.

The agency problem is more manifested in principal-principal conflict in emerging economies. One of the major conflicts is the minority shareholder expropriation or financial tunneling (Dharwadkar et al, 2000; Johnson, et al, 2000). There are a variety of expropriation strategies that controlling shareholder can use such as direct theft, transfer pricing of resources to related parties, intercorporate loans borrowed by controlling shareholders.

The ownership structure in Asian economies provides controlling shareholders the incentive and ability to expropriate minority shareholders (Lemmon & Lins, 2010). One distinct feature of the publicly listed firms is concentrated ownership (Ye, Lu & Zhang, 2007). The benefits of controlling a public firm coupled with concentrated ownership outweigh the costs associated with share price discounts, monitoring, bonding and reputation building (Claessens & Fan, 2002). In addition, the control based model of corporate governance makes expropriation problem ubiquitous China (Liu, 2006). Hence two baseline hypotheses are developed.

H1: Controlling shareholding is positively associated with expropriation of minority shareholders.

H1A: Controlling shareholding is positively associated with intercorporate loans.

H1B: Controlling shareholding is positively associated with transfer pricing.

The economic development in China is unbalanced, with coastal areas including Shanghai, Shenzhen, and Beijing being the most developed with middle and western areas of China lagging behind (Fan et al, 2010). The flow of capital investment and diffusion of technology are directed from the east to the west. Therefore the subinstitutional environment of each province may differ, with the east having more developed legal and market institutions, and the west lagging behind and catching up incrementally. Three factors in the coastal areas contribute to the protection of minority shareholders. The widespread use of Internet, the increasingly higher percentage of college graduates and the relatively developed legal and market institutions all increase the incentives of minority shareholders to protect their interest. The potential lawsuits engendered by minority shareholders in the coastal areas decrease the incentives of controlling shareholders to expropriate minority shareholders. The law enforcement institutions are better developed in these areas, making appropriating minority shareholders less attractive. The high technology development, particularly the widespread use of the Internet, mitigates the information asymmetry between majority shareholders and minority shareholder. The monitoring cost of minority shareholders in the coastal areas is substantially decreased due to co-evolution of technology and institutions, easier access information system and increased regulatory efforts of governing body (Eisenhardt, 1989, Nelson, 2008).

Since expropriation strategies differ in their own characteristics, the use of one particular form of expropriation may also vary with the characteristics of subinstitutional environment. Intercorporate loans are almost equivalent to direct theft. Controlling shareholders borrow huge amount of funds from the controlled public firm. They either use it with low or no interest or never intend to pay off. Transfer pricing, in contrast to conspicuous intercorporate loans, is a very covert approach to diverting resources from controlled public firms. It is technically difficult to tell transactions that are normal business conduct from expropriation transactions. In the absence of strict enforcement of law, the incentive to expropriate, however, still remain strong. Given the increased monitoring of minority shareholders and high legal costs involved with borrowing directly from public firms, controlling shareholders tend to use less conspicuous transfer pricing to expropriate. Therefore, we hypothesize that:

H2: The strength of the positive association between controlling shareholding and expropriation of minority shareholders is contingent on the subinstitutional environments where the focal firm is headquartered.

H2A: The association of controlling shareholding and intercorporate loans is weaker for firms headquartered in subinstitutional environments characterized by strong legal institutions and market institutions than those firms headquartered in subinstitutional environments characterized by weak legal institutions and market institutions.

H2B: The association of controlling shareholding and transfer pricing is stronger for firms headquartered in subinstitutional environments characterized by strong legal institutions and market institutions than those firms headquartered in subinstitutional environments characterized by weak legal institutions and market institutions.

When newly issued regulations are devised to reduce transaction cost and are strictly enforced, the overall incentive to expropriate will decrease, and social welfare benefits. If an illegitimate expropriation practice is legally prohibited, continuing such expropriation practice can substantially increase punitive costs incurred to controlling shareholders. Controlling shareholders themselves are less likely to risk themselves. Managers representing controlling shareholders would be held responsible for such expropriation actions.

However, without the overhaul of the whole institutional environment, controlling shareholders may turn to other strategies of expropriation which are still illegitimate but legal. To evade increased regulation, newly invented expropriation practice will be less overt and difficult to be defined as illegal, technically speaking.

On November 1, 2005, the State Council of China on behalf of CSRC issued a directive titled On Improving the Quality of Listed Companies. The directive explicitly mandates that top management of controlling shareholders be punished if controlling shareholder fails to pay back the loans borrowed from the controlled public firm by the end of 2006 (Jiang et al, 2010). This mandate illegalizes the illegitimate practice of intercorporate loans. The directive does not specify that transfer pricing is illegal. As a result, it is hypothesized that

H3: After the explicit prohibition of intercorporate loans by China Securities Regulatory in 2005, the propensity to expropriate minority shareholders shifts to more covert expropriation strategy.

H3A: The use of intercorporate loans to expropriate minority shareholders tends to decrease after 2005.

H3B: The use of transfer pricing to expropriate minority shareholders tends to increase after 2005.

METHODOLOGY

The research population comprises all the public firms listed on Shanghai Stock Exchange and Shenzhen Stock Exchanges in China from 2003 and 2007. We choose the time frame from 2003 to 2007, as 2005 is a cutoff year marking the dramatic change in regulation from CSRC. The quasi-experiment design to a large extent eliminates the endogeneity issue associated with firm and industry characteristics. It allows us to find the effect of increased regulative pressure on change of expropriation strategy.

Three major data sources are Chinese Stock Market and Accounting Research database (CSMAR) and CCER China Stock Database provided by SinoFin Information Services. CSMAR provides comprehensive corporate governance data including related party transactions and intercorporate loans and financial variables such as costs of goods sold and total assets. We retrieved the following information from CCER China Stock Database: CEO duality, independent directors, state ownership, firms' headquarter city, regulated industry and the proportion of shareholding by the largest to the fifth largest shareholder. Previous studies in corporate governance (e.g. Sun & Tong, 2003; Shen & Lin, 2009; Jiang et al, 2010) used these data sources. Data on subinstitutional environment are obtained from Fan et al, (2010). Their report of the marketization process at the provincial level in China is by now the most comprehensive measure of subinstitutional environment.

Our sample consists of 6359 firms in 13 industries ranging from manufacturing, agriculture, mining, information technology, transportation, media and entertainment, utilities, construction, trade, finance, real estate, and travel. These industries are classified according to the 1-digit CSRC industry code.

Dependent Variables

Intercorporate loan (O) represents one of the expropriation strategies employed by controlling shareholders (Shleifer & Vishny, 1997). It is a prevalent illegitimate practice by the controlling shareholders in Chinese public firms (Jiang et al, 2010). We measure intercorporate loans by other receivables owed by controlling shareholder divided by total assets. Cost of goods sold (COGS) is the second dependent variable. We use COGS to measure the impact of transfer pricing. COGS is measured by sales costs divided by sales.

Independent Variables

Controlling shareholding (CS) captures the extent to which the largest shareholder controls the focal public firm. It is measured by the proportion of shares held by the largest shareholder divided by the total shares issued. Related purchase (PUR) is measured by the total amount that public firms spends buying goods from the largest shareholder in a fiscal year. The subinstitutional environment (MKT) is measured using the marketization index compiled by Fan et al (2010). The composite index comprises four components of government-market relations, factor market development, product market development and the legal environment. Subinstitutional environment of a focal firm is defined as the province where the focal firm is headquartered. The regulatory policy mandated by State Council on behalf of CSRC is a dummy variable with 1 indicating the company year after 2005 and 0 before 2005.

Control Variables

CEO duality (DUAL) refers to the situation that CEOs also hold the position of chairman of board of directors. CEO duality affords the CEO more positional power (Finkelstein, 1994). Previous research shows that CEO duality has impacts on the relationship between organizational slack and firm performance, suggesting high CEO discretion (Peng et al., 2010). Further, in public state-owned enterprises (SOEs), board chairman is the highest executive position Therefore, CEO duality can have either deter or facilitate financial tunneling. Given the impact of concentrated power of CEO duality on financial tunneling, we include it in the control variable. CEO duality is a dummy variable coded 1 when the same person holds two positions of CEO and chairperson, otherwise 0.

The effect of independent directors (ID) on deterring tunneling among public firms in China is found to be significant. Controlling for the endogeneity problem, independent directors can curb financial tunneling (e.g. Ye et al., 2007).This variable is continuous, measured by the number of independent directors divided by the total number of directors sitting on one board of a public firm.

Minority shareholders (MS) have mitigating effects on curbing expropriation by controlling shareholders. Among the minority shareholders, institutional investors serve as an effective monitor of the behavior of controlling shareholders (Jiang et al, 2010). Recent years have also witnessed the active actions taken by the minority shareholders as a coalition to protect their own rights when confronting expropriation by controlling shareholders. Therefore to control for the effect, we include the proportion of minority shareholding measured by the total proportion of shares held by the second largest to the fifth largest shareholders. It is a continuous variable.

State owned enterprises behave differently from other types of ownership enterprises (Shleifer & Vishny,1997; Peng et al, 2010). SOEs have conflicting incentives such as providing employment opportunities and profit maximization. The differing incentives affect the corresponding appropriation behavior. This variable (STATE) is a dummy with 1 indicating the controlling shareholder being SOEs, and 0 other types of enterprises.

We include in the control variables company size (SIZE) measured by the natural log of total assets and a dummy variable of REG with 1 indicating a regulated industry and 0 otherwise. Regulated industries include mining, utilities, finance and real estate (Fan et al, 2007). Also controlled for are industry and year.

We use the Tobit model to test H1A and H2A, as 67% of the dependent variable intercorporate loans is 0.

$$\text{FT}=\alpha_0+\alpha_1 CS+\alpha_2 MKT+\alpha_3 CS*MKT+\alpha_4 DUAL+\alpha_5 ID+\alpha_6 MS+\alpha_7 STATE \\ \alpha_8 REG+\alpha_9 SIZE+industry+year+\varepsilon$$

The following model is used to test H1B and H2B:

$$\text{COGS}=\alpha_0+\alpha_1 PUR+\alpha_2 CS+\alpha_3 CS*PUR+\alpha_4 MKT+\alpha_5 CS*MKT+\alpha_6 PUR*MKT+\alpha_7 MKT*CS*PUR \\ +\alpha_8 DUAL+\alpha_9 ID+\alpha_{10} MS+\alpha_{11} STATE+\alpha_{12} REG+\alpha_{13} SIZE+industry+year+\varepsilon$$

The following model is used to test H3A and H3B, respectively:

$$\text{FT}=\alpha_0+\alpha_1 CS+\alpha_2 MKT+\alpha_3 POLICY+\alpha_4 CS*MKT+\alpha_5 DUAL+\alpha_6 ID+\alpha_7 MS+\alpha_8 STATE \\ \alpha_9 REG+\alpha_{10} SIZE+industry+\varepsilon$$

$$\text{COGS}=\alpha_0+\alpha_1 PUR+\alpha_2 CS+\alpha_3 CS*PUR+\alpha_4 POLICY+\alpha_5 CS*POLICY+\alpha_6 PUR*POLICY+\alpha_7 POLICY*CS*PUR \\ +\alpha_8 MKT+\alpha_9 DUAL+\alpha_{10} ID+\alpha_{11} MS+\alpha_{12} STATE+\alpha_{13} REG+\alpha_{14} SIZE+industry+\varepsilon$$

RESULTS

The descriptive statistics are presented in Table 1 and Table 2. Table 1 includes the results of means and standard deviations of variables. Table 2 presents variable correlations.

TABLE 1. MEANS AND STANDARD DEVIATIONS

Variables	Variables	Mean	Std. Dev.
1	Intercorporate Loans	0.01	0.05
2	Costs of goods sold	1.04	0.62
3	Related party purchase	0.04	0.10
4	Controlling shareholding	0.39	0.17
5	Subinstitutional environment	5.85	3.02
6	CEO duality	0.13	0.33
7	Independent directors	0.34	0.07
8	Minority shareholding	0.17	0.13
9	State ownership	0.72	0.45
10	Regulated industry	0.07	0.25
11	Total Assets (in billion Yuan)	12.50	201.00

TABLE 2 CORRELATIONS

Variables	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.193	1									
3	0.032	-0.032	1								
4	0.027	-0.13	0.204	1							
5	-0.054	-0.026	-0.131	-0.036	1						
6	-0.003	0.024	-0.032	-0.063	0.015	1					
7	-0.027	0.04	-0.028	-0.057	0.015	0.035	1				
8	-0.028	0.026	-0.132	-0.497	0.04	0.054	-0.061	1			
9	-0.002	-0.084	0.125	0.277	-0.029	-0.101	-0.122	-0.237	1		
10	-0.024	-0.02	-0.034	0.002	0.08	-0.011	-0.032	-0.042	-0.002	1	
11	-0.103	-0.256	0.12	0.192	0.084	-0.091	-0.14	-0.135	0.232	0.205	1

The test results of hypotheses 1a and 2a are presented in Table 3. H1A predicts that the higher proportion of outstanding shares held by controlling shareholders, the more likely controlling shareholders expropriate minority shareholders by means of intercorporate loans. Based on the results of Model 1 in Table 3, controlling shareholding is positively related to other receivables from controlling shareholders and the relationship is significant (b=0.039, p<0.001). Therefore, H1A is supported.

H2A proposes that the propensity of controlling shareholders to expropriate through intercorporate loans is lessened by subinstitutional environments characterized by strong legal institutions and market institutions where the controlled public firm is headquartered. In Model 2 of Table 3, the coefficient for the interaction term of controlling shareholding by subinstitutional environment (CS&MKT) is negative and significant (b= -0.020, p < 0.01), providing support to H2A.

TABLE 3. EFFECTS OF CONTROLLING SHAREHOLDING AND SUBINSTITUTIONAL ENVIRONMENT (H1A AND H2A)

	Dependent variable：Intercorporate Loans	
	Model 1	Model 2
Independent variables:		
CS	0.039***(3.406)	0.051***(3.910)
MKT	-0.003***(-4.688)	-0.001*(-1.862)
CS*MKT		-0.020**(-2.056)
Control variables:		
Dual	-0.004(-0.752)	-0.003(-0.711)
ID	-0.076***(-3.560)	-0.076***(-3.539)
MS	-0.072***(-4.737)	-0.070***(-4.655)
State	0.008**(1.965)	0.007*(1.871)
REG	-0.014(-0.947)	-0.014(-0.965)
SIZE	-0.003*(-1.765)	-0.003*(-1.741)
Constant	0.059(1.634)	0.050(1.396)
Industry and year dummies	Yes	Yes
Observations	6359	6359
Log Pseudo Likelihood	210.321	212.116

t-values are reported in the parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

To further explore the relationship between controlling shareholding and intercorporate loans in differing subinstitutional environments, we plot the results in Figure 1. As suggested in Figure 1, the minority shareholders expropriation through intercorporate loans rises, as the proportion of shares held by the largest shareholders increases in subinstitutional environment characterized by weak legal and market institutions. This propensity of expropriation is not salient in a subinstitutional environment featuring strong legal and market institutions. We will discuss the reasons for this in the discussion section.

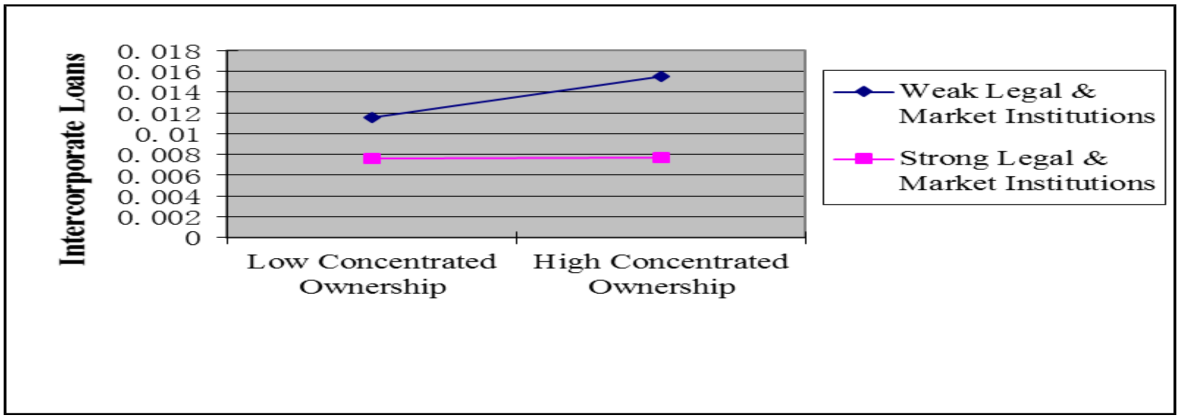

FIGURE 1. EFFECTS OF CONCENTRATED OWNERSHIP ON INTERCORPORATE LOANS

Table 4 presents the models of related party purchase on COGS. Model1 includes the controls and the main effects of controlling shareholding, related party purchase and subinstitutional environment. Model 2 adds the interaction term of controlling shareholding and related party purchase (CS*PUR). Model 3 adds the three-way interaction term of controlling shareholding, related party purchase, and subinstitutional environment (MKT*CS*PUR).

H1B predicts that controlling shareholding is positively associated with transfer pricing measured by related party purchases. Results of model 1 show the coefficient related party purchase (PUR) is positive and significant (b=0.109, p<0.001), supporting H1B. In Model 2, when the interaction term controlling shareholding by related purchase (CS*PUR) is added, the coefficient of related purchase (PUR) is negative and significant (-0.378, p<0.001), indicating that related party purchase itself in firms with controlling shareholders can reduce costs of goods sold. However, the sign of CS*PUR turns to be positive (b=1.014, p<0.001), suggesting that firms using related party purchase have increased costs of goods sold rather than decreased costs of goods sold when controlling shareholders are present. This indicates that controlling shareholders have the incentive and are more likely to increase purchase prices to transfer assets from the public firms they control. Therefore, the results of Model 2 are consistent with our expectations of H1B.

H2B proposes that controlling shareholding is more strongly associated with transfer pricing for firms headquartered in areas characterized by strong legal institutions and market institutions than for firms headquartered in areas characterized by weak legal institutions and market institutions. In model 3, the interaction between controlling shareholding and subinstitutional environment (CS*MKT) is significant and negative (b= -0.131, p<0.01), indicating that minority shareholder expropriation is alleviated in areas with more developed legal and market institutions. However, the coefficient for the interaction term of MKT*CS*PUR is positive and significant (b= 1.001, p<0.01), supporting H2B, suggesting that the more developed the legal and market institutions, the more likely controlling shareholders use related party purchase to expropriate.

TABLE 4. EFFECTS OF RELATED PARTY PURCHASE, CONTROLLING SHAREHOLDING, AND SUBINSTITUTINAL ENVIRONMENT (H1B AND H2B)

	Dependent variable：COGS		
Independent variables:	Model 1	Model 2	Model 3
PUR	0.109***(2.734)	-0.378***(-3.088)	-0.280*(-1.927)
CS	-0.353***(-5.528)	-0.387***(-5.680)	-0.309***(-4.228)
MKT	-0.002(-0.553)	-0.002(-0.517)	0.004(0.963)
CS*PUR		1.014***(4.093)	0.684**(2.469)
CS*MKT			-0.131**(-2.566)
MKT*PUR			-0.294(-1.410)
MKT*CS*PUR			1.001**(2.488)
Control variables:			
Dual	-0.012(-0.480)	-0.011(-0.457)	-0.010(-0.408)
ID	-0.041(-0.308)	-0.046(-0.348)	-0.051(-0.379)
MS	-0.312***(-3.824)	-0.309***(-3.788)	-0.303***(-3.715)
State	-0.003(-0.159)	-0.002(-0.0745)	-0.004(-0.193)
REG	-0.266***(-2.949)	-0.272***(-3.015)	-0.270***(-2.991)
SIZE	-0.137***(-9.141)	-0.137***(-9.154)	-0.137***(-9.154)
Constant	4.431***(12.67)	4.456***(12.66)	4.407***(12.70)
Industry & year dummies	Yes	Yes	Yes
Observations	6359	6359	6359
R-squared	0.097	0.098	0.099

t-values are reported in the parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% level, respectively.

We plot the use of intercorporate loans before and after 2005 in Figure 3 showing that after 2005 when CSRC declares illegal use of intercorporate loans borrowed by controlling shareholders, the illegitimate use of intercorporate loans to expropriate is substantially decreasing. However, related party purchase, an alternative strategy to expropriate minority shareholders, emerges as a salient illegitimate practice.

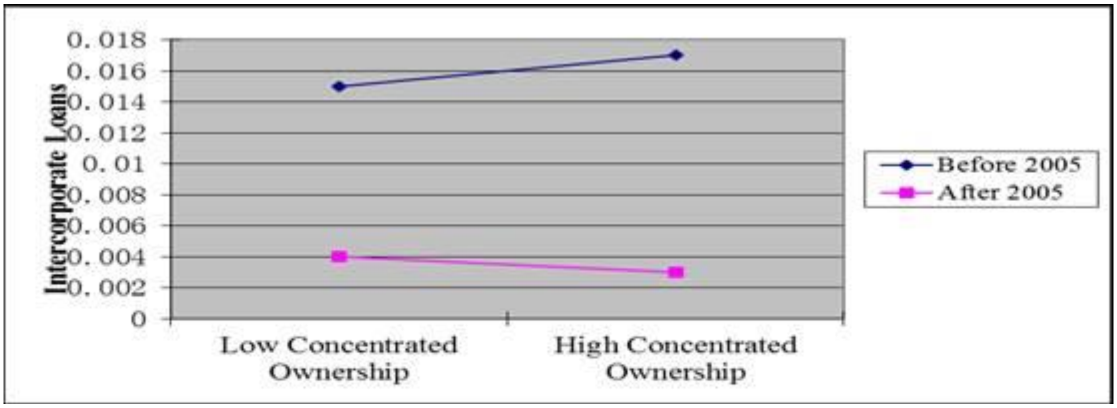

FIGURE 3. USE OF INTERCORPORATE LOANS AS EXPROPRIATION BEFORE AND AFTER 2005

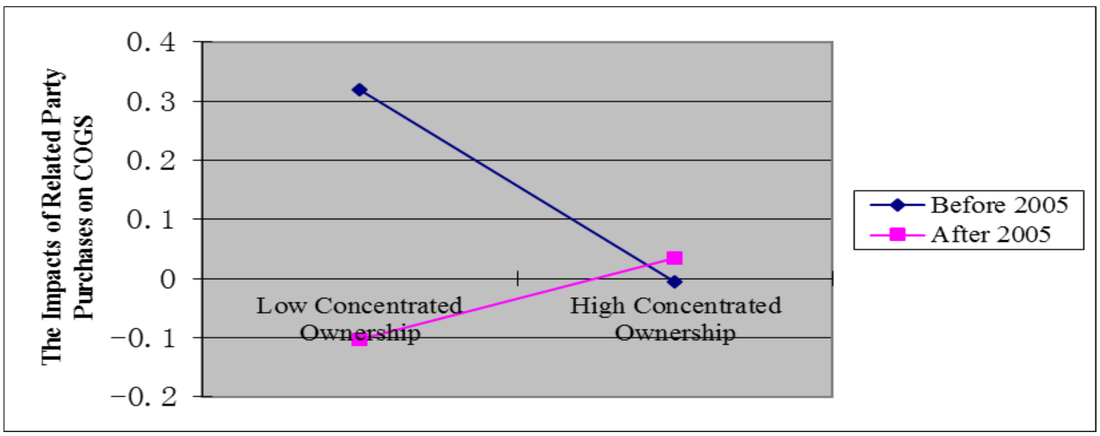

FIGURE 4. IMPACT OF RELATED PARTY TRANSACTION ON COGS

DISCUSSION AND LIMITATIONS

Our research contributes both to institutional theory and agency theory. First, our new construct of institutional heterogeneity explains how the institutional environment at the provincial level impacts the incentive of controlling shareholders to expropriate minority shareholders. The expropriation extent, by means of intercorporate loans and transfer pricing, is less severe in areas with more developed legal and market institutions than in less developed areas in China. Provinces with a high marketization score have less government intervention in the economy and markets play increasingly dominant role in resource allocation. Also, the contract enforcement is relatively strong in these areas. The improved institutions reduce the transaction costs of investor protection (North, 1990). Minority shareholders have increased incentive to protect their interests while the controlling shareholders have increased legal costs if they commit expropriation. Management representing controlling shareholders is more likely to be held responsible for lending out tremendous amount of funds to controlling shareholder.

Second, we find that the more developed the subinstitutional environment, the less likely controlling shareholders expropriate by means of intercorporate loans, and the more likely controlling shareholders employ transfer pricing to expropriate. Though the use of financial tunneling measured by intercorporate loans is illegitimate, controlling shareholders could still commit such practice, as long as they are not punished by law. However, when such illegitimate practice is prohibited by law and has punitive consequences, the illegal use of intercorporate loans becomes extinct and transfer pricing serves as the dominant expropriation strategy by controlling shareholders. Related party purchase—one form of transfer pricing and hard to define as illegal—is even more conspicuous in market-oriented geographical areas.

Our research also has practical implications for regulatory agency. Increased regulation of minority shareholder expropriation can decrease expropriation such as direct theft. On the other hand, due to a lack of external control mechanism to discipline the controlling shareholder's nonproductive behavior, the incentive to expropriate, rather than being lowered, remains still strong. The controlling shareholder could invent and manipulate new strategies to expropriate, which are technically more covert and hard to determine as illegal. This evolution of principal-principal conflict over time highlights the urgency of devising new regulation approach to tackling minority shareholder protection. Further, affording more legal rights to minority shareholders could substantially decrease expropriation incentive. Up to now, China has not allowed the class suit against controlling shareholders. External auditors, increasing the proportion of independent directors, and more shareholding by institutional investors could also contribute to curbing expropriation.

Our research has a few limitations. First, we focus on the shift of expropriation strategies by controlling shareholders without measuring the agency costs. Future research can collectively gauge the costs associated with transfer pricing and intercorporate loans. Second, our sample is drawn contextually from China, therefore, the generalizability of our findings is limited. Future research may extend our research to other countries. Third, we aggregate the minority shareholding as the second largest to the fifth largest shareholders. The mitigating role played by specific institutional investor has not been delineated, providing a potential research avenue. Institutional investors have been found to curb the expropriation behavior of controlling shareholders (Jiang et al, 2010). Future research may focus on the roles of foreign investors, pension funds, or insurance companies in the mitigation of minority shareholder expropriation.

REFERENCES

Claessens, S., Djankov, S., & Lang, L. (2000). The separation of ownership and control in East Asian corporations. *Journal of Financial Economics, 58*(1-2), 81-112.

Dharwadkar, R., George, G., & Brandes, P. (2000). Privatization in emerging economies: An agency theory perspective. *Academy of Management Review, 25*, 650–669.

DiMaggio, P. & Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*(2), 147-160.

Eisenhardt, K.M. (1989). Agency theory: An assessment and review. *Academy of Management Review, 14*(1), 57-74.
Fan, G., Wang, X., & Zhang, Z. (2003). The report on the relative process of marketization of each region in China. *Economic Research Journal, 3,* 259-288. (in Chinese)
Finkelstein, S., & D'aveni, R. A. (1994). CEO duality as a double-edged sword: How boards of directors balance entrenchment avoidance and unity of command. *Academy of Management journal*, *37*(5), 1079-1108.
Fiss, P. (2008). Institutions and corporate governance. In Royston Greenword et al. (EDs.), *SAGE handbook of organizational institutionalism* (pp 389-410). London: Sage Publications.
Haveman, H. (1993). Follow the leader: Mimetic isomorphism and entry into new markets. *Administrative Science Quarterly, 38,* 593-627.
Hoskisson, R., Hitt, M., Johnson, R., & Grossman, W. (2002). Conflicting voices: The effects of institutional ownership heterogeneity and internal governance on corporate innovation strategies. *Academy of Management Journal*, *45*(4), 697-716.
Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs, and ownership structure. *Journal of Financial Economics*, *3*(4), 305-360.
Jiang, G., Lee, C., & Yue, H. (2010).Tunneling through inter-corporate loans: The China experience. *Journal of Financial Economics, 98*(1), 1-20.
Kostova, T., & Roth, K. (2002). Adoption of an organizational practice by subsidiaries of multinational corporations: Institutional and relational effects. *Academy of Management Journal, 45*(1), 215-233.
Johnson, S., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2000). Tunneling. *American Economic Review Papers and Proceedings* 90, 22–27.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1997). Legal determinants of external finance. *Journal of Finance, 52*(3), 1131–1150.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1998). Law and finance. *Journal of Political Economy*, *106*(6), 1113–1155.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1999). The quality of government. *Journal of Law, Economics and Organization*, *15*(1), 222–279.
La Porta, R., Lopez-de-Silanes, F., & Zamarripa, G. (2003). Related lending. *The Quarterly Journal of Economics*, *118*(1), 231–268.
Lemmon, M. L., & Lins, K. V. (2003). Ownership structure, corporate governance, and firm value: Evidence from the East Asian financial crisis. *Journal of Finance, 58*(4), 1445–1468.
Lins, K. V. (2003). Equity ownership and firm value in emerging markets. *Journal of Financial and Quantitative Analysis, 38*(1), 159-184.
Liu, Q., & Lu, J. (2007). Corporate Governance and earnings management in the Chinese listed companies: A tunneling perspective. *Journal of Corporate Finance*, *13*(5), 881-906.
Luo, D., & Tang, Q. (2007). Market environment and the "tunneling" behavior of controlling shareholders: The empirical evidence from Chinese listed companies. *Accounting Research, 4,* 69-74.
Marquis, C., & Huang, Z. (2009). The contingent nature of public policy and the growth of U.S. commercial banking. *Academy of Management Journal*, *52*(6), 1222–1246.
Meyer, J. & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology, 83*(2), 340-363.

Morck, R., Shleifer, A. & Vishny, R. (1988). Management ownership and market valuation. *Journal of Financial Economics, 20,* 293-315.

Nelson, R. R. (2008). What enables rapid economic progress: What are the needed institutions? *Research Policy*, *37*(1), 1-11.

Nelson, R. (1994). The co-evolution of technology, industrial structure and supporting institutions. *Industrial and Corporate Change, 3*(1), 47-63.North, D. (1990). *Institutions, institutional change, and economic performance*. Cambridge: Cambridge University Press.

Peng, M.W. (2003). Institutional transitions and strategic choices. *Academy of Management Review*, *28*(2), 275–296.

Scott, W. R. (2001). *Institutions and organizations*. Thousand Oaks, CA: Sage Publications.

Shen, W., & Lin, C. (2009). Firm profitability, state ownership, and top management turnover at the listed firms in China: A behavioral perspective. *Corporate Governance: An International Review*, *17*(4), 443-456.

Shleifer A, & Vishny R.W. (1997). A survey of corporate governance. *The Journal of Finance, 52*(2), 737-783.

Sun, Q., & Tong, W. (2003). China share issue privatization: The extent of its success. *Journal of Financial Economics*, *70*(2), 183-222.

Tolbert, P., & Zucker, L. (1983). Institutional sources of change in the formal structure of organizations: The diffusion of civil service reform. *Administrative Science Quarterly, 28*, 22-39.

Wang, Q., Wong, T. J., & Xia, L. (2008). State ownership, the institutional environment, and auditor choice: Evidence from China. *Journal of Accounting and Economics, 46*(1), 112–134.

Walsh, J., & Seward, J. (1990). On the efficiency of internal and external corporate control mechanisms. *Academy of Management Review, 15*(3), 421-458.

Ye, K., Lu, Z., & Zhang, Z. (2007). Can independent directors deter financial tunneling of large shareholders? *Economic Research Journal*, 42(4), 101-111.

Young, M., Peng, M. W., Ahlstrom, D., Bruton, G., & Jiang, Y. (2008). Corporate governance in emerging economies: A review of the principal-principal perspective. *Journal of Management Studies, 45*(1), 196–220.

RELATIONSHIPS BETWEEN PROPOSED MEASURES OF TECHNOLOGICAL CHANGE AND EMPLOYMENT IN THE MANUFACTURING SECTOR

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ABSTRACT

Technological change has an impact on the economy of a country in terms of productivity and negative effects on employment in manufacturing. Different technology measures have been used to study the relationship between technology and employment. It is not clear from the literature how these measures relate to employment in manufacturing. In this study, we investigate the relationship between technology measures proposed in the literature (labor productivity, total factor productivity (TFP), GDP per capita, GDP per hour worked, and research and development (R&D) in manufacturing) and employment in the manufacturing sector in the United States. Using transfer function time series analysis, results showed that labor productivity, total factor productivity, and GDP per capita were positively related to employment in manufacturing. GDP per hour worked was not related to employment in manufacturing. Only R&D in manufacturing had a negative impact on employment in manufacturing. If improvement in technology is having a negative effect on employment, then from these results, it seems that the only true measure of technological change is R&D in manufacturing.

INTRODUCTION

The U.S. labor market has witnessed a sharp decrease in employment in manufacturing since the year 2000 (Figure 1). It is generally acknowledged that trade and technology are the two forces that predominantly effect employment in the United States and other developed countries. New technologies in the workplace lead to automation of tasks previously performed by low skilled workers, which contributes to a decrease in employment of unskilled workers and to more demand for skilled labor (Autor and Dorn, 2013; Edwards and Lawrence, 2013).

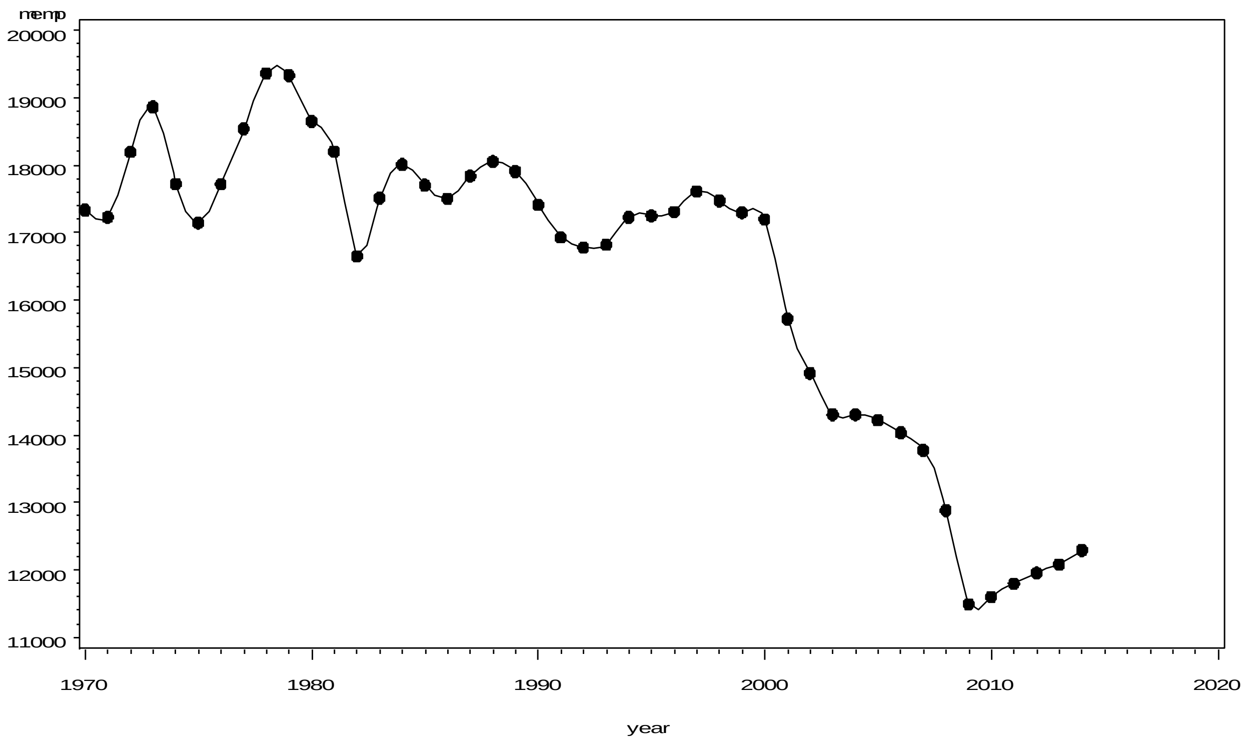

FIGURE 1. PLOT OF EMPLOYMENT IN MANUFACTURING (MEMP) OVER YEARS

There have been several indexes used to measure technological change. Labor productivity and total factor productivity (TFP) are two indexes commonly used to represent technological change. Both are based on comparing input to output. Graham (2016)) pointed out that both indexes have shortfalls in this regard. Technology change is not the only factor that changes labor and total factor productivity. For example, Changes in the quantity of input because of changes in input prices change labor and total factor productivity.

Another measure of technology proposed by Santacreu (2016) of the Federal Reserve Bank of St. Louis is GDP per hour worked. He argued that it might be a better measure of labor productivity than GDP per capita, which has been commonly used. GDP per capita can be influenced by outside variables such as fertility and mortality rates, number of hours worked, and the composition of the labor force.

Kim (2012) reported on indicators used for measuring technological change. R&D is a globally accepted indicator used by the Organization for Economic Cooperation and Development (OECD) for economic growth in terms of technological change.

The literature is mixed on the effect of technology on employment in manufacturing. It is important to determine the relationship of technological change on employment in manufacturing. In this study, we investigate, using time series analysis, the relationship between different technology indexes and employment in manufacturing. Indexes used are labor productivity, TFP, GDP per hour worked, GDP per capita, and R&D in manufacturing. As far as we know, this study is the first to utilize a state-of-the-art time series analysis of this employment problem. It should shed new light on the effect of technological change on employment in manufacturing and will determine which index, if any, is a true measure of technological change in the sense of having a negative effect on employment.

LITERATURE REVIEW

Kuehn and Braschler (1986) reported on employment losses (for the period 1975-1980) due to changes in technology measured by the labor-output ratio, which was defined as the number of employees per dollar of shipments. Increase in labor efficiency induced primarily by new technology, decreased employment in a number of industries. Decline in employment because of technology was 18.5% in the chemical industry. The decline was 21.2% in the electric and electronic industry. In addition, labor saving technology in the textile industry contributed to 18.5% loss in employment. Also, employment in the furniture and fixture industry declined by 20.1%. The authors estimated that 1.8 million jobs were lost from changes in the labor-output ratio.

Autor et al. (2015) reported that exposure to technological change had a negative effect on employment in clerical occupations and routine task-intensive production in the manufacturing as well as the non-manufacturing sectors. However, it was found that exposure to technological change had no effect on overall employment.

Chang and Hong (2013), in a study on change in technology (measured by total factor productivity) and job creation for the 1958 to 1996 period, reported that the effect of technology on labor employment varied across the manufacturing industry. However, the majority of the manufacturing industries hire workers when there is improvement in technology. Contrary to common belief, technological innovation was found to create more jobs in the short and long run.

Freeman et al. (1995) discussed the employment effects of information and communication technology (ICT) in different parts of the world. ICT has had positive and negative effects on employment as is well illustrated in the automobile industry and computers in financial services. In East Asia, ICT has contributed to high output growth, and high growth in productivity and full employment. However, in Europe and Latin America, ICT has contributed more to job reduction than to job creation; this shift to a knowledge-based economy through ICT has had adverse effects on employment and wages of unskilled manual workers.

Jenkins (2008) investigated the effects of trade and technological change on employment in South Africa. His analysis included regressing the log of employment, as the dependent variable, on the independent variables, namely the cost of labor relative to capital and trade variables, such as share of imports in domestic demands, share of exports in total output, and time trend for technological change. He found that both technology and trade had a negative effect on growth in employment in manufacturing in the 1990s. Trade and technology, however, were not the only factors contributing to reduced employment (R^2 in the regression was less than 0.28). Other important factors, not in the regression that were thought to have impacts on employment, were macroeconomic conditions, economic institutions, and social norms. The author argued that these factors, from a policy point of view, should have higher priority than technology and trade in a job creation strategy.

Fisher (2004), in a commentary on why we are losing jobs in manufacturing, stated that the main reason is labor-saving progress in technology. He stated, "An economy undergoing rapid technological progress is one in which some sectors are booming and others are senescent." Manufacturing is senescent and is no longer a primary source of economic growth. The percentage of people employed in manufacturing has declined steadily since the 1960s. The rising income in a prosperous economy like the United States has created more demand for services that resulted in a smaller share of the workforce employed in manufacturing.

Rico (1996), using data from nine firms, analyzed the effect of technological progress in terms of automation on employment in manufacturing. The author concluded that automation has not substantially affected employment in manufacturing. While some jobs were eliminated, others were created and filled by the displaced employees within the same firms. However, it was pointed out that in the long run the prospects for employment in manufacturing were not optimistic.

Chang and Hong (2006), in a study involving 458 manufacturing industries for the period 1958-1996, found that the effect of technology, measured by total factor productivity (TFP), on employment varied greatly across industry. Far more industries showed an increase in employment in the short run because of a positive change in technology, yet these results were contradictory to results by Kiley (1998), who found a negative correlation between labor productivity and employment. Chang and Hong (2006) argued that their results did not conflict with those of Kiley since different measures for technology were used in these studies. Kiley used labor productivity as the measure while Chang and Hong used TFP. Chang and Hong argued that TFP was a better measure of technological change since labor productivity reflects input mix and not only improved efficiency. They argued that TFP, rather than labor productivity, was a natural measure of technology.

In their study, Brynjolfsson and McAfee (2011) argued that IT and automation are contributing factors to reduced employment in manufacturing. Acemoglu et al. (2014), using data from U.S. manufacturing over the period 1980 to 2009, in their study concluded that IT-intensive industry did not show an increase in productivity, which could imply that IT had no effect on reducing employment in manufacturing.

Mullen et al. (2009) studied the effect of investment in technology (measured by spending on research and development and on investment in information and communication technology) by manufacturing companies on employment. They concluded that technology investment significantly decreased employment of unskilled workers in manufacturing.

METHODS

Time Series Transfer Function Model

The transfer function methodology is the best approach to modeling a linear relationship between an input and output time series. A time series transfer function model relating a stationary output series y_t to a stationary input series x_i can be expressed in general as:

$y_t = v(B)\, x_t + a_t$ (1)
where $v(B) = w(B)B^c/\eta(B)$. (1a)
Here, $w(B) = w_0 - w_1B - \ldots - w_sB^s$
$\eta(B) = 1 - \eta_1B - \ldots - \eta_rB^r$.
and c represents the time delay (or lag) until the input variable x_t produces an effect on the output variable y_t.
We assume that the input series follows an ARMA process, $\frac{\varphi(B)}{\theta(B)}$ x_t. The function v(B), with its lags, is determined from the cross correlations between the white noise input series $\frac{\varphi(B)}{\theta(B)} x_t$ and the output series $\frac{\varphi(B)}{\theta(B)} y_t$; namely the significance at a given lag and the pattern of the cross correlations over lags (Wei, 2006).

For instance, if the cross correlation is significant at only lag 0, then Equation (1) becomes
$y_t = w_0x_t + a_t$.

Once v(B) is identified, one can express a_t in Equation(1) as $a_t = y_t - v(B)\, x_t$ (2)
and identify the appropriate time series model for Equation (2). With a_t known, one can determine the final model in Equation (1). For example, if a_t were identified using its autocorrelation and partial autocorrelation characteristics as an AR(1) process ($a_t\,(1-\phi B) = e_t$), then a_t in Equation (1) would be replaced by $e_t/(1-\phi B)$, where e_t is random error.

If y and x are not stationary, then the series can be differenced to make them stationary. Stationarity was determined by the autocorrelation rate of decay over lags and by the augmented Dickey-Fuller test (Wei, 2006; Cryer and Chan, 2008). The SAS software was used to specify v(B), to estimate the parameters of the model, and to test for their significance.

DATA

Data for this study came from the Federal Reserve St. Louis economic data (FRED) and the Bureau of Labor Statistics (BLS). The Labor productivity index, as output per hour all persons and total factor productivity (measured as percent change from previous year) for the manufacturing sector for the period 1988 – 2014, were obtained from the BLS, U.S. Department of Commerce. Data for GDP per capita in dollars for the period 1970-2014 were obtained from FRED. Yearly data for

GDP per hour worked in the U.S. (1970-2014), R&D in manufacturing (1988- 2014) (measured as percent change from previous year), total factor productivity index (national level), and employment in manufacturing in 1000 (1970-2014) were obtained from the FRED database..

EMPIRICAL RESULTS

R&D in Manufacturing

The identified time series model (from equation (1)) relating R&D data in manufacturing (Figure 2) as the input series to employment in manufacturing (differenced once for stationarity) as the output series is:

$$y(1)_t = 247.69 - 1701.9\, x_t + e_t \,, \qquad (3)$$

where $y(1)_t = y_t - y_{t-1}$

y = employment in manufacturing on a yearly basis.

x = Percent change in R&D in manufacturing from the previous year and e_t = random error

All the coefficients in Equation (3) were highly significant ($p < 0.001$). As can be seen from (3), there is a negative relationship between change in employment in manufacturing and the percent of change in R&D in manufacturing. Also, the cross correlation between the two series was negative and highly significant ($r_k = -0.828$ at lag 0). This means that as investment in research and development in manufacturing increases employment in manufacturing decreases. This implies that an improvement in technology has the effect of replacing jobs in manufacturing. If technology has the effect of replacing workers, the R&D in manufacturing proved to be a true measure of technology change.

When R&D in manufacturing, measured as an index, was used, the results were the same, namely a negative highly significant cross-correlation of -0.82 at lag zero between employment in manufacturing and R&D. Unlike R&D in the manufacturing sector, R&D for all industry did not show a significant relationship with employment in manufacturing**.**

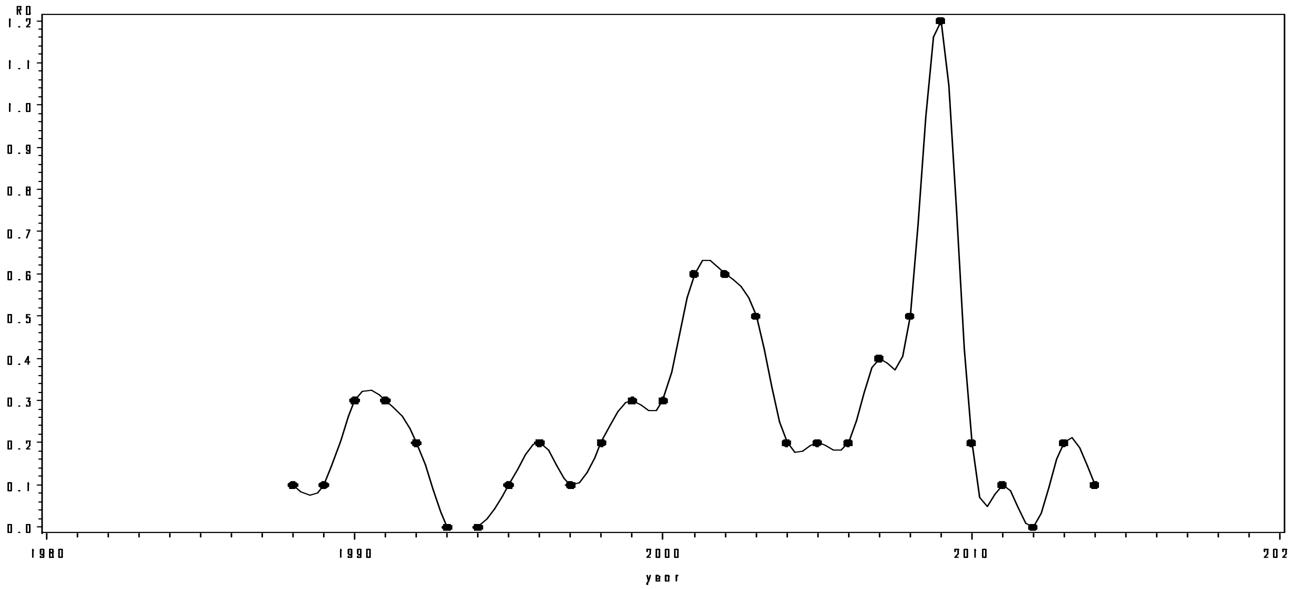

FIGURE 2. PLOT OF PERCENT CHANGE FROM YEAR AGO OF RESEARCH AND DEVELOPMENT (RD) IN MANUFACTURING OVER YEARS

GDP Per Hour Worked

GDP per hour worked used as the input variable in Equation (1) had no significant effect on employment as the output variable.

GDP Per Capita

The GDP per capita (Figure 3), differenced once, was related to employment in manufacturing (on a quarterly basis) through the equation:

$$y(1,4)_t = -42.89 + (0.183\ x(1)_t - 0.093\ x(1)_{t-1})/(1 - 1.54B + 0.85B^2) + (1 - ,65B^4)\ e_t/\ (1-0.46B) \quad (4)$$

Here, y = employment in manufacturing, x is the GDP per capita, B is the Backshift operator, and e is random error. $y(1,4)_t$ was differenced at lags 1 and 4 for stationarity and $x(1)_t$ was the first difference.

All coefficients in Equation (4) were highly significant ($P< 0.001$). Only the p value was 0.066 for the estimate 0.093. In order to determine the relationship between x and y, we multiply ($0.183\ x(1)_t - 0.093\ x(1)_{t-1}$) by (1-.46B) and simplify to obtain the expression
$0.183\ x(1)_t - 0.177\ x(1)_{t-1} + 0.0428\ x(1)_{t-2}$ It is seen that with past values ($x(1)_{t-1}$ and $x(1)_{t-2}$) fixed, employment in manufacturing (y_t) is positively related to a change in GDP per capita ($x(1)_t$) One

can conclude that if improvement in technology works to reduce employment, then GDP per capita is not a good measure of technology, since it is positively correlated with employment.

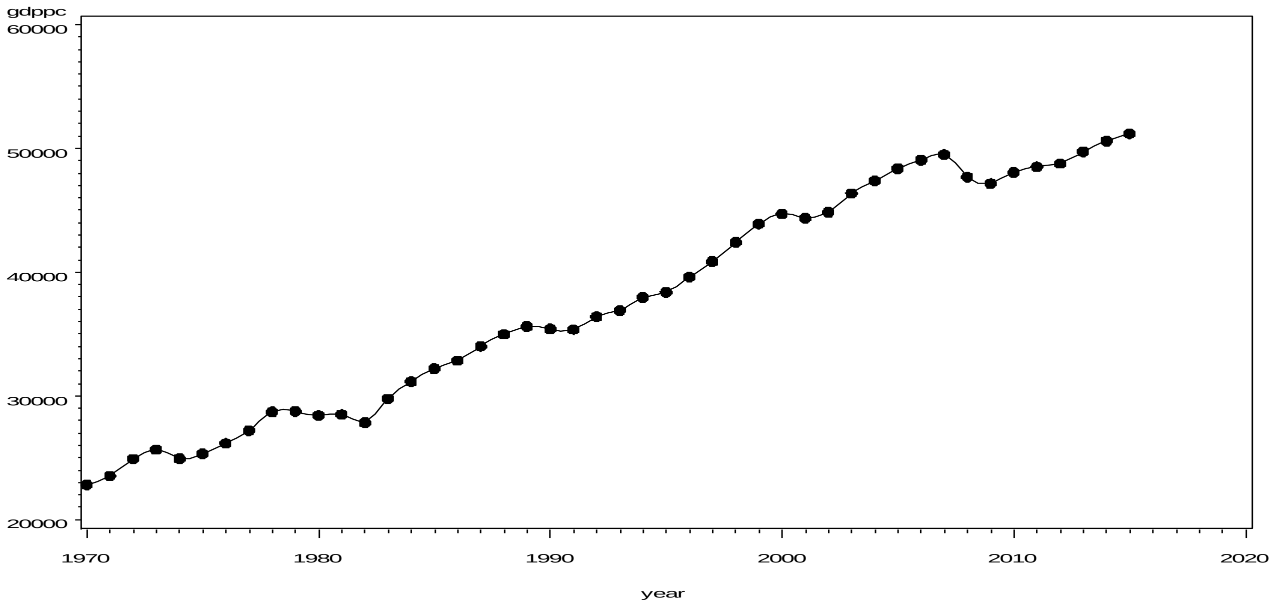

FIGURE 3. PLOT OF GDP PER CAPITA IN DOLLARS (GDPPC) OVER YEARS

Labor Productivity

When labor productivity data (Figure 4), differenced once, was used as the input variable in Equation (1) and employment (on a quarterly basis) as the output variable, the relationship was shown to be:

$y(1,4)_t = -37.36 + 33.75\, x(1)_{t-1} / (1 - 1.108\,B + 0.699B^2) + (1 - 0.633\,B^4)\, e_t / (1 - 0.671B)$ (5)

All the coefficients in Equation (5) were highly significant ($p < 0.001$).

The relationship between x and y can be revealed by multiplying $33.75\, x(1)_{t-1}$ by $/(1 - 0.671B)$ and simplifying to obtain the expression $33.75\, x_{t-1} - 56.4\, x_{t-2} + 22.65\, x_{t-3}$. With x_{t-2} and x_{t-3} fixed, employment (y_t) is positively related to labor productivity (x_{t-1}).

Hence, an increase in labor productivity will increase employment in manufacturing (The effect manifests itself after a one quarter lag or delay) This is contrary to expectation if labor productivity is a true measure of technological change, which has been proposed to be negatively related to employment.

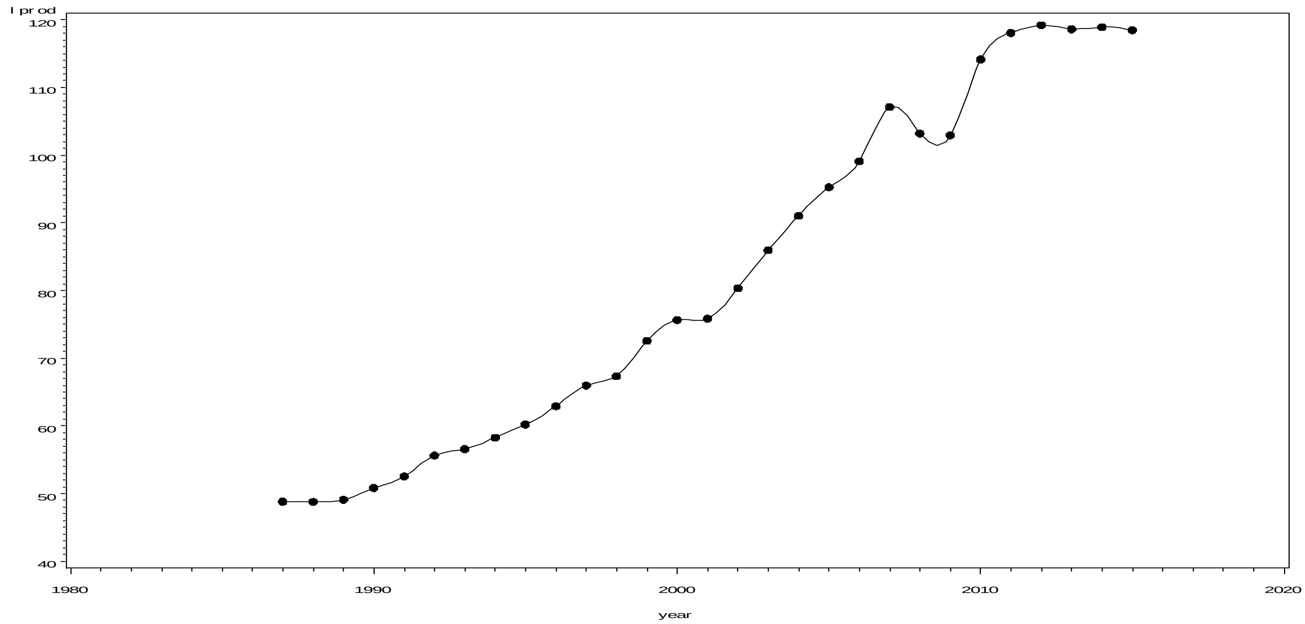

FIGURE 4. PLOT OF LABOR PRODUCTIVITY OVER YEARS

Total Factor Productivity (National Level)

The relationship of the input series, total factor productivity (Figure 5), differenced once, and the output series employment in manufacturing (on a yearly basis) was identified as:

$$y(1)_t = -383.27 + 39310.3\, x(1)_t + e_t / (1-.51B) \quad (6)$$

It is clear from Equation (6) that there is a positive relationship between total factor productivity and employment in manufacturing. Multiplying 39310.3 $x(1)_t$ by (1-.51B) and simplifying, one obtains the expression 39310.3 x_t – 59358.55 x_{t-1} + 20048.25 x_{t-2}.

As can be seen, an increase in total factor productivity at time t (x_t) (with x_{t-1} and x_{t-2} fixed) will increase rather than decrease employment. This indicates that total factor productivity is not a good measure of technological change, assuming that an increase in technology would have a negative effect on employment.

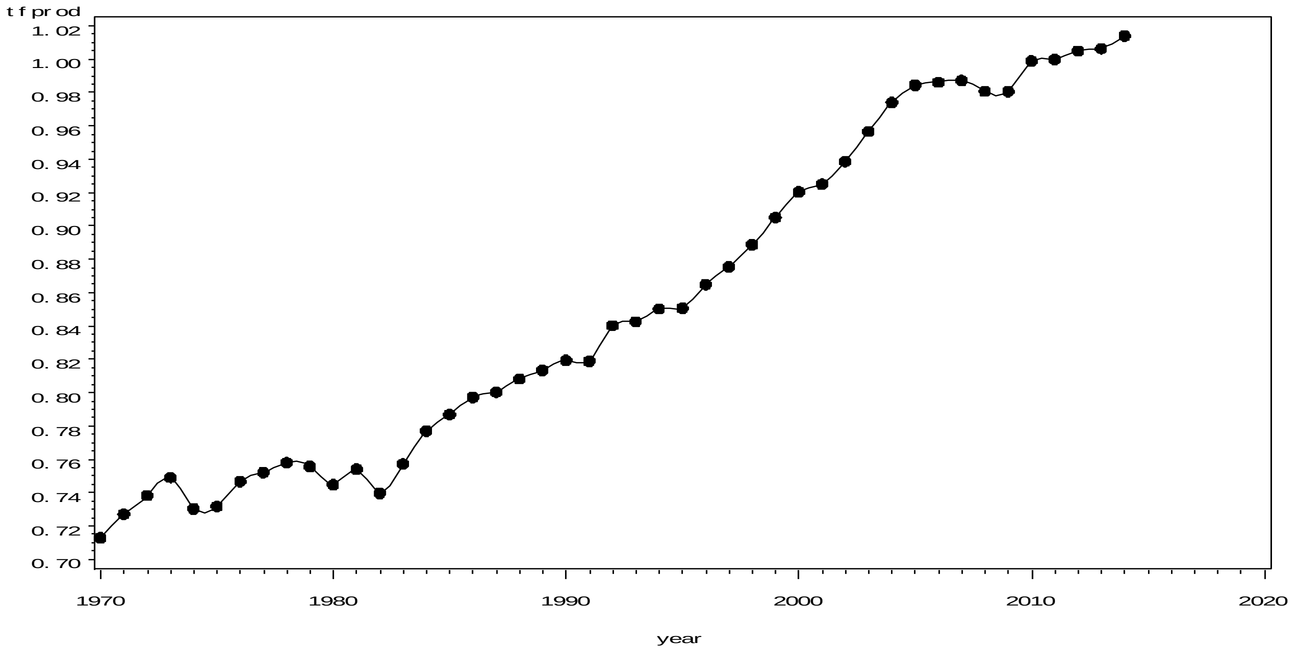

FIGURE 5. PLOT OF TOTAL FACTOR PRODUCTIVITY IN THE US (TFPROD) OVER YEARS

Total Factor Productivity in Manufacturing

The total factor productivity in manufacturing as the input series x (measured as percent change from the year before, Figure 6) was related to employment in manufacturing y (on a yearly basis) as follows:

$$y(1)_t = 122.97\ x_t + e_t/(1\text{-}0.783B) \qquad (7)$$

The coefficients in (7) were highly significant ($p< 0.001$).

Multiplying 122.97 x_t by (1-0.783B) and simplifying, one has the inequality 122.07 $x_t -$ 96.28 x_{t-1}. This shows that an increase in total factor productivity at time t (x_t) (with x_{t-1} fixed) will increase employment in manufacturing. This is contrary to expectation if total factor productivity is a good measure of technology.

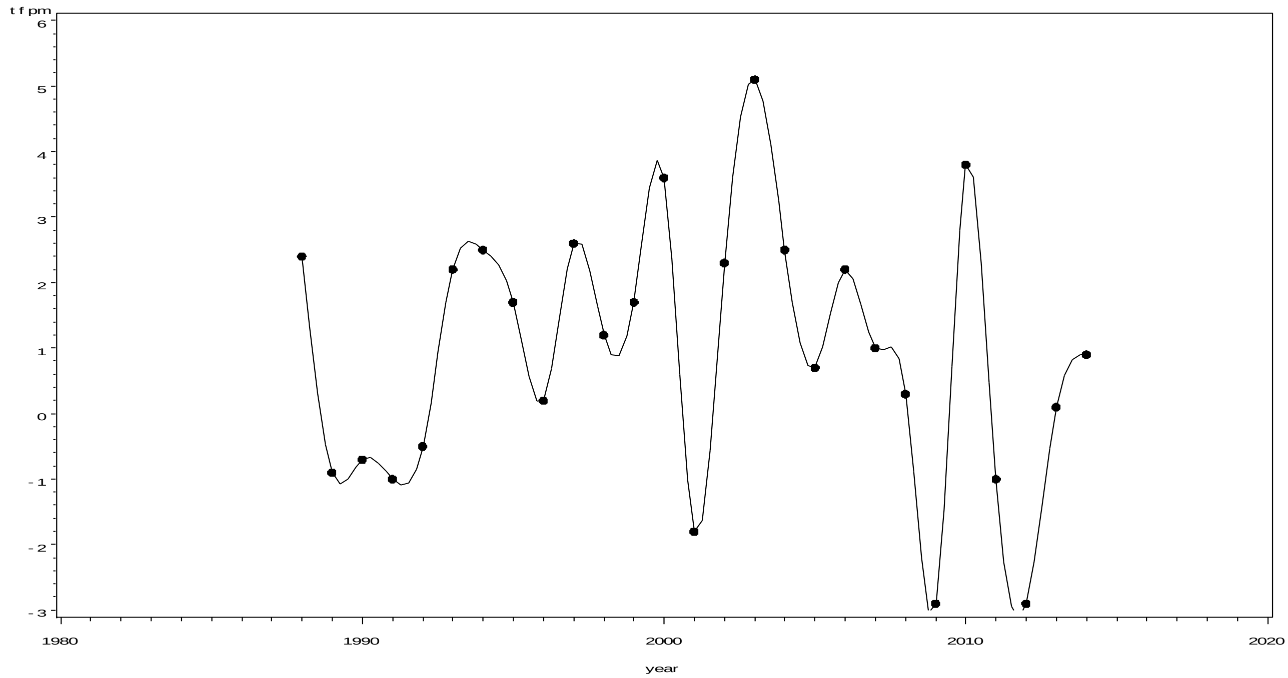

FIGURE 6. PLOT OF TOTAL FACTOR PRODUCTIVITY IN MANUFACTURING (TFPM) OVER YEARS

DISCUSSION

It is seen from this time series analysis that labor productivity, total factor productivity, and GDP per capita all have a positive effect on employment in manufacturing. Only Research and Development in the manufacturing sector had a negative effect on employment in manufacturing.

Graham (2016) pointed out that technological change is not the only factor that changes labor productivity and total factor productivity. For instance, since labor and total factor productivity are both based upon the amount of input and the quantity of output produced, change in input prices will have an effect on changing labor and total factor productivity. Viewed as such, labor productivity and total factor productivity (the two factors mostly used as measures of technology) may not be true measures of technological change. Our analysis showed that both measures are positively (rather than negatively) related to employment.

From this analysis, it seems that, from all the measures investigated, the only true measure of technological change is R&D in the manufacturing sector. It is clearly shown that an increase in R&D in manufacturing has the effect of reducing employment in manufacturing. This is in agreement with expectations, and with some of the studies in the literature, namely Brynjolfsson and McAfee (2011) and Mullen et al. (2009). Research and development can translate into investment in automation and information technology, which can have a negative effect on employment. It is of interest to note that R&D for industry as a whole had no relationship with employment in manufacturing. This suggests that one should consider R&D for the sector under consideration as a measure of technological change for that sector.

CONCLUSION

Technological change in a country has an impact on its economy and affects employment in manufacturing. Different technological measures were used in the literature in order to study their relationships to employment. Results are mixed as to how each measure may relate to employment in manufacturing. In this study we use the transfer function time series modeling approach where an output series (employment in manufacturing) is related to an input series (technology measure). The measures considered are those proposed in the literature, namely labor productivity, total factor productivity (TFP), GDP per capita, GDP per hour worked, and research and development (R&D) in manufacturing. Results from the analysis revealed that only R&D in manufacturing had a negative and significant effect on employment in manufacturing. GDP per hour worked was not related to employment and all the rest of the measures above were positively related to employment in manufacturing. If improvement in technology decreases employment in manufacturing, then a true measure of technological change is R&D in manufacturing and not any of the other proposed measures.

REFERENCES

Acemoglu, D., Autor, D. H., Dorn, D., Hanson, G. H., & Price, B. (2014). Return of the Solow Paradox? IT, productivity, and employment in US manufacturing. *American Economic Review: Papers and Proceedings, 104*(5), 394-399.

Autor, D. H., & Dorn, D. (2013). The growth of low skill service jobs and the polarization of the US labor market, *American Economic Review*, *103*(5), 1553–97.

Autor, D. H., Dorn, D., & Hanson, G. H. (2015). Untangling trade and technology: Evidence from local labour markets. *The Economic Journal, 125*(584), 621–646.

Brynjolfsson, E., & McAfee. A. (2011*). Race against the machine*. Lexington, MA: Digital Frontier Press.

Chang, Y. & Hong, J.H. (2013). Does technology create jobs. *SERI Quarterly*, 45-53.

Chang, Y. & Hong, J.H. (2006). Do technological improvements in the manufacturing sector raise or lower employment? *American Economic Review, 96*(1), 352-368.

Cryer, J., & Chan, Kung-sik. (2008). *Time series analysis: With applications in R* (2nd ed., Springer texts in statistics). New York: Springer.

Edwards, L. & Lawrence, R.Z. (2013). *Rising Tide: Is growth in emerging economies good for the United States?* Washington, DC: Peterson Institute for International Economics.

Fisher, E (2004). *Why are we losing manufacturing jobs?* Federal Reserve Bank of Cleveland. Research Department, P.O. Box 6387, Cleveland, OH 44101

Freeman C., Soete, L & Efendioglu, U. (1995). Diffusion and the employment effects of information and communication technology. *International Labor Review, 134*, 588-603.

Graham. R. J. (2016). *How to determine impact of technological change in managerial economics*. Retrieved from http://www.dummies.com/education/economics/how-to-determine-impact-of-technological-change-in-managerial-economics/

Jenkins, R. (2008) Trade and technology in South Africa. *Journal of Development Studies, 44*, 60–79.

Kim, B. S. (2012). Measuring technological change –concept, methods, and implications. Technological Change, Dr. Aurora Teixeira (Ed), ISBN 978-953-51-0509-1. IntechOpen, DOI: 10.5772/36251. Available from: https://www.intechopen.com/books/technological-change/measuring-technological-change-concept-methods-and-implications

Kuehn, J.A. & Braschler, C. (1986). Technology and foreign trade impacts on U.S. manufacturing employment 1975–80. *Growth and Change Journal, 17*(4), 46-60.

Mullen, J.K. and Panning, J. (2009). Foreign sourcing of intermediate inputs: Impacts on unskilled labor in US manufacturing industries. *Eastern Economic Journal, 35*(2), 160–173.

Rico, L. (2016). Automation and manufacturing employment: A reappraisal. *Management of Personnel Quarterly, 5*, 5-9.

Santacreu, A. M. (2015). How should labor productivity be measured? http://www.stlouisfed.org/on-the-economy/2015/march/how-should-labor-productivity-be-measured?/

Wei, W. (2006). *Time series analysis: Univariate and multivariate methods*. Addison-Wesley, Inc.: New York.

PROPOSING A ROBUST OPTIMIZATION MATHEMATICAL MODEL FOR SITE SELECTION- HOSPITAL WASTE DISTRIBUTION

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ABSTRACT

The environmental, social and economic effects of hospital waste are the vital issue for managers. In this paper a mathematical model is provided for hospital waste management with the site selection of disposal, recycling and treatment of hospital waste taken into consideration. The strength of the proposed model is to reduce the cost of transporting waste materials between the disposal, treatment and recycling centers.

An application of the proposed model for waste management of a hospital in Iran is provided. Some of the model parameters are considered uncertain parameters and we use a robust optimization approach to solve it. The reason of using robust optimization is the ability of this method to find the optimal solution under varying degrees of uncertainty.

INTRODUCTION

Determining the location of incinerating centers for the hazardous materials is an important issue due to the environmental, social, and economic effects. Costs associated with these facilities and risks against the population that are near these materials are important challenges. Medical waste disposal site selection is a complex and important social problem because decisions related to site selection impose costs and high risks on those who use these facilities. Due to the fact that the costs and risks are too great, such facilities are often established by the government centers. In the event that such decisions are not directly made by a government entity, they are strictly monitored by the government (Almeida et al., 2009).

Pollutants in the air are among the major concerns to determine the location of hospital wastes especially issues involved with incinerating the materials. Emissions of atmospheric pollutants impose risks to different people both continuously and randomly. Mathematical programming is applied to the problems of air quality control. The severity of the risk depends on several factors such as the location of emissions sources, weather conditions (eg, wind direction), and the persons who may be affected. The potential for random emission with large negative effects on different subsets of the population generally leads to real inequality in the distribution of risks. As a result, in recent years issues related to environmental justice have received considerable attention on the part of news media, policy makers, environmentalists, and academic researchers (Chakraborty and Armstrong, 1995).

Moreover, benefits, costs, and risks associated with the hospital waste facilities are scattered among different people. As a result, considerable studies have analyzed these problems. The use of mathematical programming techniques in site selection of the hospital waste goes back to the late 1970s. This special issue is first appeared in 1995 (Brimberg and Weselowsky, 2000). Multidimensional methods for determining the location of public facilities and hospital waste sites are among the first applications. Total risk, the share of imposed risk and dollar costs associated with the site selection projects are the three important purposes discussed in the literature. Several methods have been adopted to address the share of risk. Minimizing the risk imposed on any person or in any area has been an important approach for risk modeling (Current et al., 1995). In this paper, robust modeling is utilized to select the site location of hospital waste disposal.

REVIEW OF LITERATURE

ReVelle et al. (1991) made the first attempt to model the routing problem, utilizing a system that includes HAZMAT. They developed a model to routing model to minimize both the cost and the risk of transportation. They used 0 and 1 mathematical programming for the shortest route and method of multi-function weighting programming to solve the problem. Cappanera et al. (2003) presented a central site selection and method of routing the discrete harmful activities.

Since the proposed NP model was difficult, they proposed a Lagrangian method to decompose the problem into two different site-selection and routing problems, and used the branch-and-bound approach to solve the problems. Alumur & Kara (2007) modeled the location- and routing problem, in which the location of the disposal center and health centers, and the type of technology used by the centers should be defined. They presented the use of the model by implementing it in Central Anatolia in Turkey utilizing CPLEX software. They solved the multi objective routing problem by a meta-heuristic method based on taboo search to study the site of two plants for solid animal waste disposal. Their objective function included: 1) minimizing the fixed costs 2) minimizing the transportation costs 3) minimizing rejection by the cities through which the trucks pass 4) minimizing losses of between involved cities and 5) minimizing rejection by the cities close to the factory. This model was used by some other researchers too (Samanlioglu, 2013; Dai et al., 2011; Cabalro et al., 2011; Cabalro et al., 2007).

Zhao& Zhao (2010) used a multi-purpose mixed integer programming model for simultaneous location- routing HAZMAT and used a technique for overcoming the cost and risk symmetry normal percentage. They developed a target based programming technique to solve the problem. Zee et al. (2010) solved the location- routing. Zee et al. (2010) solved the location- routing problem by allowing various modes for transportation that can be changed when necessitated. In the heuristic method they consider a set of M cases of the best candidate solutions that is upgraded whenever a new solution with higher quality is found. Thus by the termination of the heuristic solution the result includes M cases of the best solutions that are close to optimal results.

In general there are four types of problems in case of HAZMATs. These problems include: routing/scheduling, risk analysis, location analysis, and waste management (Moungla and Jost, 2010). Samanlioglu (2013) mentioned that industrial hazardous waste management includes collection, transportation, recycling, and disposal of industrial hazardous substances that cause damage to the environment (Samanlioglu, 2013). He proposed a new multi-dimensional location – routing model developed and implemented in Turkey's Marmara region. The model can help the decision makers to determine the location of treatment plants using different technologies, different types of industrial hazardous waste routing to the adapted treatment plants, site selection of the recycling centers and routing of hazardous residual waste to these centers, and site selection of waste disposal sites and routing the waste residuals.

In the mathematical model, three criteria have been considered: (1) minimizing the total costs that include the total cost of transporting the hazardous materials and waste residuals, (2) the fixed cost of creating the treatment, disposal and recycling centers, and (3) minimizing the risk and potential cost to both the population living along the hazardous material transportation routes and to those who live around the treatment and disposal center sites.

The weighted Tchebycheff Samanlioglu formula has been developed and calculated using CPLEX software to determine the efficient solutions of the problem. The data on the Marmara region was obtained by Arcview GIS 9.3 and the geographical database software in Marmara region. Kang et al (2014) proposed a model to determine the routing for HAZMAT transport based on the confidence level for the specified risk called VAR. VAR is a threshold value so that the probability of loss greater than the VAR value is less than the probability level. The purpose of their model is to determine a path that minimizes the risk that exceed the thresholds.

Multiple properties have been established for the VAR model. An exact solution has been proposed and tested for solving a single trip. To test the application of this approach, the paths obtained by the VAR model were compared with the paths obtained by other HAZMAT goals in a numerical example. Also a HAZMAT routing scenario was extracted from the Albany area of New York State. Depending on the confidence level, the VAR model presents different routes and it is concluded that routing is a function of the decision-maker’s level of risk tolerance. Higher modifications of the VAR model have been also discussed.

Today, especially in the systems that deal with HAZMAT, in addition to minimizing the cost of operations in the facilities and routing, assessing the risk of this operation is an important consideration. Arjmand et al (2015) proposed a new mathematical model for site selection and routing in the disposal centers and sites. In their research, the risk and cost of transportation from the center to clients was considered.

The mathematical model presented the total weight of the cost and risk by identifying the following: (1) the central site (facility) that produces the HAZMAT (2) the location of disposal sites; (3) which customer should be allocated to which facility 4) which facility should be allocated to which disposal center (5) which route should be selected to provide services to the customers., and (6) which route should be selected to reach the disposal sites. A new genetic algorithm (GA) was used to solve the model.

The GA results presented the optimized solutions with high quality and suitable execution times. Generally the studies in this area could be divided into site selection, routing, risk consideration, and providing the mathematical models. In this regard, Table 1 shows a summary of these studies.

TABLE 1. ANALYSIS OF PREVIOUS STUDIES ON WASTE MANAGEMENT

Author	Year	Main features				
		Site selection	Routing	Risk consideration	Mathematical modeling (Operations Research)	Robust optimization approach
Cohon, and Shobrys	1991	✓	✓	✓	✓	
Stowers and Palekar	1993	✓	✓	✓	✓	
Jacobs and Warmerdam	1994	✓	✓	✓	✓	
Caballero et al.	2007		✓		✓	
Alumour & Kara	2007	✓	✓		✓	
Bafi et al.	2008	✓			✓	
Zhao and Zhao	2010	✓	✓	✓	✓	
Xie et al.	2012	✓	✓		✓	
Zee et al.	2012	✓	✓		✓	
Samanlioglu	2013	✓	✓	✓	✓	
Kang et al.	2014		✓	✓	✓	
Arjmand et al	2015	✓	✓	✓	✓	

A review of past studies indicates that the uncertainty factor has not been seriously studied. However, not much research has been done on site selection and routing the HAZMAT with uncertainty factors. Based on the lack of research in this area and the increased demand for it, this study attempts to present and analyze a robust optimization model for site selection and transporting hospital waste. The developed model of this study has been applied to two cases using different networks to demonstrate its application.

MATERIALS AND METHODS

Indices Used in the Model

Medical waste generation centers: G = {1, … , g}
Potential centers for the treatment of hospital waste: T = { 1, … , t}
Available centers for the treatment of hospital waste: T′ = {1, … , t′}
Potential centers for disposal of hospital waste: D = {1 , … , d}
Available canters for disposal of hospital waste: D′ = { 1 , … , d′}
Potential centers for recycling of hospital waste: H = { 1 , … , h}
Available centers for recycling of hospital waste: H = { 1 , … , h}
Available centers for recycling of hospital waste: H′ = { 1, … , h′}
Type of hospital waste: W= { 1, … , w}
Potential technologies for dealing with hospital waste: Q = {1, … , q}
Available technologies for dealing with hospital waste: Q′ = { 1, … , q′}

Parameters Used in the Model

The cost of transporting a unit of waste between the waste generation and its treatment centers: $C_{i,j}$
The cost of transporting a unit of waste residual between the treatment and disposal of it: $cz_{i,j}$
The cost of transporting a unit of waste residual between the recycling and disposal of it: $cv_{i,j}$
The cost of transporting a unit of residual waste between the generation and recycling of it: $cr_{i,j}$
The cost of transporting a unit of treated recyclable waste between the recycling and recycling of it: $crr_{i,j}$
Fixed cost of establishing a treatment technology in a treatment center: $fc_{q,i}$
Fixed cost of establishing a waste disposal center: fd_i
Fixed cost of establishing a waste recycling center: fh_i
The number of people existing in the distance between waste generation and treatment centers: $POPgt_{i,j}$
The number of people existing in the distance between waste treatment and disposal centers: $POPtd_{i,j}$
The number of people existing in the treatment center with Q technology: $POPA_{q,i}$
The number of people existing within the area of a center: $POPB_i$
The amount of w waste generated in the generation center i: $gen_{w,i}$
Recycling percentage of waste w generated in the generation center i: $a_{w,i}$
Recycling percentage of waste w recycled by technology Q: $\beta_{w,q}$ $r_{w,q}$
Percentage of total waste recycled at the recycling center i: γ_i
Q technology capacity to recycle the waste in the center i: $TC_{q,i}$
The minimum level of waste that can be treated by Q technology: $tc_{q,i}^{m}$

Waste disposal capacity in the waste disposal center i: dc_i
Minimum required waste to create a waste disposal center: dc_i^m
The capacity to recycle the waste in the recycling center i: rc_i
The minimum required waste to establish a recycling center in node i: rc_i^m
0 and 1 parameter: it takes the value 1 is the type of the waste i is compatible with Q technology: $com_{w,q}$

Decision Variables

The amount of waste w transferred between the waste generation and treatment centers: $X_{w,i,j}$
The amount of residual waste transported between the waste treatment and disposal centers: $Z_{i,j}$
The amount of recyclable waste transported from the waste generation and recycling centers: $L_{i,j}$
The amount of recyclable waste transported from the waste treatment i to the waste recycling j centers: $K_{i,j}$
The amount of final waste transported from the waste recycling 1 to the waste disposal j centers: $V_{i,j}$
The amount of waste w that will be treated in the treatment center i using the technology q: $Y_{w,q,i}$, $y_{w,q,j}$
The amount of waste that is lost in the waste disposal center j: dis_i , dis_j
The amount of waste that is lost in the waste recycling center i: hr_i,hr_j
If the q technology is established in the waste recycling center i: $F_{q,i}$
If the waste disposal center is established in the center i: dz_i
If the waste recycling center is established in the center i: b_i

Linear Mathematical Model

$$\min f_1(x) = w1\left(\sum_{i\in G}\sum_{j\in T}\sum_{w\in W} c_{i,j} \times x_{w,i,j} + \sum_{i\in T}\sum_{j\in D} cz_{i,j} \times z_{i,j} + \sum_{i\in H}\sum_{j\in D} cv_{i,j} \times v_{i,j} + \sum_{i\in G}\sum_{j\in H} cr_{i,j} \times l_{i,j} + \sum_{i\in T}\sum_{j\in H} crr_{i,j} \times k_{i,j} + \sum_{i\in T}\sum_{q\in Q} fc_{q,i} \times f_{q,i} + \sum_{i\in D} fd_i \times dz_i + \sum_{i\in H} fh_i \times b_i\right) \quad (1)$$

$$\min f_2(x) = w2\left(\sum_{i\in G}\sum_{j\in T}\sum_{w\in W} POPgt_{i,j} \times x_{w,i,j} + \sum_{i\in T}\sum_{j\in D} POPtd_{i,j} \times z_{i,j}\right) \quad (2)$$

$$\min f_3(x) = w3\left(\sum_{w\in W}\sum_{q\in Q}\sum_{i\in T} POPA_{q,i} \times y_{w,q,i} + \sum_{i\in D} POPB_i \times dis_i\right) \quad (3)$$

$$gen_{w,i} = \alpha_{w,i} \times gen_{w,i} + \sum_{j\in T} x_{w,i,j} \qquad \forall i \in G \quad (4)$$

$$\sum_{w\in W} \alpha_{w,i} \times gen_{w,i} = \sum_{j\in H} l_{i,j} \qquad \forall i \in G \quad (5)$$

$$\sum_{i\in G} x_{w,i,j} = \sum_{q\in Q} y_{w,q,j} \qquad \forall w \in W, \forall j \in T \quad (6)$$

$$\sum_{w\in W}\sum_{q\in Q} y_{w,q,i}\left(1-r_{w,q}\right)\left(1-\beta_{w,q}\right)=\sum_{j\in D} z_{i,j} \qquad \forall i\in T \tag{7}$$

$$\sum_{w\in W}\sum_{q\in Q} y_{w,q,i}\left(1-r_{w,q}\right)\left(\beta_{w,q}\right)=\sum_{j\in H} k_{i,j} \qquad \forall i\in T \tag{8}$$

$$f_{q,i}=1 \qquad \forall q\in Q^{\prime},\forall i\in T^{\prime}$$

$$(\sum_{i=T} k_{i,j}+\sum_{i=G} l_{i,j}=hr_j \qquad \forall j\in H \tag{9}$$

$$hr_j(1-y_i)=\sum_{j\in D} v_{i,j} \qquad \forall j\in H \tag{10}$$

$$b_i=1 \qquad \forall i\in H^{\prime}$$

$$\sum_{i\in H} v_{i,j}+\sum_{i\in T} z_{i,j}=dis_j \qquad \forall j\in D \tag{11}$$

$$dz_i=1 \qquad \forall i\in D^{\prime}$$

$$\sum_{q\in Q} y_{w,q,i}\leq tc_{q,i}\times f_{q,i} \qquad \forall q\in Q\ ,\forall i\in T \tag{12}$$

$$\sum_{q\in Q} y_{w,q,i}\geq tc^{m}_{q,i}\times f_{q,i} \qquad \forall q\in Q\ ,\forall i\in T \tag{13}$$

$$tc^{m}_{q,i}\times f_{q,i}+\Gamma_3\times\tau_3+\varphi_3\times\sigma_{3,q,i}\leq\sum_{q\in Q} y_{w,q,i} \qquad \forall q\in Q\ ,\forall i\in T \tag{14}$$

$$\tau_3+\sigma_{3,q,i}\geq t\hat{c}^{m}_{q,i}\left|f_{q,i}\right| \qquad \forall q\in Q\ ,\forall i\in T \tag{15}$$

$$\tau_3\ ,\sigma_{3,q,i}\geq 0 \qquad \forall q\in Q\ ,\ \forall i\in T$$

$$y_{w,q,i}\leq tc_{q,i}\times com_{w,q} \qquad \forall w\in W,\forall q\in Q,\forall i\in \mathrm{T} \tag{16}$$

$$dis_i\leq dc_i\times dz_i \qquad \forall i\in D \tag{17}$$

$$dis_i+\Gamma_1\times\tau_1+\varphi_1\times\sigma_{1,i}\leq dc_i\times dz_i \qquad \forall i\in D \tag{18}$$

$$\tau_1+\sigma_1\ ,i\geq dc\hat{}\_i \qquad \forall i\in D \tag{19}$$

$$\tau_1\ ,\sigma_{1,i}\geq 0$$

$$dis_i\geq dc^{m}_{i}\times dz_i \qquad \forall i\in D \tag{20}$$

$$hr_i\leq rc_i\times b_i \qquad \forall i\in H \tag{21}$$

$$hr_i+\Gamma_2\times\tau_2+\varphi_2\times\sigma_{2,i}\leq rc_i\times b_i \qquad \forall i\in H \tag{22}$$

$$\tau_2+\sigma_{2,i}\geq rc_i \qquad \forall i\in H \tag{23}$$

$$\tau_2\ ,\ \sigma_{2,i}\geq 0 \qquad \forall i\in H$$

$$hr_i \geq rc_i^m \times b_i \quad \forall i \in H \tag{24}$$

$$x_{w,\mathrm{i},\mathrm{j}}, z_{i,j}, l_{i,j}, k_{i,j}, v_{i,j}, y_{w,q,i}, y_{w,q,j}, dis_i, dis_j, hr_i, hr_j \geq 0$$

$$f_{q,i}, dz_i, b_i \in \{0,1\}$$

Objective Function and Constraints Description

First Objective Function

The first objective function is cost minimization to reduce the following costs respectively:

A. Total cost of waste transfer between the waste generation and treatment centers
B. Total cost of waste transfer between the waste treatment and disposal centers
C. Total cost of waste transfer between the waste recycling and disposal centers
D. Total cost of recyclable waste transfer between the waste generation and recycling centers
E. Total cost of recyclable residual treated waste transfer between the waste treatment and recycling centers
F. Total fixed cost of establishing treatment technologies in the treatment centers
G. Total fixed cost of establishing waste disposal centers
H. Total fixed cost of establishing waste recycling centers

Second and Third Objective Function

The second objective function is aimed at reducing individuals' risk of contamination due to potential exposure to hazardous materials at the point of waste generation and during transport to the treatment centers. The third objective function is aimed at reducing individuals' risk of contamination due to potential exposure to hazardous materials at the point of waste treatment and during transport to the waste disposal centers.

Constraints

Equations 3, 5 and 6 are associated with the flow balance between the source and destination centers.

Equations 7 and 8 control the flow level from the treatment center to disposal center. These two constraints also consider the use of various treatment technologies.

Equation 9 sorts and lists available centers with total existing technologies.

Equation 10 defines the flow rate between waste generation and treatment centers and the waste recycling center.

Equation 11 defines the flow rate between waste recycling and waste disposal centers.

Equation 12 defines the existing waste recycling centers.

Equation 13 specifies and estimates the waste flow from the treatment and recycling centers to the waste disposal center.
Equation 14 determines the available waste disposal centers.
Equations 16, 17 and 18 are capacity constraints for treatment, disposal and recycling centers.

As it is clear the uncertainty is considered in equations 15, 17 and 19. It means that it is assumed that the following parameters are uncertain and their exact amount is not available:

"The minimum level of waste that can be treated by Q technology"
"The capacity of waste disposal in waste disposal center"
"The capacity of waste recycling in the waste disposal center"

It should be noted that these parameters are selected among all parameters with the capability to consider uncertainty. In other words, all expressed parameters in the proposed mathematical model can be considered as an uncertain parameter but this is due to the complexity of the model. Thus the mentioned parameters are extracted as important and sample uncertain parameters.

Numerical example

In order to evaluate the performance of the proposed model a numerical example is coded by GAMS software and run. The numerical example relates to a hospital and real data are used to run the model.

The initial information is based on the following descriptions:

The number of waste generation centers of Hospital:	1
The number of potential centers for the waste treatment of hospital:	2
The number of available centers for the treatment of hospital waste:	0
The number of potential sites for the disposal of hospital:	2
The number of available centers for hospital waste disposal:	0
The number of potential centers for recycling hospital waste:	2
The number of available centers for recycling hospital waste:	0
The number of hospital waste types:	1
The number of potential technologies dealing with hospital waste:	2
The number of existing technologies dealing with hospital waste:	0
The cost of transporting a unit of waste between the waste generation and its treatment centers:	10
The cost of transporting a unit of waste residual between the treatment and disposal of it:	15
The cost of transporting a unit of waste residual between the recycling and disposal of it:	8
The cost of transporting a unit of residual waste between the generation and recycling of it:	10
The cost of transporting a unit of treated recyclable residual waste between the treatment and recycling of it:	11
The fixed cost of establishing a treatment technology in a treatment center:	9
The fixed cost of establishing a waste disposal center:	200
The fixed cost of establishing a waste recycling center:	200

The number of people existing in the distance between waste generation and treatment centers:	150
The number of people existing in the distance between waste treatment and disposal centers:	200
The number of people existing in the treatment center with Q technology:	250
The number of people existing within the area of a center:	200
The amount of w waste generated in the waste generation center i:	500
Recycling percentage of w waste generated in the waste generation center i:	0.8
Recycling percentage of waste w recycles by technology q:	0.8
Percentage of total wastes recycled at the recycling center i:	0.5
Q technology capacity to treatment the waste in the center i:	1000
The minimum level of waste that can be treated by Q technology:	60
Waste disposal capacity in the waste disposal center i:	2000
Minimum required waste to create a waste disposal center:	10
The capacity to recycle the waste in the disposal center i:	2000
The minimum required waste to establish a recycling center in node i:	30
0 and 1 parameter: the value is 1 if the type of the waste i be compatible with Q technology:	1

In the numerical example a fixed value is considered for all parameters. As stated previously, some of the essential parameters of the model are identified and (these parameters are intended for uncertainty) the uncertainties are taken into account. These parameters include:

1. The minimum level of waste that can be treated by Q technology
2. Waste disposal capacity in the waste disposal center
3. The capacity to recycle the waste in the disposal center

RESULTS AND DISCUSSION

The results of the numerical example have shown below:

The amount of waste w transferred between the waste generation and treatment centers:
$X_{1,1,1} = 350$, $X_{1,1,2}=150$
The amount of residual waste transported between the waste treatment and disposal centers:
$Z_{1,1}=40$, $Z_{1,2}=5$, $Z_{2,1}=80$, $Z_{1,1}=0$
The amount of recyclable waste transported from the waste generation and recycling centers: 0
The amount of recyclable waste transported from the waste treatment center i to the waste recycling center j: k1,1=60 , k1,2=30 , k2,1=0 , k2,2=0
The amount of final waste transported from the waste recycling center i to the waste disposal center j: 0
The amount of waste w that will be treated in the treatment center i using the technology q:
$y_{1,1,1}=230$, $y_{1,1,2}=70$

To better assessment of the proposed model, three other numerical examples are randomly generated and studied. Table 2 shows the overall results:

TABLE 2. THE RESULTS OF THE SOLUTION OF NUMERICAL EXAMPLES

No	Number of hospitals	Number of recycling centers	Number of disposal centers	Number of treatment centers	Value of the objective function in uncertainty level 0	Value of the objective function in uncertainty level 0.5	Value of the objective function in uncertainty level 1
1	1	2	3	3	45852	45852	45852
2	1	3	3	5	2546	2548	3500
3	1	5	6	6	685412	685412	685412

The above table is interpreted as follows:

A. Other-parameters data are generated randomly using MATLAB software and presented to GAMS randomly.

B. In this table, only the uncertainty of the waste disposal center capacity is investigated. Other-parameters uncertainty are expected to show similar behavior.

C. The problem of the case study is solved in certain mode. This is due to the lack of uncertainty in the data obtained from the case study (Hospital).

D. According to the above table for problems 1 and 3 the uncertainty had no effect on the optimal solution of the problem. This is because this center had the ability to respond to all disposed waste even in the worst cases. However, in problem 2, by increasing the uncertainty level, the amount of the objective function is worsened; this means the wastes that could have been disposed are transferred to another center for strict considerations or they are removed from the cycle that has increased the costs, thus worsening the objective function.

CONCLUSION

In this paper, a mathematical model is proposed for hospital waste management. Taken into consideration are site selection of disposal, recycling, and treatment centers of hospital waste Based on the numerical results obtained in this paper, it is possible to obtain the optimal location for the recycling, treatment and disposal of hospital waste.

The most important function of this model is to reduce the cost of transporting the waste materials among disposal, treatment and recycling centers. To evaluate the performance of the proposed model, a real case study utilizing actual hospital data to obtain optimal locations for site selection of disposal, recycling, and treatment centers of hospital waste. Based on the obtained results, the proposed model is capable of providing optimal solutions to small and medium-sized problems.

Also another innovation of the proposed model is considering uncertainty factors. The robust optimization approach is used to solve parameters that are considered as uncertain parameters. It is also possible to change the parameters of the model to analyze the effect of them on the system and to identify the critical parameters as well.

According to the research gaps identified during the study, the authors propose future studies be conducted on providing an optimal solution method for large-size problems utilizing the method discussed. Although this study did not focus on reducing hospital waste generation, future research could lead to the reduction of hospital pollution through effective hospital management.

REFERENCES

Alçada-Almeida, L., Coutinho-Rodrigues, J., & Current, J. (2009). A multiobjective modeling approach to locating incinerators. *Socio-Economic Planning Sciences, 43*(2), 111-120.

Alumur, S., & Kara, B. Y. (2007). A new model for the hazardous waste location-routing problem. *Computers & Operations Research, 34*(5), 1406-1423.

Arjmand, E., Weckman, G., Park, N., Taherkhani , P., & M. Singh. (2015). Applying genetic algorithm to a new location and routing model of hazardous materials. *International Journal of Production Research, 53*(3) , 916-928.

Brimberg, J., & Wesolowsky, G.O. (2000). Facility location with closest rectangular distances, *Naval Research Logistics, 47*(1) , 77-84.

Caballero, R., González, M., Guerrero, F.M., Molina, J., & Paralera, C. (2007). Solving a multiobjective location routing problem with a metaheuristic based on tabu search. Application to a real case in Andalusia. *European Journal of Operational Research, 177*(3), 1751-1763.

Cappanera, P., Gallo, G., & Maffioli, F. (2003). Discrete facility location and routing of obnoxious activities. *Discrete Applied Mathematics*, *133*(1-3), 3-28.

Chakraborty, J., & Armstrong, M.P. (1995). Using geographic plume analysis to assess community vulnerability to hazardous accidents. *Computers, Environment and Urban Systems, 19*(5/6), 343 – 361.

Current, J., & Ratick, S. (1995). A model to assess risk, equity and efficiency in facility location and transportation of hazardous materials. *Location Science, 3*(3), 187-201.

Dai, W., Yu, J., & Zhu, C. (2011). A bi-objective model for hazard materials location and routing problem. *8th International Conference on Service Systems and Service Management (ICSSSM),* 1-5.

Kang, Y., Batta, R., & Kwon, C. (2014). Value-at-risk model for hazardous material transportation. *Annals of Operations Research, 222*(1) , 361-387.

Moungla, N.T., & Jost, V. (2010). *Routing of hazardous material: models and optimization*. In Global Optimization Workshop, 153-156. Toulouse: IEEE.
ReVelle, C., Cohon, J., & Shobrys, D. (1991). Simultaneous siting and routing in the disposal of hazardous wastes. *Transportation Science, 25*(2), 138-145.
Samanlioglu, F. (2013). A multi-objective mathematical model for the industrial hazardous waste location-routing problem. *European Journal of)Operational Research, 226*(2), 332-340.
Zee, BM., Levin, RS., DiMaggio, PA., & Garcia, BA.(2010). Global turnover of histone post-translational modifications and variants in human cells. *Epigenetics Chromatin*, *3*(1), 22.
Zhao, J., & Zhao, J. (2010). Model and algorithm for hazardous waste location-routing problem. *International Conference of Logistics Engineering and Management (ICLEM),* 2843-2849.
Xie, Y., Lu, W., Wang, W., & Quadrifoglio,L. (2012). A multimodal location and routing model for hazardous materials transportation. *Journal of Hazardous Materials, 227/228*:135-141.

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