Cross-country technology gap in Latin America: Growth accounting and non-parametric approaches

By: Esra Memili, Kaustav Misra, Surender Reddy, Gail E. Sype, and Diane H.W. Welsh.

Kaustav M., Memili, E., Welsh, D. H. B., Reddy, S., Sype, G. E. 2015. "Cross-country technology gap in Latin America: Growth accounting and non-parametric approaches", *Cross Cultural Management*, 22 (4) 630-648.

Abstract:

Purpose
– The purpose of this paper is to investigate the factors influencing the total factor productivity (TFP) gap between the USA and eight Latin American countries for the period of 1970-2000.

Design/methodology/approach
– The paper provides an explicit application of TFP estimation by employing a growth accounting approach (Solow Residual) in the presence of non-constant returns to scale and a non-parametric approach (DEA – Malmquist Index) while relaxing the scale-related constraint. A macro-based economic model of innovator and follower countries is employed to explore the linkage between technology gaps and innovations, labor productivity, trade openness, foreign direct investment, and adult workforce illiteracy rates. A pooled model and a fixed effects model are used to determine the factors of the technology gap between the innovator and the follower countries.

Findings
– The results show that the labor productivity gap, adult work force illiteracy rates, patent filing gap, and trade openness are significant determinants of the technology gap between innovator and follower country.

Practical implications
– Latin American countries would benefit from the technology diffusion from an innovator country; but a minimum threshold of human capital, such as adult workforce illiteracy rates and

patent filing has to be met. The authors find government policies on trade openness also have large effects on technology limitations in foreign countries.

Originality/value
– This paper is of value to researchers, policy makers, and economic development specialists trying to improve the rate of technology adoption and innovation.

Keywords: Trade openness | Productivity | Technology diffusion | Patent | Growth accounting approach | Malmquist Index

Article:

I. Introduction

Innovation and knowledge is one of the major drivers for economic growth, but countries widely vary in how they manage innovation or knowledge. For example, developed countries pursue innovation or knowledge creation while developing or under-developed countries practice knowledge adaptation through technology diffusion. Grossman and Helpman (2001) indicated that globalization is one of the primary channels for technology diffusion. Not surprisingly, technological absorptive capacity, which can create technology gap, also varies among nations. Thus the primary objective of this paper is to determine the key macroeconomic factors which drive the nations' technological absorptive capacity and provide policy framework to these countries to minimize the variations.

Many scholars emphasized that technology innovations or knowledge can be measured through changes in total factor productivity (TFP) levels. TFP growth across countries has received decades of research attention. One taxonomy links TFP growth to two sources: technological change and efficiency improvement. Technological change leads to an expansion of the feasible output set (Romer, 1990). According to Romer (1990), technological change provides the incentive for continued capital accumulation and then capital accumulation and technological change can substantially contribute to increased output. The authors draw attention to the importance of accumulation, particularly human capital. Hence, this type of expansion is generally assumed to occur in the world's most developed and innovative economies.

Conversely, efficiency improvements represent a movement toward an existing productive frontier. Developing or follower economies are able to adopt the new technologies developed in the leader countries and thus improve TFP through greater efficiency rather than generating their own technological innovations that shift the productive frontier (Keller, 2004). Keller (2004)suggests that foreign sources of technology are important, particularly for under-developed or developing countries. Indeed, technological innovations tend to diffuse from the leader (developed) country to the follower (less developed) countries (Barro and Sala-i-Martin, 1995). However, technology adoption by under-developed and developing countries does not occur automatically since it requires technology investments which take time (Keller, 2004). This results in a time lag between the technology diffusion and increases in productivity. Some under-developed and developing countries can attain productivity benefits faster than others. However, to date, we do not know enough about why some under-developed and developing countries can respond to technology diffusion and enjoy productivity benefits faster and more than others. In an attempt to fill this gap in the literature, our study examines the impact of trade openness, Foreign Direct Investment (FDI), patents, labor productivity, and past technological gap on the current technological gap.

The emerging importance of international trade increases the probability of technology diffusion in the form of knowledge transfer across countries (Rosa and Mohnen, 2008). Several studies have documented that cross-country technology diffusion, through the trade flows (Coe and Helpman, 1995) or bilateral trade flows (Madsen, 2007) has been an important engine of economic growth. It has long been recognized that technological advancement plays a major role in an economy’s long-term economic growth. However, new technologies are rarely adopted by all potential users at the same rate. The diffusion rates of new technology can vary from five to 50 years, depending on the innovation (Mansfield, 1968). For example, certain developing countries such as India and China take less time to adopt a technology than other developing countries, such as Guatemala and Peru. This may largely be because adaptation to foreign technology is not costless. The difference in technology adoption rates also depends on countries’ international trading characteristics, such as trade openness (Blyde, 2004; Caselli and Coleman, 2001; Schiff and Wang, 2003; Xu and Chiang, 2005). It is also important to recognize the cultural difference between these Latin American countries affect the innovation. For example, Kassa and Vadi (2008) indicated that individual initiatives and risk taking or opportunity seeking behavior are very different among cultures, which indirectly or directly affect innovation.

Xu and Chiang (2005) find that the adaptation time of a new innovation differs from country-to-country due to several important factors, including government policies on the protection of intellectual property rights and trade openness. Xu and Chiang (2005)focus mainly on the policy-related issues, such as foreign intellectual property rights and the magnitude of international trade activity, but do not include domestic patent contribution specifically, which may also have an impact on domestic TFP growth. However, using macro-level data, Caselli and Coleman (2001) argue that the determinants of adaptation to technology in a country are still not clear. Multinational firms can generate technological learning externalities for domestic firms in host countries (Fosfuri *et al.*, 2001). Indeed, FDIs play a key role in today’s global economic context (Apaydin, 2009; Kouznetsov, 2010). However, research shows that FDIs may not have substantial impact on technology transfer in industrialized or developed countries (e.g. Veugelers and Cassiman, 2005; Xu and Wang, 2000). We still do not know enough about whether there are different levels of impact of FDI on technology diffusion among under-developed and developing countries.

Rosa and Mohnen (2008) find that an increase in physical distance between the industry and university R & D centers decreases the transfer of knowledge, after controlling for all unobserved individual heterogeneity. Similarly, Deltas and Karkalakos (2007)investigate the extent to which the positive spillover effect of knowledge diffusion depends on the similarity of research activities by the originator and recipient of the knowledge. Findings also suggest that the rate of R & D spillover effects diminish as the distance between the originator and recipient increases.

Since long run standards of living are largely determined by resource productivity, the issue of how technology diffuses across countries has important ramifications for the well-being of individuals in low- and middle-income countries. With persistent, cross-country productivity growth differences, how country-specific policies and institutions influence technology adaptation capabilities is a question of significant interest. Therefore, this paper investigates the diffusion of technology at the aggregate level by examining the contributing factors of TFP gaps across countries in Latin America. Our study focusses on Latin America because this part of the continent involves mostly under-developed and developing economies and is thus representative of the population of under-developed and developing countries. Additionally, considering that the benefits from foreign spillover decreases by distance (Keller, 2006), these countries are also similar in their distance to the USA, the technology leader country, unlike countries from overseas.

The contribution of this paper is twofold. The first and most important contribution is the application of various methodologies to provide a more consistent prediction about the determinants of technology diffusion. We provide an explicit application of TFP estimation by employing a growth accounting approach (Solow Residual) in the presence of non-constant returns to scale as well as a non-parametric approach (Malmquist Index), relaxing the scale-related constraint. Second, we apply a comparative analysis among Latin American countries to examine the impact of patents, labor productivity, trade openness, FDI, and past technological gap on the current technological gap. This cross-country comparative analysis in Latin America helps to generate country-specific solutions rather than general recommendations which are based on aggregate analysis. Our paper is structured as follows. In Section II, the economic model is presented. Then, data sources are reported in Section III and the empirical estimation is presented in Section IV. The last section summarizes and concludes the paper.

II. Economic model

Past research has modeled international technology diffusion at the micro and macro levels, but there is no consensus concerning the nature of technology spillover among countries. Many studies confirm that the contribution of foreign countries to domestic productivity is large (Rensman and Kuper, 1999). Hence, the estimation technique for calculating TFP becomes important. There are several ways to estimate TFP for a country including the Solow growth accounting approach, the non-parametric approach, and the parametric approach. This paper concentrates on the two approaches to estimate the TFP and compare the results.

Growth accounting approach

The growth accounting methodology begins with the assumption that factor markets are competitive and the aggregate production function takes the Cobb-Douglas form. It is possible to measure TFP as the growth rate of output minus the growth rate of inputs weighted by their cost share. It is also assumed that TFP growth is due to technological change and institutional change for a country or industry (Baier *et al.*, 2002). The Solow residual (1956) measures TFP, and is defined as:

$$A = g_y - \propto \times g_k - (1 - \propto) \times g_L \qquad (1)$$

where A is total factor productivity (Ozyurt, 2009), g_y is the growth rate of aggregate output, g_k is the growth rate of the capital stock,g_L is the growth rate of labor, α is the capital share, and $(1-\alpha)$ is the wage share. To simplify, we assume that technology change is the only source of TFP variation.

Non-parametric approach

Malmquist (1953) explained productive performance by introducing an index consisting of inputs and outputs. This work was extended by Caves and Christiansen (1982) who developed the Malmquist TFP Index (MPI). A parametric approach (stochastic frontier analysis) or non-parametric approach (data envelopment analysis (DEA)) can be employed to estimate a distance function which can then be used to calculate a MPI TFP Index. The distance function is convenient as it does not require any behavioral assumptions, such as cost minimization or profit maximization. In this paper, a DEA or non-parametric approach is employed to calculate TFP growth from 1970 to 2000.

Technology spillover model

In this section, we develop a modified version of Barro and Sala-i-Martin's Technology Diffusion Model. Barro and Sala-i-Martin (1995) provide an approach to quantifying international technological diffusion at the macro or micro levels that has been widely used in research. In this model, the world is divided into leader countries and follower countries. The countries that develop a new technology are called the leader or innovator country and the rest of the countries are defined as the follower countries. The following economic model briefly introduces the link between the leader country and follower country:

$$ln\left(\frac{y_I}{y_F}\right) = 1/(1-\propto)ln\left(\frac{A_I}{A_F}\right) + ln\left(\frac{N_I}{N_F}\right) \qquad (2)$$

Barro and Sala-i-Martin (1995) assume that aggregate output, Y_I, is a function of labor, L_I, technology, A_I, and a series of intermediate inputs; y_I is labor productivity for the innovator country, I, and where $0 < \alpha < 1$. The innovator country has discovered $N_I$of these inputs, whereas Y_F is defined as the final output produced by country F (follower country), N_F is the number of intermediate goods diffused from the innovator country to the follower country, and y_F is their labor productivity. This model implies that the ratio of labor productivity (Equation 3) between the follower and innovator countries depends on the technological gap between these two countries and relative values of the Ns. The difference between A_F and A_I is the technological gap between these two countries, which derives from country-specific factors such as educational level of the follower country, number of patent discoveries by the innovator country, and trade-related policies (trade openness). An extension of the Barro and Sala-i-Martin (1995) technology of diffusion model is obtained by incorporating some of these specific variables to measure the relationship with the technological spillover or gap. Equation (2) is the modified version of model (1):

$$ln\left(\frac{A_I}{A_F}\right) = f\left[ln\left(\frac{y_I}{y_F}\right),\ ln\left(\frac{N_I}{N_F}\right),\ TRADE, GDP, I\ Rate\, ln\left(\frac{A_I}{A_F}\right)(t-i)\right] \qquad (3)$$

Ultimately, the factors that influence this technology gap can lead the follower countries to adopt policies to reduce it and achieve higher economic growth.

III. Data

The sample in this paper consists of eight Latin American countries over the period of 1970 to 2001. The Solow residual or TFP is calculated as the difference between the logs of output and inputs using the growth accounting method. Capital and labor are used as inputs in this production function, weighted by wage share and capital share. The variables used to calculate TFP are derived from the Extended Penn World Table. However, there are missing observations in wage share data; hence the average wage shares from neighborhood years were used[1].

The dependent variable, technology gap, was derived from Equation (3). The Apergis *et al.* (2008) methodology was used to calculate the technological gap, namely, the difference in TFP between the innovator country and the follower country for a given year. The large difference between the number of patents filed between the USA and the Latin American countries is the primary reason for choosing the USA as the innovator country. Xu and Chiang (2005) argue that technology adaptation in a country varies with their development stage. The difference in technology adaptation of countries creates a gap between these countries and the USA. To minimize this gap, the contributing factors must be examined. Therefore, as an extension of Xu and Chiang's paper, several potential factors, which influence the technological gap between innovator and follower countries, are considered.

Higher trade openness indicates greater interaction among countries in the open economy, which increases the opportunity to absorb and adopt the new technology through trade flow. Hence, countries with higher trade openness are expected to be more technologically efficient. For example, Keller (2004) identified the importance of international trade and FDI in cross-country technology diffusion. Keller (2004) mentions that imports are a significant channel for technology diffusion. In contrast, this paper uses the contribution of trade relative to GDP instead of differentiating between exports and imports. In the international economics literature, this variable is known as "trade openness." The specification of this variable varies in previous studies, and we follow the World Bank specification to define trade openness. The trade data are taken from the World Bank Development Indicators 2008 CD[2].

There are several works, such as Blomström and Kokko (1998), Saggi (2000), and Keller (2004), which emphasize the importance of FDI in technology diffusion. These findings provide evidence that trade and FDI are important mechanisms through which technology is transmitted across countries, and thus these variables are included as a potential determinant of the technology gap.

To investigate the endogenous reasons for technology diffusion, Mukoyama (2003) found that the return to education is higher in the presence of technology diffusion. A country with a higher amount of skilled labor will adopt new technology faster than a country with less-skilled labor.

Data on skilled and less-skilled workers are not available, so as a proxy, we employ the illiteracy rate for a country in order to capture its level of human capital, as our control variable.
The last variable included is the number of patents. The World Intellectual Property Organization collects patent data from member countries. This data set is a series of patent counts filed by residents or non-residents. This variable allows for testing the association between technology productivity and patents.

None of the previous literature included the labor productivity variable in their analysis. This paper investigates how the labor productivity of a country can affect cross-country technology diffusion. This investigation of labor productivity can shed light on technology spillover. Indeed, it is reasonable to assume that a more productive labor force will take less time to adopt a new technology than a less productive labor force. Descriptive statistics for each variable are reported in Table I.

Table 1 Variables description

Variable	Description (expected sign)	Source
Dependent variable		
Technology gap	Difference between innovator country (USA) and follower country	Extended Penn World Table (Calculated)
Explanatory variable		
Labor productivity gap	Difference in labor productivity between innovator country (USA) and follower country (+) (Calculated)	Extended Penn World Table
Trade openness	Percentage trade contribution to GDP (–) Indicators 2003 CD	World Bank Development
Foreign direct investment	Foreign direct investment, net inflows (% of GDP) (-)	World Bank Development, Indicators 2003 CD
Illiteracy rate	Illiteracy rate, adult (% of ages 15 and above) (+)	World Bank Development Indicators 2003 CD
GDP per capita growth rate	GDP per capita growth (annual %) (–) Indicators 2003 CD	World Bank Development
Patent	Patent Application by patent office (–)	WIPO Statistics Database, December 2008

IV. Econometric model

Each country's aggregate output is assumed to follow the Cobb-Douglas production function. TFP is calculated as the difference between the log of output and factor of input (Schiff and Wang, 2003) from this production function. "A corresponds to TFP or the Solow residual which is in general, assimilated to technological change" (Ozyurt, 2009). There are several different approaches to calculate TFP including growth accounting, parametric, and non-parametric approaches. In the parametric approach, the underlying assumptions are the choice of functional form, the structure, and the form of the error term. Alternatively, the non-parametric approach is relying on both linear programming techniques and on these above assumptions (Grifell-Tatje and Lovell, 1995).

This paper employs the growth accounting and non-parametric methods to estimate TFP. Employing the growth accounting technique is the goal of the first section and later on the non-parametric technique, specifically DEA to analyze technology diffusion will be employed. In either case, calculating the TFP will allow the construction of the dependent variable, “technology gap,” for analysis.

The ultimate goal of this paper is to investigate the determinants of the technology gap between innovator and follower countries. A variety of regression models based on the following econometric model are developed.

$$\ln\left(A_I/A_F\right)_{it} = C + \alpha\times\ln(y_I/y_F)_{it} + \partial\times\ln\left(N_I/N_F\right) + \beta\times\ln\left(A_I/A_F\right)_{i(t-1)} + \gamma\times X_{it} + \varepsilon_{it} \qquad (4)$$

where (A_I/A_F) is the technology gap between innovator country, the USA and follower country *I* in year *t* (y_I/y_F) is the gap in labor productivity, the gap in number of patents per year is (N_I/N_F), and X_{it} is a set of other explanatory variables. $\in_{it}$ is independently and identically distributed among countries and years. All variables included in the vector X are available at an annual frequency. There is considerable controversy regarding estimation technique in cross-country technology spillover studies. Cross-country data limitation is the primary reason for all of these controversies. The selection of the econometric model is solely driven by the availability of data. For example, Caselli and Coleman (2001) use panel model estimation techniques which include fixed effect and random effect models; Deltas and Karkalakos (2007) and Rosa and Mohnen (2008) employ spatial regression analysis; and several other authors such as Mukoyama (2003) and Schiff and Wang (2003) use time series analysis to estimate their technology diffusion model.

The data set employed in this paper is a panel of eight countries over 31 years (from 1970 to 2000). Time series methods are ruled out due to the limited number of time periods. The selection is made between a pooled model and fixed or random effects model. The random effect estimator is the most efficient and is consistent under the assumption that the effect of countries must be uncorrelated with other explanatory variables. The fixed effect estimators do not require this assumption (Caselli and Coleman, 2001). Before selecting the correct model for the analysis, a series of tests were employed to confirm the correct econometric model for this paper. The Breusch-Pagan and Hausman tests confirm the model specification[3]. Both of these tests confirm that both the pooled model and fixed effect model need to be used.

V. Results

The employed data set is primarily based on Latin American countries, however the cultural differences among these countries are surprisingly different. It is reasonable to consider that technology diffusion and/or gap is highly dependent on country’s specific cultural context. Hence, providing a common policy framework might not accommodate all Latin American countries’ in managing their technology or knowledge gap in a uniform manner. Therefore, a comparative analysis as well as aggregate analysis to segregate the effect of culture and other unobserved attributes which might have a role in managing technology diffusion is necessary.

Tables II and III represent the cross-sectional analysis of each Latin American country from 1970 to 2001. Table II includes the individual country estimates and Table III summarizes the results from all countries. All the regressions in this table were estimated using ordinary least squares (OLS) corrected with Webber and White's (2010) heteroskadasticity – consistent covariance estimation method. The country-specific analysis will help to determine policy for an individual country to reduce the technology gap. The dependent variable is technology gap, which is the relative performance of an individual country with respect to the USA The traditional growth accounting approach was used to measure the TFP for each country.

Table II Descriptive statistics

	Growth accounting method TFPGAP	Non-parametric method (The Malmquist TFP Index) TFPGAP	Labor productivity GAP	Trade	FDI	Illiteracy rate	GDP	Patent
Mean	1.08	0.99	0.44	37.76	1.51	25.54	1.37	3018.30
SE	0.03	0.03	0.01	1.22	0.12	0.85	0.28	212.91
SD	0.54	0.04	0.14	19.23	1.82	13.32	4.44	3352.91
Minimum	−0.43	0.8	0.02	10.34	−3.58	6.34	−13.86	41
Maximum	2.07	1.13	0.80	97.57	12.30	63.13	11.32	17509
Count	248	248	248	248	248	248	248	248

Notes: Mean patent gap: 139037.18; Maximum: 265647.53; Minimum: 90171

Table III Results: comparative analysis

Variable	Argentina[a] Coefficient (Std. Error)	Brazil[a] Coefficient (Std. Error)	Chile Coefficient (Std. Error)	Colombia[a] Coefficient (Std. Error)	Costa Rica[a] Coefficient (Std. Error)	Mexico[a] Coefficient (Std. Error)	Peru[a] Coefficient (Std. Error)	Venezuela Coefficient (Std. Error)
Dependent								
Log technology tap								
Explanatory								
Constant	1.20**	1.13***	−0.02	1.20	−0.03	−2.23***	−1.44***	−1.62***
	(0.43)	(0.23)	(0.69)	(0.74)	(0.52)	(0.21)	(0.35)	(0.52)
Log labor productivity gap	−0.02	−0.21	1.91**	−0.71	1.14***	0.69	0.81***	2.39***
	(0.37)	(0.27)	(0.80)	(0.47)	(0.30)	(0.59)	(0.16)	(0.49)
Trade openness	−0.01	0.002	0.02**	0.02***	0.003**	0.03***	0.01***	0.01***
	(0.01)	(0.002)	(0.01)	(0.01)	(0.001)	(0.01)	(0.003)	(0.002)
Foreign direct investment	−0.01*	−0.01	−0.02	−0.01	−0.02*	0.02*	−0.02**	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Illiteracy rate	−0.01	0.01***	0.01	−0.001	0.02*	0.04***	0.01***	0.03***
	(0.02)	(0.002)	(0.02)	(0.01)	(0.01)	(0.004)	(0.003)	(0.01)
GDP per capita growth rate	−0.004*	−0.01***	−0.001	0.01*	−0.01*	−0.02***	−0.001	0.003
	(0.002)	(0.002)	(0.005)	(0.01)	(0.002)	(0.01)	(0.001)	(0.005)
Log patent gap	−0.24***	0.05	−0.19	−0.30	−0.16	−0.10	−0.37***	0.42***
	(0.08)	(0.13)	(0.39)	(0.19)	(0.10)	(0.12)	(0.06)	(0.12)
Lag log of technology productivity gap	0.55***	0.21**	−0.13	0.46***	0.43***	0.29***	0.70***	0.15**
	(0.09)	(0.10)	(0.23)	(0.14)	(0.13)	(0.09)	(0.09)	(0.06)
R^2	0.92	0.90	0.70	0.76	0.81	0.96	0.98	0.95

Notes: [a]Heteroskedasticty Corrected Model. Webber and White test as performed in each of this model to confirm the heteroskedasticty. Standard error is reported in bracket. *,**,***Significant at 10, 5, and 1 percent level, respectively

Comparative analysis

To develop the comparative analysis, we regressed these variables at the individual country level and we report the results in Table IV. All the regressions in this table were estimated using OLS corrected with Webber and White's (2010) heteroskadasticity – consistent covariance estimation method for each Latin American country from 1970 to 2001. In all the regressions, the constant enters with its expected sign, except for Mexico, Peru, Venezuela, and Colombia. It is reasonable to expect a country to move forward without any technology diffusion, as each country's own innovation will advance them over the years. Hence, a negative sign is expected with this variable. Thus, keeping all of these variables at a constant level, each year Mexico (Peru or Venezuela) will reduce the technology gap by 2.23 percent (1.14 percent or 1.62 percent) and this variable is significant at a 1 percent level. However, this variable has an unexpected positive sign for the countries Argentina, Brazil, and Colombia, which indicates that each year the technology gap between the innovator country and these follower countries is going to increase, while keeping all other influential factors at a constant level. The reason for this result could be country specific. The factors such as political stability, unemployment policy, or health standards vary from country to country. Political instability, higher unemployment rate, or workers with poor health conditions can hinder economic growth and possibly technology growth, and hence increase the technology gap (Mayer, 2001).

Table IV Pooled results: growth accounting method and non-parametric method (the Malmquist TFP Index)

Variable	Growth accounting method Pooled model Column 1	Growth accounting method Fixed effect model Column 2	Non-parametric method (The Malmquist TFP index) Pooled model Column 3	Non-parametric method (The Malmquist TFP index) Fixed effect model Column 4
Dependent				
Log technology gap				
Explanatory				
Constant	−0.40***		0.01	
	(0.13)		(0.01)	
Log labor productivity gap	0.62*** (0.23)	0.62*** (0.23)	−0.01*** (0.03)	−0.03** (0.01)
Trade openness	−0.005** (0.002)	−0.005** (0.002)	−0.0001 (0.0002)	−0.00001 (0.0001)
Foreign direct investment	0.002 (0.02)	0.001 (0.02)	0.003 (0.002)	−0.002** (0.001)
Illiteracy rate	0.01*** (0.002)	0.01*** 0.002	0.002 (0.0002)	0.002 (0.0001)
GDP per capita growth rate	−0.001 (0.01)	−0.001 (0.01)	0.0001* (0.001)	−0.0002 (0.004)
Log of patent gap	0.20*** (0.07)	0.21*** (0.07)	0.01** (0.01)	−0.007** (0.004)
Lag log of technology productivity gap	0.66*** (0.04)	0.66*** (0.04)	0.33** (0.08)	−0.08 (0.06)
R^2	0.60	0.61	0.12	0.29

Note: Fixed effect model includes 30 dummy periods in both cases. Results will be available upon request

Next, the extent of a country's labor productivity gap in relation to the technology gap was examined. Before testing the significance and relationship of this variable, the Granger causality test was performed to confirm the direction of influence because the cause and effect relationship between the technology gap and labor productivity gap is uncertain. Does technology growth influence labor productivity or does labor productivity affect technology growth? We employed the Granger causality test to explain the direction of influence. The Granger causality tests for individual countries support the conclusion that technology influences labor productivity (see footnote 3).

The Labor productivity variable appears significant in all of these models with an expected sign except for Mexico, Argentina, Brazil, and Colombia. A positive relationship indicates that a higher labor productivity gap will increase the technology gap between the innovator and follower country, while keeping all other factors in the model at a constant level. Therefore, a country with low labor productivity with respect to the USA will be less likely to take the advantage of improved technology flow. Hence, regardless of the technology diffusion rate, such countries will absorb the technology less efficiently. The unemployment rate, worker health, country's infrastructure, and workers' education levels could be major sources of difference in labor productivity from country to country.

Trade openness gives access to foreign goods and technology to the follower countries. Eaton and Kortum (2002) argue that trade is one important channel for technology diffusion, specifically for less developed countries. A negative relationship between trade openness and technology gap is therefore expected. However, Argentina is the only country with the expected sign, but it is not significant at the 10 percent level. This variable enters the rest of these equations with a significant positive sign, which indicates that increasing trade openness widens the technology gap, while keeping the rest of the variables in the model constant. This result does not support Eaton and Kortum's (2002) results but it provides similar evidence to Keller's (2004) findings.

The importance of FDI has long been emphasized in the literature. Keller (2004) shows that FDI directly or indirectly stimulates the technology diffusion from developed countries to less developed countries, which indicate that an increasing portion of FDI will reduce the technology gap between the follower and innovator country. There are various models suggesting that multinational companies generate technological externalities for domestic firms (see Fosfuri *et al.*, 2001). Our study found that more FDI transactions between the leader and follower country decreases the technology gap between the two countries, while keeping all other factors constant.

On average an increase of one million US dollars in FDI will significantly decrease the technology gap between the USA and Costa Rica by 3 percent or between the USA and Peru by 2 percent, while keeping all other variables constant. This variable enters with the expected sign in most of these equations but only Argentina, Costa Rica, Venezuela, and Peru showed significance at the 10 percent level. This result supports the evidence found by Kugler (2006) and Blalock and Gertler (2009)that FDI increases the domestic level of technology, and hence the gap between the innovator and follower countries will decrease over time.

An increasing number of domestic innovations should decrease the technological gap between countries. The results show that this variable has a mixed impact on the dependent variable in all of these Latin American countries. Venezuela is the only country where this variable significantly enters into the equation with the expected sign; in Mexico, it enters with the opposite sign. Our findings show that the impact of this variable on the technology gap is very low for all countries.

The last variable included in this analysis is the lag of the dependent variable. Other than Brazil, this variable significantly enters into all the equations with the expected sign. A direct relationship with the dependent variable indicates that the current technological gap is driven by the past technological gap. Thus, countries with a larger technological gap in the previous period tend to see an increase in the gap in the present period. If the size of the technological gap is large, then the follower country will need a longer time to catch up with the innovator country compared to a country with a smaller gap in the past period, while keeping all other variables in this model constant.

Control variables

A majority of authors confirm that the contribution of domestic human capital in the technology adoption process is very important. In this paper, the illiteracy rate among workers 15 years and over as a proxy of human capital is employed to measure the nation's adoptive capacity of foreign technology. This variable enters in most of these equations with an expected positive sign and is significant in the equations for Brazil, Costa Rica, Mexico, Peru, and Venezuela. This result indicates that on average, higher illiteracy rates in a country will increase the technology gap between the innovator and follower country. The foreign technology adoption capacity is less for less-educated countries as the population is less prepared to adopt new technology. This result is in the same vein as Keller's (2006) findings.

GDP per capita is an important indicator of an economy's performance. In the economic development literature, the growth rate in GDP per capita is often used as a proxy for the standard of living. A better standard of living increases aggregate productivity for a country, and the country associated with higher productivity will have a higher capability to adopt new technology, which ultimately reduces the technological gap between the innovator country and follower country. GDP per capita growth rate significantly enters into the equations with the expected sign except for the countries Chile, Peru, and Venezuela. Keeping all other variables constant, a unit increase in the growth rate of GDP per capita will significantly reduce the technological gap between Argentina and the USA by 0.04 percent, or by 1 percent between Brazil and the USA.

To summarize the first section of analysis, the OLS model of country-specific technological gap was estimated. The Webber and White test was employed to check country-specific heteroskedasticity. This analysis indicates that factors, such as human capital accumulation (as proxied by the illiteracy rate), patents, and GDP growth per capita growth have negative impacts on the technological gap. These findings are similar to the results found in Abreu *et al.* (2004). The rest of the variables in the models show mixed results.

Aggregate analysis

Making general conclusions is difficult when the comparative analysis is restricted to individual countries. To make more general conclusions about the determinants of the technological gap for Latin American countries, a pooled model is used. The focus of this section of the paper is the empirics of international technology diffusion and its determinants. Selecting the proper model for this panel data set is a challenge. A selection is made between the pooled model, the fixed effects model, and the random effects model. The panel diagnostic analysis confirms that either the pooled model or the fixed effects model needs to be used.

The pooled model and the fixed effects model results are reported in Table IV. Columns (1) and (2) display the results of Equation (3) using the sample of eight follower countries for 31 years. Independent variables for the follower countries include labor productivity gap, trade openness, FDI, illiteracy rate, GDP per capita growth rate, and the number of patents. Instead of presenting the disaggregated results for each country for this specified period, a pooled model with all of Latin America was used. Analyzing these determinants provides hints of policy prescriptions that these Latin American countries could use to minimize the technology gap and improve economic growth.

It is interesting to note that the technology gap is declining over time as the constant term entered both of these models with a negative sign. This is the expected sign because all these countries do achieve a higher level of technological efficiency over time but it enters insignificantly into both equations.

Results displayed in Columns (1) and (2) from Table IV show that the labor productivity gap is positively related to the technology gap between the follower country and innovator country. This variable is significant at the 1 percent level in both cases. Keeping other factors in the model constant, a 1 percent increase in the labor productivity gap will increase the technology gap by 0.62 percent. The impact of trade regulations is captured by the parameters associated with trade openness in both equations. The estimated parameters are both significant and negative. This result indicates that higher intensity of trading will decrease the technology gap. The magnitude of this variable is quite similar in both of these equations and is significant at the 10 percent level. Keeping all other factors constant, a 1 percent increase in trade openness will decrease the technology gap between the follower and innovator country by 0.5 percent.

With regard to the role of human capital, represented by the illiteracy rate and number of patents, our findings are in line with past studies (Mayer, 2001; Keller, 2004; Saffu *et al.*, 2008). According to previous literature, human capital not only improves labor productivity through better knowledge and skill, but it also increases the new technology adaptation capability of the workforce. Most of the previous papers in technology diffusion include R & D expenditures or education, but these proxies fail to measure the efficiency or new technology adoption capacity. The number of patents would be a better proxy instead of R & D expenditures because a country's yearly innovation is directly related to its efficiency. Therefore, not adequately accounting for the role and level of human capital accumulation and efficiency could lead to a biased estimate. Both the number of patents and illiteracy rate significantly enter both the pooled model and fixed effects model with the expected sign. Higher illiteracy rates are positively related to the technology gap, since lack of skills or knowledge make workers less capable of adopting new technology. Conversely, if a country produces a larger number of patents each year, the workforce becomes more productive and they will have a higher level of technology adaptation than a country that produces fewer patents. A positive sign on this variable indicates that a decreasing patent gap will decrease the technological gap between the innovator and follower country. The lag of technology gap is positively related with the current period technology gap, and this variable is significant at a 1 percent level in both of these econometric models. The previous year's technology gap will significantly increase the technological gap in the current period, while keeping all other variables constant.

The other variables to discuss in this paper are the net inflow of FDI and GDP growth per capita. Although research finds both of these variables have significant impact on technology diffusion, we did not find support for this in our study. In both the pooled and the fixed effect models, the GDP per growth capita and FDI have the expected sign, but are insignificant.

In summary, the technology gap between these Latin American countries and the USA largely depends on the labor productivity gap, trade openness, illiteracy rate, and the gap in the number of patents. Results from this paper help to clarify the contribution of each of these factors separately. In addition, testing for Granger causality confirms the direction of influence between the technology gap and labor productivity gap. The empirical investigation on the pooled data set employing the pooled and fixed effects models confirms that labor productivity, illiteracy rate, patents, and trade openness are the driving forces of the technology gap. In the growth accounting approach to estimating TFP, the capital share and wage share are required, but the reliability of these data sets are often questionable. To avoid this problem, a DEA non-parametric estimation was used to calculate the TFP.

The Malmquist TFP index: an alternative TFP estimation approach

The Malmquist TFP index, which is an alternative measure of technology diffusion first introduced by Caves and Christiansen (1982), was used to calculate the technological gap for each country during a specific year. This variable was then used as a dependent variable and followed the earlier procedure to estimate technology gap models.

Table IV shows the results from the pooled model and fixed effects model. The results obtained are very similar to the growth accounting method with the exception of the variable labor productivity gap. The Webber and White test with this data set confirmed the absence of heteroskedasticty. The Bruch-Pagan, and Hausman tests were utilized to choose the estimation technique for this data set. The only noticeable difference between the growth accounting and non-parametric method that was observed is the value of the $R2$ (pooled model 0.12 and fixed effects model 0.29). In the growth accounting model, the $R2$ (pooled model 0.6 and fixed effects model 0.61) value is much higher than in the non-parametric method.

This may suggest that determinants of the technology gap between the innovator country and follower country will remain the same, regardless of the method of TFP calculation. The results highlight that the work force illiteracy rate, trade openness, FDI, and labor productivity are the primary stimulators of the international technology diffusion process. An improvement in the educational system with enhancement of infrastructure creates a higher level of knowledgeable, skillful, and productive workers in the economy. This, in turn, attracts more foreign investors and more technological diffusion, while increases in trade openness also move the follower country to the production frontier. A more productive worker will increase the interest of foreign investors to invest in the country, which results in more imported capital goods that embody international technology, reducing the technology gap. This finding is in the same vein as Xu and

Chiang's (2005) findings. The results imply that a low- and middle-income Latin American country with a more literate labor force, high trade openness, and more labor productivity will adopt foreign technology faster than other counties. According to these results, follower countries should adjust their policy by concentrating on increasing the literacy rate, increasing the number of patents, and trade openness to enhance their economic growth.

VI. Conclusion

Knowledge and innovation management has become much more crucial than in the past. There have been significant number of studies conducted at firm or company levels, however, there is not much contribution in this topic at the country level since knowledge and innovation management vary across countries. We use level of technology to measure country's level of knowledge and employed various methodologies to measure the technology level for a country. This paper investigated the technology gap between the leader country, the USA, and imitator countries employing a sample of eight Latin American countries from 1970 to 2000. It is essential to understand the determinants of the technological gap in order to understand the channels of foreign technology spillover across under-developed and developing countries since these are the ones that benefit from foreign technology sources the most. Various factors including the patent gap, labor productivity, trade openness, FDI, and past technological gap were examined in relation to the current technology gap between the countries by controlling for adult workforce illiteracy rate and GDP per capita growth rate.

There has been an ongoing discussion about the appropriate methodology to calculate the TFP in international technology diffusion literatures. Several researchers use the growth accounting approach to estimate the TFP while others employ a non-parametric approach to calculate the TFP. This paper is the first attempt to compare both of these methodologies in order to calculate the TFP using macro-level data. The parametric approach is another popular method in the productivity analysis field to calculate the efficiency or inefficiency. To make this contribution more complete, the parametric approach will be included in future research to calculate the TFP.

To understand the source of this gap, we first divided the sample into eight countries and then grouped together for panel analysis. We found that a country's labor productivity, adult work force illiteracy rate, and the gaps in patent filing are significant determinants of the technology gap. The trade openness also significantly influences the technological gap. Improving the policies relevant to these factors will help to minimize the technology gap and also facilitate the chances of these Latin American countries catching up with the US economy. Finally, using the growth accounting method and the non-parametric approach to estimate the TFP yields similar conclusions.

In our study, we focussed exclusively on Latin American countries. Future research may want to focus on other continents such as Africa to investigate the determinants of technology gaps. Indeed, there may be continental differences in the technology gap among under-developed and developing countries as research suggests geographical differences in technology transfer and adoption (Keller, 2006). In terms of public policy, policies oriented toward these factors may help these countries to catch up with the USA or other developed countries in terms of standard of living through increased technology adoption capabilities. Human capital accumulation is a critical element in technology adoption and can also attract more technology-oriented multinationals to invest into the under-developed and developing countries. This can further accelerate the transferring and absorbing of technology. Despite the globalization and standardization in trade policies, a “one size fits all” strategy may not be appropriate for every country concerning the technology transfer and adoption. Hence, relevant public policy in different countries may need to be revised according to the economic and geographic conditions discussed in our paper to minimize technology gaps. The country-level analysis also verifies that that there are some unobserved country-specific attributes, such as culture, that plays a role in managing knowledge or innovation or technology. Although countries fin this sample are from similar regions, the national cultures intervene in the process of knowledge and innovation management. Again, national and international policy makers need to consider these factors.

Discussion about the knowledge or innovation management at the firm level is well recognized. However, the literature at the country level on this topic is scare and far from being conclusive. Therefore, multinational companies should use this study as a sample case to understand the linkage between technology diffusion or knowledge gap and various other economic factors. Based on the country-level analysis, it can be argued that the FDI and trade openness play crucial roles in determining knowledge or technology gap. Multinational companies based on Latin America should move forward toward open economies and provide incentive to the foreign direct investors to increase investments. Paying more attention toward education and investing resources on research and development to increase knowledge or technology level should be multinational companies’ other important objective.

Furthermore, other time periods can be investigated. In our study, we focussed on Latin American developing countries from 1970 and 2000 owing to the data availability for this longitudinal time frame. However, further increased globalization, political, legal, economic, and technological changes after this time period are likely to affect the links we have examined (Burstein and Vogel, 2010;Nissanke and Thorbecke, 2006; Zhouying, 2005). Hence, future research can examine the more current technology gap issues among these countries.

In conclusion, instead of depending entirely on international technology, Latin American countries may benefit from extending their local knowledge level, labor productivity, and domestic intellectual contributions (Hermelo and Vassolo, 2012). Our findings are consistent with research suggesting that under-developed and developing countries meeting a minimum human capital threshold (Saffu *et al.*, 2008) and investing in domestic technology can benefit from technology diffusion (Keller, 2004, 2006) faster, mitigating the technology gap. However, since the impact of technology diffusion channels on the technology gap vary even among under-developed and developing countries, local public policies on improving economic conditions are essential aside from policies set through global economic development and trade agreements. The policymakers in each country need to design and implement strategies directed toward facilitating the access to technology, technology diffusion from leader countries, elevating absorptive capacity, continuous innovation, and consequently mitigating their technology gap. Hence, developing countries need to build upon their domestic capabilities in a global technological setting.

Notes

1. Interpolation is another method to construct missing data points.
2. Please visit www.worldbank.org for more information.
3. Results are available upon request.

References

1. Abreu, M.A., Groot, H.L. and Florax, R.J. (2004), "Spatial patterns of technology diffusion", Discussion Paper, Tinbergen Institute, Amsterdam.

2. Apaydin, M. (2009), "Analyzing FDI trends in emerging markets: Turkey vs. CSEE and the Middle East",*International Journal of Emerging Markets* , Vol. 4 No. 1, pp. 72-97.

3. Apergis, N., Economidou, C. and Filippidis, I. (2008), "Innovation,technology transfer and labor productivity linkages: evidence from a panel of manufacturing industries", *Review of World Economics* , Vol. 144 No. 3, pp. 491-508.

4. Baier, S.L., Dwyer, G.P. and Tamura, R. (2002), "How important are capital and total factor productivity for economics growth?", *Economic Inquiry* , Vol. 44 No. 1, pp. 23-49.

5. Barro, J.R. and Sala-i-Martin, X. (1995), *Economic Growth* , McGraw-Hill, New York, NY.

6. Blalock, G. and Gertler, P.J. (2009), "How firm capabilities affect who benefits from foreign technology",*Journal of Developmental Economics* , Vol. 90 No. 2, pp. 192-199.

7. Blomström, M. and Kokko, A. (1998), "Multinational corporations and spillovers", *Journal of Economic Surveys* , Vol. 12 No. 3, pp. 247-277.

8. Blyde, J. (2004), "Trade and technology diffusion in Latin America", *The International Trade Journal* , Vol. 18 No. 3, pp. 177-197.

9. Burstein, A. and Vogel, J. (2010), "Globalization, technology, and the skill premium: a quantitative analysis (No. w16459)", National Bureau of Economic Research NBER Working Paper No. 16459, Cambridge, MA, October.

10. Caselli, F. and Coleman, W.J. (2001), "Cross-country technology diffusion: the case of computers",*American Economic Review, American Economic Association* , Vol. 91 No. 2, pp. 328-335.

11. Caves, D.W. and Christiansen, L.R. (1982), "The economic theory of index numbers and the measurement of input, output and productivity", *Econometrica* , Vol. 50 No. 6, pp. 1393-1414.

12. Coe, D.T. and Helpman, E. (1995), “International R & D spillovers”, *European Economic Review* , Vol. 39 No. 5, pp. 859-887.

13. Deltas, G. and Karkalakos, S. (2007), “Similarity of R & D activities, physical proximity, and the extent of R & D spillovers” MPRA Paper 45962, University Library of Munich.

14. Eaton, J. and Kortum, S. (2002), “Technology, geography, and trade”, *Econometrica* , Vol. 70 No. 5, pp.1741-1779.

15. Fosfuri, A., Motta, M. and Rønde, T. (2001), “Foreign direct investment and spillovers through workers’ mobility”, *Journal of International Economics* , Vol. 53 No. 1, pp. 205-222.

16. Grifell-Tatje, E. and Lovell, C.K. (1995), “A note on the Malmquist productivity index”, *Economics Letters* , Vol. 47 No. 2, pp. 169-175.

17. Grossman, M.G. and Helpman, E. (2001), *Innovation and Growth in the Global Economy* , The MIT Press and Massachusetts Institute of Technology, ISBN 0-262-57097-1, Cambridge, MA.

18. Hermelo, F.D. and Vassolo, R. (2012), “How much does country matter in emerging economies? Evidence from Latin America”, *International Journal of Emerging Markets* , Vol. 7 No. 3, pp. 263-288.

19. Kaasa, A. and Vadi, M. (2008), “How does culture contribute to innovation? Evidence from European countries”, working paper, University of Tartu and Tartu University Press, Estonia, ISBN 978-9949-11-960-8.

20. Keller, W. (2004), “International technology diffusion”, *Journal of Economic Literature* , Vol. 42 No. 3, pp.752-782.

21. Keller, W. (2006), “The international trade, foreign direct investment, and technology spillovers”, Working Paper No. 15442, National Bureau of Economic Research, Cambridge, MA.

22. Kouznetsov, A. (2010), *Industrial and Geographical Diversification of Russian Foreign Direct Investments* , Pan-European Institute, No. 7, Turku School of Economics.

23. Kugler, M. (2006), “Spillovers from foreign direct investment: within or between industries?”, *Journal of Development Economics* , Vol. 80 No. 22, pp. 444-477.

24. Madsen, J.B. (2007), “Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries”, *Journal of International Economics* , Vol. 72 No. 2, pp. 464-480.

25. Malmquist, S. (1953), “Index numbers and indifference surfaces”, *Trabajos De Estadistica* , Vol. 4 No. 2, pp. 209-242.

26. Mansfield, E. (1968), *Industrial Research and Technological Innovation: An Econometric Analysis* ,Norton, New York, NY.

27. Mayer, J. (2001), “Technology diffusion, human capital and economic growth in developing countries”, United Nations Conference of Trade and Development, UNCTAD/OSG/DP/154, Geneva.

28. Mukoyama, T. (2003), “A theory of technology diffusion”, working paper, Department of Economics, Concordia University and CIREQ, p. 40.

29. Nissanke, M. and Thorbecke, E. (2006), “Channels and policy debate in the globalization – inequality – poverty nexus”, *World Development* , Vol. 34 No. 8, pp. 1338-1360.

30. Ozyurt, S. (2009), “Total factor productivity growth in Chinese industry: 1952-2005”, *Oxford Development Studies* , Vol. 31 No. 1, pp. 1-17.

31. Rensman, M. and Kuper, G.H. (1999), *The Role of R&D and Patent Activity in Economic Growth: Some Empirical Evidence* , University of Groningen, Research Report 99C03, Research Institute SOM.

32. Romer, P.M. (1990), “Endogenous technological change”, *Journal of Political Economy* , Vol. 98 No. 5, pp. S71-S102.

33. Rosa, J.M. and Mohnen, P. (2008), “Knowledge transfer between canadian business enterprises and universities: does distance matter?”, *Annales d’Economie et de Statistique, ENSAE* , Nos 87/88, pp. 303-323.

34. Saffu, K. , Apori, S.O. , Elijah-Mensah, A. and Ahumatah, J. (2008), “The contribution of human capital and resource-based view to small-and medium-sized tourism venture performance in Ghana”,*International Journal of Emerging Markets* , Vol. 3 No. 3, pp. 268-284.

35. Saggi, K. (2000), *Trade, Foreign Direct Investment, and International Technology Transfer: A Survey* ,The World Bank, No. 2349, WB Paper Series in International Economics, Washington, DC.

36. Schiff, M. and Wang, Y. (2003), “Regional integration and technology diffusion: the case of the North America free trade agreement”, Working Paper No. 3132, World Bank Policy Research, Washington, DC.

37. Solow, R. (1956), “A contribution to the theory of economic growth”, *The Quarterly Journal of Economics*, Vol. 70 No. 1, pp. 65-94.

38. Veugelers, R. and Cassiman, B. (2005), "R & D cooperation between firms and universities: some empirical evidence from Belgian manufacturing", *International Journal of Industrial Organization* , Vol. 23 No. 5, pp. 355-379.

39. Webber, D.J. and White, P. (2010), "Productivity and proximity", *Empirical Economics Letters* , Vol. 9 No. 4, pp. 323-330.

40. Xu, B. and Chiang, E.P. (2005), "Trade, patents and international technology diffusion", *Journal of International Trade and Economics Development* , Vol. 14 No. 1, pp. 115-135.

41. Xu, G. and Wang, R. (2000), "The effect of foreign direct investment on domestic capital formation, trade, and economic growth in a transition economy: evidence from China", *Global Economy Journal* , Vol. 7 No. 2, pp. 1-21.

42. Zhouying, J. (2005), "Globalization, technological competitiveness and the catch-up challenge for developing countries: some lessons of experience", *International Journal of Technology Management & Sustainable Development* , Vol. 4 No. 1, pp. 35-46.

About the authors

Dr Kaustav Misra, PhD is an Assistant Professor Economics at the Saginaw Valley State University. His research has been published in refereed journals such as *Entrepreneurship Theory and Practice, Economics of Education Review, The Journal of Socio-Economics, Journal of Family Business Management, International Entrepreneurship and Management Journal and of Developmental Entrepreneurship*. Dr Kaustav Misra is the corresponding author and can be contacted at: kmisra@svsu.edu

Dr Esra Memili, PhD is an Assistant Professor at the Bryan School of Business and Economics at the University of North Carolina-Greensboro. She is the author of published and/or accepted manuscripts in the *Entrepreneurship Theory and Practice*, *Family Business Review, Journal of Family Business Strategy, Academy of Management Best Paper Proceedings*, and others.

Dr Dianne H.B. Welsh, PhD is the Hayes Distinguished Professor of Entrepreneurship and Founding Director of the award-winning Cross-Disciplinary Entrepreneurship Program at the University of North Carolina-Greensboro. She is a globally known scholar in international franchising, family business, and entrepreneurship. She is the President of the Small Business Institute® and Program Chair for the Technology and Innovation Management Division of the Academy of Management.

Dr Surender Reddy, PhD is a Professor of Management and Marketing at the Saginaw Valley State University. He is the author of numerous scholarly articles on Supply Chain Management and Strategic Management. His research has been published in refereed journals such as *Journal of Academy of Business and Economics* and *International Journal of Business Research*.

Dr Gail E. Sype, PhD is an Associate Professor of Management and Marketing at the Saginaw Valley State University. She is the author of numerous scholarly articles and books in management. Her research has been published in refereed journals such as*Journal of Behavioral and applied management* and *International Journal of Business Research*.