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Oil, gold, US dollar and stock market interdependencies: a global analytical insight

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Abstract

Purpose – The purpose of this paper is to examine, in a global perspective, the oil, gold, US dollar and stock prices interdependencies and to identify instantaneously direct and indirect linkages among them.

Design/methodology/approach – A methodology based on simultaneous equations system was used to identify direct and indirect linkages for the period 1995-2015. The authors try initially to find theoretical answers to main question of the study by discussing causal bilateral relationships while focusing on multilateral interactions.

Findings – The results show significant interactions between all markets. The authors found a negative relation between oil and stock prices but oil price is significantly and positively affected by gold and USD. Oil price is also affected by oil futures prices and by Chinese oil gross imports. Gold rate is concerned by changes in oil, USD and stock markets. The US dollar is negatively affected by stock market and significantly by oil and gold price. Indirect effects always exist which confirm the presence of global interdependencies and involve the financialization process of commodity markets.

Originality/value – Motivation of this research paper is the substantial implications of price movements on real economy and financial markets. Understanding that co-movement has great value for investors, policy makers and portfolio managers. This paper differs from previous studies in several aspects. First, most of the research papers focus on bilateral linkages solely, while the authors' investigation was implemented on all the four markets simultaneously. Second, the study was developed in a global framework using international data. The global analysis allows avoiding country specific effects.

Keywords Stock market, Oil price, Gold price, Trade-weighted exchange rate, Simultaneous equations

Paper type Research paper

1. Introduction

The sustained rise in interdependence of global markets along with the international financial integration have accelerated the financialization process of commodity markets (Tang and Xiong, 2012) and led stock and foreign exchange (hereafter forex) markets to be more sensitive to commodity prices.

Moreover, the unusual breaking events and the shortage of liquid financial assets make investors questioning their worldview about market risk and triggered a particular interest in precious metals and energy markets (Caballero *et al.*, 2008). Commodity markets have then attracted international investor's attention not only as "safe haven" but also as a alternative investment with greater sense of certainty during turmoil periods (Baur and McDermott, 2010).

JEL Classification — F31, G15, Q02

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Oil and gold are the most widely traded commodities that have become among the most popular economic indicators.

In the presence of financialization process of commodity markets, oil, gold, US dollar and stock prices have acquired further diversification properties and become sharing similar statistical properties with other common characteristics (Vivian and Wohar, 2012; Chkili *et al.*, 2014). They are correlated with each other and with the outlook of the global business cycle. In that framework, the price dynamics of all these assets is an important indicator of market expectations on the future state of the world economy and investment horizons. What investors feel about the future might be reflected in the information content of those prices.

We motivate this research paper by the substantial implications of price movements of the present assets and commodities on real economy and financial markets. Therefore, understanding their co-movement prices has great meaning for portfolio managers and policy makers.

The aim of this study is to highlight the interdependent relationships between all the markets. We try to perform a global analytical insight while pointing to potentially important direct and indirect interactions. We first discuss theoretically the causal bilateral relationships directly and through the effect of other asset prices and then, empirically, the all-party interdependencies through a simultaneous analysis. We develop the study in a global framework using international data. Indeed, we employ Brent crude oil price, international gold price, broad trade-weighted US dollar index and the world stock market return index as principal data. Other representative data associated with the expected world economic state, monetary policy, financialization of oil markets, and corporate default risk were employed to control for exogenous and indirect effects.

The theoretical possibility of both direct and indirect channels calls for a simultaneous equation methodology. The empirical methodology used to meet aims of the study is then a simultaneous equation system which allows studying all these linkages and grants on the possibility of more adequately investigating the complex system of interactions among oil, gold, forex and stock prices. This approach allows relying on potential links via other indirect effects. We then specify an equation to each endogenous variable, which includes the other endogenous variables as exogenous, and other exogenous variables to capture indirect effects. Fundamentally, we attempt to answer the following questions: to what extent oil, gold, forex and stock market are interdependent? And what nature and direction of effects portray their interdependencies?

The main results founded show significant interactions between oil price, gold rate, USD and stock prices. Indeed, we found that oil price is significantly affected by stock markets, gold and trade-weighted USD exchange rate. Oil price is also affected by oil futures price as well as by Chinese oil gross imports. Gold price is concerned by changes in oil, USD and stock markets but slightly depends on US oil imports and default premium. The USD exchange rate is significantly affected by oil, gold and stock market prices. The USD is also negatively affected by US consumer price index (CPI). We note that indirect effects exist which confirm the presence of global interdependencies and the financialization process of commodity markets. We explain the obtained results by the increased use of both oil and gold as financial assets either for speculation or for hedging, which intensifies such interdependencies.

This paper differs from similar previous studies in several aspects. First, most of research papers focus on bilateral linkages such as oil vs stock markets (Jones and Kaul, 1996; Arouri *et al.*, 2012; Mollick and Assefa, 2013), oil price vs gold price (Ewing and Malik, 2013), gold prices vs stock markets (Gaur and Bansal, 2010; and Le and Chang, 2012), oil price vs exchange rates (Basher *et al.*, 2012) and other on trilateral linkages such as oil price, exchange rates and stock prices (Olugbenga, 2012; Fratzscher *et al.*, 2014).

We implement our investigation on the four markets simultaneously. Second, we develop our study in a global framework and use international data. Indeed, we employ Brent oil price, gold price, broad trade-weighted US dollar index and the international stock market index. The global analysis allows avoiding country specific effects that may be inherent to domestic sectoral or industrial specialization, foreign exchange regimes, PPP or inflationary economies, financial development, domestic market sizes, etc. Third, the simultaneous equation approach makes it possible to answer to many questions associated with bilateral interactions and to control for direct and indirect effects in so far as the four markets represent different economic sectors, different patterns of specialization, national monetary policies, and miscellaneous stock markets microstructures. Finally, the global framework of this study provides useful insights for investment, managerial and governmental executive purposes.

The remainder of the paper is organized as follows. The second section presents a glance at the existing literature. The third section presents the used data and a theoretical analysis and then declares hypothesis of the study. The fourth section outlines the empirical methodology. The fifth section discusses empirical results and the final section concludes the study.

2. A glance at the existing literature

The relationships between financial and commodity markets are documented in a sizeable literature. We present and discuss here bilateral relationships with an interest in multilateral interactions.

2.1 *Oil price vs US dollar exchange rate*

The relation between oil price and exchange rates was initially documented by Golub (1983) and Krugman (1983) who put forth compelling arguments as to why the movements in oil price should affect exchange rates. Golub reasons that since oil price is denominated in USD, an increase in oil price will lead to an increase in demand for US-dollars. However, Krugman's (1983) analysis is based on the relationship among portfolio investment preferences of oil exporters and exchange rates movements. Indeed, rising oil price will increase portfolio investment possibilities of oil exporters. In Krugman's (1983) analysis, exchange rate movements are determined primarily by current account movements. If rising oil price lead to deterioration of country's current account, then exchange rates will fall. More recent evidence on this effect can be found in the study of Bodenstein *et al.* (2011), Jean-Pierre Allegret *et al.* (2014), etc.

Sadorsky (2000) found that exchange rates impact oil prices. Akram (2009) also found that a weaker dollar leads to higher commodity prices. More recently, Fratzscher *et al.* (2014) found bidirectional causality between the USD and oil price.

There is a sizeable difference in the strength of transmission between direct and indirect channels. For instance, they find no direct effect of equity market on oil price, but a sizeable and significant effect via shocks on interest rates and risk. Similarly, the effects of shocks on both oil price and the US dollar are stronger than the direct effects. This result is important as it suggests that the transmission of shocks on financial markets to and from oil price is not uni-directional and limited to individual asset prices, but that the transmission process is complex and occurs often indirectly via third asset markets.

2.2 *Oil price vs stock prices*

The literature includes various studies that confirm the interdependency between oil price and stock prices. For instance, Basher and Sadorsky (2006) reported strong evidence that oil price risk impacts stock returns on emerging markets. Miller and Ratti (2009) used a VECM

for the period 1971-2008, and observed that stock market respond negatively to oil shocks in the long run, but this negative relationship disintegrated after September 1999. Their results support the existence of structural breaks in this relationship. Oberndorfer (2009) was interested in the period 2002-2007, using both ARCH and GARCH models and found that rises in oil prices affect the European stock returns negatively. Basher *et al.* (2012) used an SVAR on monthly data for the period 1988-2008, and found that positive oil price shocks tend to depress stock prices on emerging market and USD exchange rates in the short run.

On balance, these studies confirm the evidence that changes in oil price have an effect on stock prices.

2.3 Oil price vs gold price

Melvin and Sultan (1990) contended that both changes in oil price and political unrests are significant determinants of gold rate. Narayan *et al.* (2010) was interested in the long-run relationship between gold and oil spot and future prices of different maturities through the inflation channel and observed bidirectional causality.

In the presence of common factors effect, Tang and Xiong (2012) stated that as a result of the financialization process, futures prices of non-energy commodities became increasingly correlated with oil after 2004. This trend has been triggered by the sub-prime crisis. Zhang and Wei (2010) analyzed cointegration and causality between gold and oil prices and found that there are consistent trends between oil price and gold price with a significant positive correlation during the sampling period 2000-2008. They observed in advance that oil price dynamics linearly Granger cause volatility of gold price.

Reboredo (2013) analyzed the oil-gold dependence structure using copula approach for the period 2000-2011, and found a positive and significant relationship between them suggesting that gold cannot hedge against oil price volatility. Wang and Chueh (2013) found positive interaction between gold and oil prices for the period 1989-2007.

2.4 Gold price vs stock market prices

Gaur and Bansal (2010) confirmed that, in periods of crisis, falling stock market always results in rising gold rates. Le and Chang (2012) found a significant relationship between stock market prices and gold prices and stated that stock market is a reason for increasing gold rate. Gilmore *et al.* (2009) used daily time series for the sampling period 1996-2007, and found that stock market index was linked with gold mining companies' price index in the long run and that both variables influence each other in the short run.

There is apparent evidence that in turbulent periods with economic uncertainty, as equity prices fall gold price rises and attention focuses on gold as a safe haven.

2.5 US dollar vs Stock market prices

As far as the relationship between stock market and forex is concerned, the existing literature endows with paradoxical reasoning. Traditional approach (at microeconomic level) states that exchange rates lead stock prices (Dornbusch and Fischer, 1980; Yau and Nieh, 2006), whereas portfolio approach (at the macroeconomic level) states that stock market mechanisms determine exchange rates (Granger *et al.*, 2000; Caporale *et al.*, 2002).

Wang *et al.* (2010) used daily data to explore the impacts of fluctuations in crude oil price, gold price, and US dollar on stock price indices of the US, Germany, Japan, Taiwan and China. The results show that there exist cointegration between fluctuations in oil price, gold price and the US dollar and the stock markets in Germany, Japan, Taiwan and China. Sekmen (2011) explained the negative impact of exchange rate volatility on US stock prices by the rising costs associated with hedging foreign exchange rate risk. Olugbenga (2012) found a significant influence of foreign exchange rates on the Nigerian stock market (as Nigeria is an

oil-exporting country). The author concluded that volatility of forex market could be used as predictor for stock market. Kang and Yoon (2013) examined price returns and volatility linkages between forex market and stock markets in South Korea from January 1990 to December 2009. They found strong causality from stock prices returns to forex returns.

3. Data and theoretical analysis

3.1 Presentation of the data and declaration of hypothesis

A special feature in the relationship among oil, gold, forex and stock markets is that the magnitude of their interdependencies is illustrated in the informational contents of their respective prices. Generally, unusual events are summarized in stock market dynamics and international oil price. We depict and discuss here theoretically bilateral relationships and then declare the hypothesis for each relation.

Oil price vs US dollar exchange rate. The focus is first on the link between oil price and the US dollar. In the beginning, we mentioned that oil as commodity is broadly invoiced in USD. It will be a close relationship between a price and a good demanded by wide range of countries. Consequently, a negative correlation can arise because changes in the USD exchange rate affect oil price negatively. More specifically, exchange rates can change oil price by way of an effect on oil supply and demand, and by financial markets. It's the terms of trade[1]. Backus and Mario (2000) show that variation in oil price even determines most of the variation in the terms of trade. First, on the supply side of oil market, a depreciation of the USD may lead oil producers to limit oil supply to raise oil price and stabilize their positions in dollars. Yousefi and Wirjanto (2003, 2005) provide evidence on this channel. Second, a depreciation of the dollar value may also increase the global demand for oil, as oil imports become cheaper in local currency for countries besides the USA (De Schryder and Peersman, 2015; Beckmann and Czudaj, 2013). Moreover, several countries such as China peg their national money to the US dollar. Dependent on their oil consumption intensity, depreciation could lead to an increase in oil demand driven by higher exports (Bénassy-Quéré *et al.*, 2007).

Exchange rates can also affect oil price directly through financial markets or indirectly through other financial assets, and particularly portfolio rebalancing and hedging practices. It is the wealth effects. As oil price is expressed in USD, oil futures may be a good hedge against expected depreciations in the USD. Krugman (1983) and Golub (1983) documented that higher oil price will transfer wealth from oil importers to oil exporters, which leads to a change in the exchange rate of the importing country through current account imbalances and portfolio reallocation. The last impact is associated with the dependence on oil and the share of exports to oil-exporting countries.

Other observers and academics argued that the negative correlation between exchange rates and oil price could be driven by monetary policy and interest rate changes in so far as a reduced interest rate in one country results in capital flights and then weakens PPP of the local currency in that country. Subsequently, national imports become expensive on international markets. At the same time, a reduced interest rate by Federal Reserve (FED) weakens US dollar on international forex markets and then results in cheap imports of dollar-denominated commodities. In inflationary times, international investors may prefer to invest in real assets like oil, which drives oil price up of course when considering the elasticity price. Consequently, we expect to find a negative interaction and then declare the null hypothesis as follows:

H_0 . There is a negative relationship between oil price and US dollar exchange rate.

Oil price vs stock market prices. For equity markets, there is evidence that higher oil price lowers stock market prices, and that this effect mainly materializes through a demand channel associated with costs and profitability of listed firms (Kilian and Park, 2009; Masih *et al.*, 2011). Demand shocks are indeed widely held responsible for the evolution in oil

price since 2003, as emerging economy commodity demand growth pushed oil price upwards (Kilian, 2009; Lombardi and Robays, 2011). Accordingly, one enlightenment of the negative correlation between exchange rates and oil price could exactly be the great growth of demand in China, and BRICS's economies, which lifted oil price upwards (from 2000 to 2008) and at the same time was associated with a weaker US dollar. The opposite evidence occurred with the slower growth in those countries since 2010 which helped bring oil price down in 2014 by demanding much less of it and appreciated the USD.

On the topic of uncertainty and risk aversion, there exists compelling evidence that a rise in financial market risk generally results in an appreciation of the USD (Bekaert *et al.*, 2013) as US financial assets are perceived as safe and liquid, triggering what is referred to as FTS (flight-to-safety) phenomenon (Fratzscher, 2009). Oil price volatility increases in period of improved uncertainty (Robays, 2016). Accordingly, we expect to find a negative interaction and declare the null hypothesis as follows:

H1. There is a negative relationship between oil price and stock market prices.

Oil price vs gold price. International oil and gold prices share common features, especially when they are traded either for hedging or speculation purposes. Zhang and Wei (2010) support the evidence that both commodity markets tend to be influenced by common factors, such as US dollar, economic fundamentals and geopolitical events. Gold is often regarded as a substitute currency and a pretty safe haven for risk aversion. Oil can also be used as an inflation hedge for asset portfolios because it is a significant driver of inflation, although developed economies have improved their energy efficiency and weakened inflation risk. Both oil and gold are likely to rise in response to a falling dollar, but their bilateral relationship is less straightforward than that as oil is perceived as risky asset and gold as the opposite. During periods of risk on trade, oil will be bought whereas gold is more likely to be sold, so there should be a negative correlation between them.

Moreover, an instantaneous thought suggests a direct causal relationship but a second argument supports an impact of oil on shares of gold listed companies and argues that the gold and oil prices are driven by a common factor through stock markets. In the main, oil-gold relationship obeys to three major theories:

- (1) First, oil influences gold: one possible argument states that raising oil price is bad for the economy, dampening growth and dropping stock prices so investors look for alternative assets such as gold. Thus, oil price indirectly affects the price of gold.
- (2) Second, oil affects gold mines: another view sees an inverse causation between oil price and stock prices of gold mining listed companies. Expensive oil makes gold extraction more expensive and therefore minimizes the profit margin of gold mines. This is because a big fraction of mine extraction consumes energy.
- (3) Third, inflation impacts gold and oil: both oil and gold trade are invoiced in the USD. Therefore, their pricing process depends on the strength of that currency, as driven by its inflation rate. It can be argued that sharing similar trend is not because one influences the other, but because their prices are driven by a common factor: the US inflation rate.

The third theory is a reminder that correlation, meaning a similar pattern between two variables, does not necessarily imply causation. One explanation might be indeed causation: oil price directly influences gold price. As a result, we expect to find a close bidirectional relation while expressing a reservation about the sign of that relation. From where, we declare the null hypothesis as follows:

H2. There is a close relation between oil price and gold price.

Gold prices vs stock market prices. Gold is an accepted standard of value and is not subject to the same systematic risk that stock market is exposed to. So when business cycle collapses, stock exchanges and the dollar move downward and become less attractive but gold becomes more pretty and its value increases as well. In fact, stock market expresses the soundness of national money to determine how nation's businesses get higher. However, this inverse relationship is frequently known as unstable. Therefore, we expect to observe a negative relation and then declare the null hypothesis as follows:

H3. There is a negative bidirectional relation between stock prices and gold rate.

Gold prices vs US dollar. The correlation between gold and the US dollar seems to be awkward at the beginning, in so far as gold is priced in this currency. Would it not be impossible to settle on such relationship? Otherwise, the relationship between gold and a currency can be associated with the foreign exchange rate of that currency. As about the US dollar, the existing literature marks two facts:

- Fact 1: between 2004 and 2006, the correlation between gold and the US dollar Index was -0.44 ; between 1997 and 2006, it was -0.28 ; and between 1989 and 2006, the relationship was -0.28 . It means an inverse correlation.
- Fact 2: from 2001 until 2009, gold and the USD had a nearly perfect negative correlation. When gold price decreases, the dollar increases. However, since the end of 2009, this is no longer the case.

In fact, gold moved to floating exchange rates after 1971. This made its price exposed to the USD's external value. In 2008, the IMF estimated that 40-50 percent of moves in gold price since 2002 were dollar related. A 1 percent change in the effective external value of the US dollar leads to more than a 1 percent change in gold price. First, a falling dollar increases the value of other local currencies which increases the demand for commodities including gold. Second, when the USD starts losing its value – compared to its trading partners – investors look for alternative investment sources to store value, which is gold.

However, it's important to realize that it's possible for the USD and gold price to increase at the same time. This can occur in presence of a crisis in some other countries or regions. This would cause investors to flock to safer assets – USD and gold. The USD is also driven by other factors – like monetary policy and inflation and economic prospects in the USA vs other countries. Investors and portfolio managers need to consider all of these factors as well as historical facts given that history may repeat itself. Consequently, we expect to observe a negative relation and declare the null hypothesis as follows:

H4. There is a negative relation between US dollar and gold price.

US dollar vs stock market prices. Generally, stock market can impact forex in different ways. For instance, if the US stock market start getting higher registering impressive gains, we are likely to see a large influx of foreign investment into the USA, as international investors rush in to join the party. This influx of money would of course be very positive for the USD. The opposite also holds true: if the stock market is bearing, foreign investors will most likely rush to sell their US equity holdings and convert USD's into their domestic currencies which would lead to substantially negative impacts on the dollar back. This fact can be applied to all other currencies and equity markets around the world. It is also the most basic usage of equity market flows to trade forex.

The results presented in previous studies are best mixed. The reasons behind the mixed results could be difference in specialization or in the trade volumes or there could be a difference in the degree of capital mobility. We go forward in the discussion of

this relationship. The US dollar and stock market interactions have mostly one way: inverse relationship. The majority of impact flows from the dollar (cause) to the stock market (effect). The transmitted effects occur through three channels: effects on exports, repatriated profits from abroad and foreign capital. Effects on exports: stocks of US-listed exporter companies, which rely on the competitiveness of their exports abroad, gain direct positive benefits from a weaker dollar. As weaker dollar increases. The companies benefit from increased foreign sales, and their equity prices rise when earnings are reported. Repatriated profits from abroad: According to the “National Center for Policy Analysis”, the US’ share of world GDP is relatively constant at 26.7 percent since 2009, which means that there is more economic activity out of the country than there is inside the United States. For instance, Ford and McDonald’s are getting more than 60 percent of their revenue from overseas. Companies doing business overseas that greatly will be strongly affected by foreign exchange fluctuations against the dollar. If a company makes 1 million euros in profit, and the dollar falls in value, then those euros will translate to additional dollars. The market collapses when those extra unearned profits come in. It sounds ridiculous to look at companies for the strength of their business, but stock market involves a lot of perception, not just economic realities. Foreign capital: the relative increase in foreign currencies from a depreciating dollar does not just benefit institutional investors but also wealthy individuals overseas see that they can get more US-dollars for their own currency and therefore buy more financial assets on the US stock market. As the institutional investors rise, and the dollar gets stronger, they can sell their now appreciated USDs and convert them back into their domestic currency, thus getting a higher return than if they invested in their own currency. We then expect to observe a negative relation and then declare the null hypothesis as follows:

H5. There is a negative bidirectional relation between stock market prices and US dollar.

In Figure 1, we summarize the all-party direct and indirect relationships, as detected in the literature and discussed theoretically before.

3.2 Statistical properties of variables

We use monthly data for the sampling period spanning from January 1995 to October 2015. The data are Brent crude oil price, gold price, broad trade-weighted average of the foreign exchange values of the US dollar against the currencies of a broad group of major US trading partners, and the MSCI world stock market index. The data have been, respectively, sourced from the US Energy Information Administration, Bank of England, Board of Governors of the Federal Reserve System and MSCI barra.

Other additional controls monthly data are: US interest rate (Effective Federal Funds Rate) used to control for monetary policy impacts, US CPI to control for socio-economic conditions, Chinese and US gross imports of crude oil as proxies for global economic outlooks, default premium as the differential between Baa and Aaa Moody’s rated US

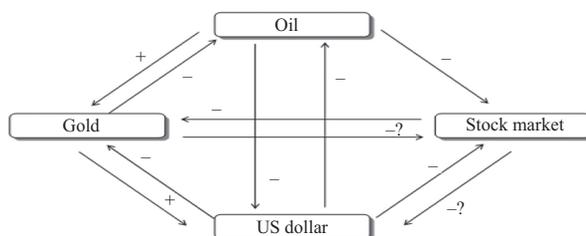


Figure 1.
Direct and indirect
relationships: evidence
from the literature

corporate bonds to control for default risk effects as well as for financial and banking crises on international financial markets and, finally, crude oil futures contracts to control for investors' expectations as well as the financialization process of oil markets. All the data have been obtained from Federal Reserve Economic Data and Energy Information Administration[2].

4. Empirical methodology and econometric issues

The empirical methodology makes use of the simultaneous equation approach which allows to adequately investigating the multipart interactions among oil price, gold rate, US dollar exchange rate and stock market prices. We then estimate the following system of equation simultaneously:

$$Stock_t = \alpha_0 + \alpha_1 Oil_t + \alpha_2 Gold_t + \alpha_3 USD_t + \alpha_4 X_{1t}^s \quad (1)$$

$$Oil_t = \beta_0 + \beta_1 Gold_t + \beta_2 USD_t + \beta_3 Stock_t + \beta_4 X_{2t}^o \quad (2)$$

$$Gold_t = \delta_0 + \delta_1 Oil_t + \delta_2 USD_t + \delta_3 Stock_t + \delta_4 X_{3t}^g \quad (3)$$

$$USD_t = \gamma_0 + \gamma_1 Oil_t + \gamma_2 Gold_t + \gamma_3 Stock_t + \gamma_4 X_{4t}^d \quad (4)$$

Oil price, gold price, US dollar exchange[3] rate and stock prices are all endogenous variables and X_i ($i = 1, \dots, 4$) contains vectors of their exogenous determinants as additional controls needed to achieve identification. A fine identification of the system requires differences between X_i . Accordingly, the vector of exogenous variables X_i ($i = 1, \dots, 4$) consists in monetary policy and default premium for X_1^s , oil gross imports and oil futures contracts, as representation of oil market financialization process, for X_2^o , and monetary policy and consumer confidence index for X_4^d .

All variables were introduced in the system at time " t ," except for oil futures price which is introduced at time " $t+1$," in order to capture markets expectations on oil price and their implications on economic outlooks and stock markets dynamics.

Masih *et al.* (2011) and Basher *et al.* (2012) were interested in α_1 arguing that higher oil price lowers stock markets. Yousefi and Wirjanto (2005) focused on β_2 while Zhang and Wei (2010) and Fratzscher *et al.* (2014) focused on both β_2 and γ_1 and observed bilateral causality. Sekmen (2011) studied α_3 in the USA, Olugbenga (2012) focused on α_3 on Nigerian stock market, while Kang and Yoon (2013) studied α_3 on South Korean context and finds strong causality between foreign exchange and stock market. Narayan *et al.* (2010) found bidirectional causality between oil price and gold price (β_1 and δ_1) and later Le and Chang (2012) confirmed the close link between them. More recently, Wang and Chueh (2013) were interested in δ_1 and found positive interaction between oil and gold. Gaur and Bansal (2010) focused on δ_3 arguing that falling stock market results in rising gold price. Bekaert *et al.* (2013) paid attention to γ_3 arguing that rise in financial market risk generally results in an appreciation of the USD. Finally, Wang *et al.* (2010) were interested in α_1 , α_2 and α_3 and found cointegration between fluctuations of oil price, gold price and the USD on one side and stock market on the other side in Germany, Japan, Taiwan and China.

It's worth noting here that although previous studies were interested in direct relationships, we do not observe consistent investigation on indirect relationships as well as an exploration of possible simultaneous multipart interactions. The simultaneous equation estimation allows to concluding about both direct and indirect relationships. Direct effects of each variable can be observed through its associated coefficient, while indirect effects can be

decomposed into more than one component. Theoretical interpretation of the model allows providing plausible insights, since we aim at exploring the direct and indirect effects. For instance, the direct effect of gold on stock shows that a change in gold price by one unit can also induce a change in stock prices by α_2 and the direct effect of US dollar can be represented by α_3 . The indirect effect of US dollar on stock, taking into account the role of crude oil price can be determined by the derivative of stock prices with respect to US dollar which is equal to:

$$\frac{\partial \text{stock market}}{\partial \text{US dollar}} = \alpha_1 \frac{\partial \text{oil}}{\partial \text{US dollar}} = \alpha_1 \beta_2. \quad (5)$$

The total effect of the US dollar on stock, taking into account the role that may play oil price as transmission channel, in the simultaneous equations estimation is represented by the derivatives of stock with respect to the US dollar:

$$\frac{\partial \text{stock market}}{\partial \text{US dollar}} = \alpha_3 + \alpha_1 \frac{\partial \text{oil}}{\partial \text{US dollar}} + \alpha_1 \frac{\partial X_2^{\text{oil}}}{\partial \text{US dollar}} \quad (6)$$

which is equal to $\alpha_3 + \alpha_1 \beta_2 + \alpha_1 \beta_4 = \alpha_3 + \alpha_1 (\beta_2 + \beta_4)$. The third term captures the magnitude of the financialization degree of the dollar or the financialization of international oil markets.

5. Empirical results and discussion

Table I reports estimation results of the simultaneous equation system. We rely here on the relative contribution of direct and indirect effects and then put emphasize on the total effect.

Equation (1) shows that stock market is positively and significantly affected by oil price, gold price, USD and the US interest rate. Also, changes in default premium have a positive effect on stock market prices. The direct effects support the traditional approach and recent findings of Wang *et al.* (2010) and Sekmen (2011). Regarding their indirect effects, changes in those variables result in a significant negative influence on stock prices. The switch from positive direct effect to negative indirect effect may be explained by the nature of the relationship between stock market prices and the channels through which the indirect effect was produced. As for the total effects, the negative relationship between oil price and stock markets corroborate results of Oberndorfer (2009) on European stock markets and afterward Masih *et al.* (2011), and Basher *et al.* (2012) on emerging markets. The US economic and monetary policy (as represented by broad trade-weighted USD exchange rate, US interest rate and US CPI) results in a significant unrest on international stock markets. Indeed, economic expectations will be behaviorally transmitted to stock market such as speculative, herding or hedging reactions.

Equation (2) points out that oil price is positively affected by stock markets and significantly by gold price and USD exchange rate and support findings of Wang and Chueh (2013) and Reboredo (2013) for positive interaction between oil and gold. Crude oil price is also significantly affected by oil futures price as well as by Chinese oil gross imports. In the framework of indirect effects, oil price is affected significantly by gold price, stock market behaviors, and US socio-economic conditions as represented in CPI and interest rate. The corporate default premium has an indirect negative effect on international oil price. Also, Chinese oil gross imports have a negative influence on international oil price. We explain this evidence by the fact that the worldwide demand on oil commodity is associated with corporate risk rating. Tang and Xiong (2012) stated that as a result of the financialization process, oil price has become increasingly correlated with futures price of non-energy commodities after 2004. The total effects confirm the existing direct and indirect influences on oil price and corroborate findings of Yousefi and Wirjanto (2005) that USD

Variables	Direct Effects Coef. (SD)	Indirect effects Coef. (SD)	Total effects Coef. (SD)
<i>Crude oil price</i>			
Oil	–	0.0332 (0.0125)***	0.0332 (0.0125)***
Gold	0.0153 (0.0021)***	–0.0114 (0.0011)***	0.0038 (0.0023)*
USD	0.1415 (0.0641)**	0.0063 (0.0305)	0.1478 (0.0674)**
Stock	0.0020 (0.0021)	–0.0069 (0.0010)***	–0.0049 (0.0023)**
US CPI	–	0.01648 (0.0337)***	0.1648 (0.0337)***
US IR	–	–0.6022 (0.1921)***	–0.6022 (0.1922)***
DP	–	–0.0004 (0.0006)	–0.0004 (0.0006)
OFP	0.9432 (0.0391)***	0.0313 (0.0252)	0.9745 (0.0292)***
US Oil import	0.0001 (0.0004)	4.28e-06 (0.00001)	0.0001 (0.0004)
CN Oil import	–0.0193 (0.0111)*	–0.0006 (0.0007)	–0.0199 (0.0116)*
Const	–20.2239 (6.1672)***	–	–
<i>Gold price</i>			
Gold	–	–0.5586 (0.0567)***	–0.5586 (0.0567)***
Oil	17.8585 (1.6889)***	–12.1336 (0.9018)***	5.7249 (1.0333)***
USD	34.4538 (6.6154)***	–28.0662 (3.7046)***	6.3876 (3.1927)**
Stock	–0.2607 (0.1803)	–0.1033 (0.1200)	–0.3639 (0.0804)***
US CPI	–	7.1211 (1.1059)***	7.1211 (1.1059)***
US IR	–	–44.1064 (7.6078)***	–44.1064 (7.6078)***
DP	–	–0.0327 (0.0475)	–0.0327 (0.0475)
OFP	–	5.3998 (0.8521)***	5.3998 (0.8521)***
US Oil import	–	0.0007 (0.0022)	0.0007 (0.0022)
CN Oil import	–	0.1104 (0.0648)*	–0.1104 (0.0648)*
Const	–3687.348 (721.1831)***	–	–
<i>US dollar</i>			
USD	–	–0.8058 (0.1190)***	–0.8058 (0.1190)***
Oil	–0.1039 (0.0562)*	–0.2708 (0.0526)***	–0.3747 (0.0328)***
Gold	–0.0517 (0.0068)***	0.0327 (0.0054)***	–0.0190 (0.0016)***
Stock	–0.0407 (0.0068)***	0.0370 (0.0056)***	–0.0037 (0.0041)
US CPI	1.1148 (0.1202)***	–0.8984 (0.1459)***	0.2164 (0.0431)***
US IR	–	–0.4494 (0.2968)	–0.4494 (0.2967)
DP	–	–0.0003 (0.0005)	–0.0003 (0.0005)
OFP	–	–0.3535 (0.0335)***	–0.3535 (0.0335)***
US Oil import	–	–0.00005 (0.0001)	–0.00005 (0.0001)
CN Oil import	–	0.0072 (0.0042)*	0.0072 (0.0042)*
Const	–18.4043 (13.8534)	–	–
<i>Stock market</i>			
Stock	–	–0.4343 (0.0846)***	–0.4343 (0.0845)***
Oil	4.1045 (1.0856)***	–4.8112 (0.7209)***	–0.7067 (1.0167)
Gold	0.8677 (0.1070)***	–0.9716 (0.0871)***	–0.1039 (0.1022)
USD	26.4588 (2.4047)***	–15.1723 (1.0831)***	11.2865 (1.6721)***
US CPI	–	12.5826 (0.7475)***	12.5826 (0.7475)***
US IR	121.185 (11.0378)***	–52.6349 (9.1257)***	68.5474 (5.3205)***
DP	0.0898 (0.1293)	–0.0390 (0.0561)	0.0508 (0.0734)
OFP	–	0.6665 (0.6495)	–0.6665 (0.6495)
US oil import	–	–0.0001 (0.0003)	–0.0001 (0.0003)
CN oil import	–	0.0136 (0.0158)	0.0136 (0.0158)
Const	–2,874.573 (316.657)***	–	–
Log-likelihood	–12,441.742		
χ^2	325.01 (0.0000)		
No. of obs.	250	250	250

Table I.
Estimation results

Notes: ***, ***, ***Indicate that coefficients are statistically significant at 10, 5 and 1 percent levels, respectively

exchange rate affects oil price via demand and supply on international markets and support recent results of Fratzscher *et al.* (2014) for bidirectional causality between oil and USD and results of Le and Chang (2012) about the close link between prices of oil and gold.

Equation (3) shows that gold price on international markets is positively and significantly affected by oil price and USD. Changes in stock market prices have a negative effect on gold price. This evidence is very plausible and support findings of Sumner *et al.* (2010) and Gaur Bansal (2010) that falling stock markets results in rising gold price. The current results confirm our theoretical analysis and the previous literature. We cite *inter alia*, Le and Chang (2012). The indirect effects confirm the close tie between gold and oil and USD. Gold price is also indirectly and significantly affected by US CPI, US interest rates, oil futures price and Chinese oil gross imports. Regarding the total effects, gold price is concerned by changes in oil price, stock markets, USD exchange rate, US inflation and US interest rate, oil futures price and Chinese oil gross imports. It is important to note here that US oil gross imports and default premium have slight effects on gold price but the informational content of gold price highlights well the global economic and financial outlooks.

Equation (4) points out that broad US dollar exchange rate is negatively and significantly affected by oil, gold and stock prices but positively affected by US CPI. The present findings confirm the theoretical analysis and the existing empirical literature, especially the portfolio approach which argue that stock market mechanisms determines exchange rates Granger *et al.* (2000), Caporale *et al.* (2002), and recently Bekaert *et al.* (2013). The USD is also indirectly and significantly affected by US CPI, oil futures price and Chinese oil imports. The total effects confirm the negative and significant effects of oil price, gold and stock market prices (Bodenstein *et al.*, 2011; Allegret *et al.*, 2014), and effects of the other additional controls.

Figure 2 provide some intuition about the issue under scrutiny by plotting bilateral interactions between endogenous variables. All illustrations present bilateral relationships and confirm the stated hypothesis and obtained results, while the last one reports the multipart interactions. It confirms the close link between oil and US dollar and between gold and stock markets. A falling stock market results in strong worldwide demand for gold as safe haven. The bilateral direct interaction is then negative in the short run but positive or cointegrated in the long run.

6. Conclusion

The interdependencies among oil price, gold price, US dollar and stock markets put forward fundamental importance for either investment or managerial decisions.

The aim of this paper is to highlight the interdependencies between all the markets using the simultaneous equation approach for the period 1995-2015. Our findings show the evidence of factual effect as well as significant interactions among oil price, gold price, USD and stock prices. Indeed, we found that oil price is significantly affected by stock markets, gold and USD. Oil price is also affected by oil futures price and by Chinese oil gross imports. Gold price is concerned by changes in oil, USD and stock markets but slightly depend on US oil imports and default premium. The USD exchange rate is significantly affected by oil price, gold price and stock market prices. The USD is also negatively affected by the US CPI. Indirect effects always exist which confirm the presence of global interdependencies and highlights the financialization process of commodity markets. We explain the obtained results by the increased use of oil and gold as financial assets either for speculation or hedging, which intensifies direct and indirect ties between all the markets and thus confirms that the performance of these markets become dependent between each other. Moreover, we note many variables to consider over such interdependencies. Undeniably, new oil suppliers, the less US

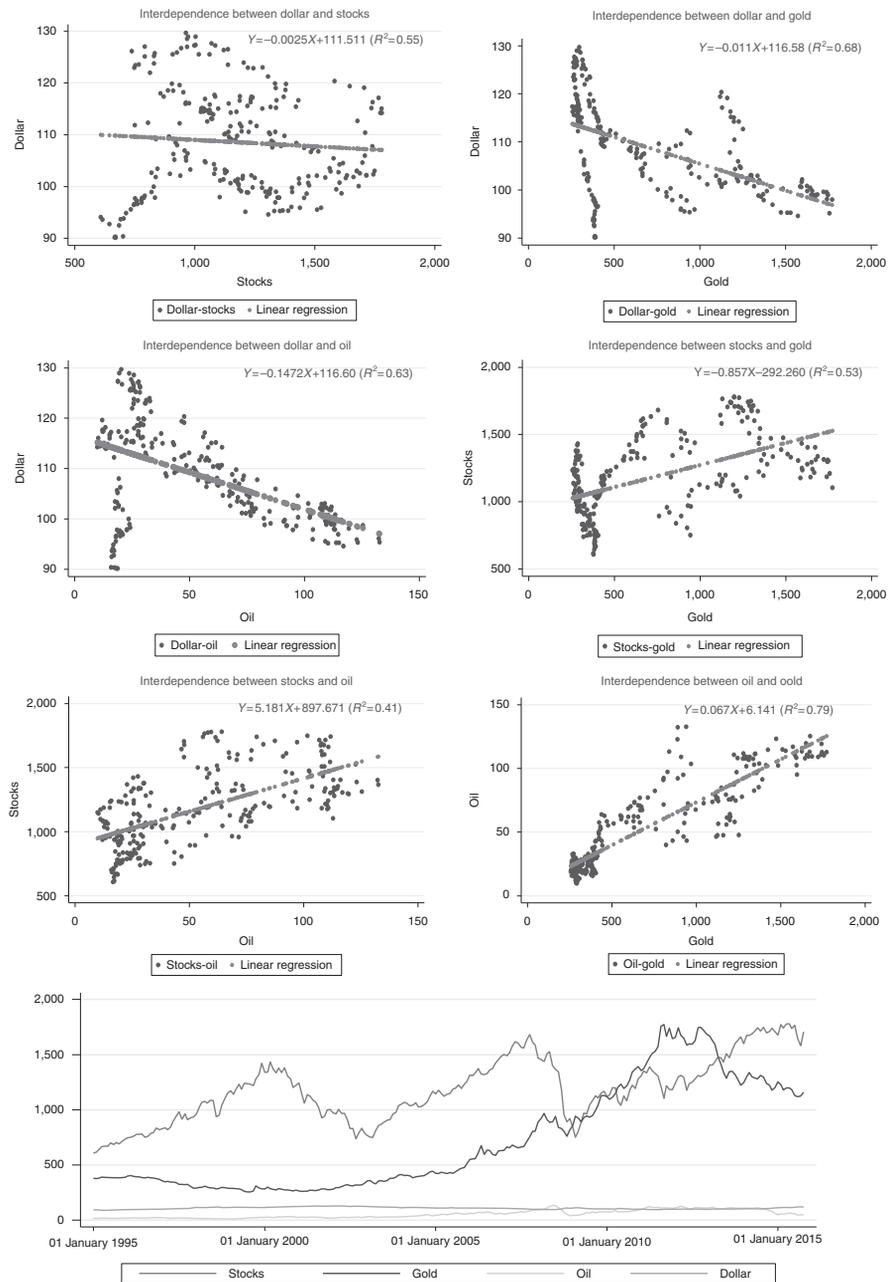


Figure 2.
Bilateral interdependencies between the relevant endogenous variables

dependency on foreign oil, the current Chinese' slowed economy and the continued struggles of emerging markets along with the trend to softer world economy in addition to the current strategic and geopolitical events move all forward these challenges to be drivers over crude oil, gold and US dollar beyond this decade.

Notes

1. When the price of an import rises, in the presence of inelastic demand for that import (i.e. hardly demanded quantities fall at all when the price increase as is the case for oil), the trade balance get worse, which will decrease the value of the local currency.
2. Statistical properties of the data and pairwise correlations between all variables are not presented here to save space but are ready to be presented upon request.
3. The broad index is a weighted average of the foreign exchange values of the US dollar against the currencies of a large group of major US trading partners. The index weights, which change over time, are derived from US export shares and from US and foreign import shares. For details on the construction of the weights, see the article in the winter 2005 Federal Reserve Bulletin.

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Further reading

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Enriching the ECSI model using brand strength in the retail setting

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Abstract

Purpose – The purpose of this paper is to investigate the role of the retailer’s brand strength as a potential predictor of loyalty. It also examines the role of customer satisfaction (CS) to the retailer’s loyalty as well as its impact on the retailer’s brand strength.

Design/methodology/approach – The study was conducted in the grocery context and in a market under recession using the European Customer Satisfaction Index (ECSI) model. Data were collected through a telephone survey from 2,000 participants responsible for the household grocery shopping with a quota of 250 respondents from each of the leading grocery retailers in Greece. A formative measurement model was developed and the collected data were analyzed using partial least square path modeling.

Findings – The findings revealed that the strength of the retailer’s brand and CS influence retail loyalty and that brand strength mediate the strength of CS to loyalty. Results also suggested that the expectations and the perceptions toward the retailer’s product offering are the most important drivers of CS and loyalty. Thus, the study has proved the importance of the functional store attributes to CS and loyalty in the grocery store setting.

Originality/value – Research examining the suitability of the ECSI model in the grocery setting and in a market under economic crisis is scarce. This paper addresses these shortcomings by examining a customer loyalty model which incorporates the brand strength construct and investigates the role of brand strength as a potential predictor of loyalty as well as the role of CS in the brand strength and loyalty.

Keywords Loyalty, Brand strength, Retail branding, Grocery stores, European Customer Satisfaction Index

Paper type Research paper

1. Introduction

Grocery retailers are dominant players in the retail industry. Out of the 250 largest retail companies in the world the top eight are food retailers (Deloitte, 2016). Total grocery sales in Western Europe have reached USD1,508 billion during 2015 (Euromonitor, 2016). Furthermore, the grocery industry is characterized by intense competition with big multinational players expanding geographically (Cardinali and Bellini, 2014; Kumar *et al.*, 2017). Thus, in a mature industry which is easily influenced by economic fluctuations (Cardinali and Bellini, 2014), it is difficult for grocery retailers to differentiate and to maintain their profitability (Kumar *et al.*, 2017).

Customer loyalty is fundamental to business success; it is recognized as a strategic priority and as an important asset to businesses (Aksoy, 2013). Loyalty is important to a firm’s long-term success and profitability (Lam *et al.*, 2004; Helgesen, 2006). Given the current situation is very challenging for grocery retailers to establish loyalty. However, in contrast to the research on brand loyalty, little research has been conducted on retail loyalty and its antecedents (Kumar *et al.*, 2013) and particularly in the context of grocery retailers and in a market under economic crisis.

Several models for assessing customer satisfaction (CS) and its antecedents in predicting loyalty have been introduced. The European Customer Satisfaction Index (ECSI) represents



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a variation on the ACSI model and it was introduced in 1998 (Kristensen *et al.*, 2000). A major advantage of ECSI is its flexibility due the use of generic questions. The ECSI is one of the well-established models for assessing CS and its antecedents in predicting loyalty (Ball *et al.*, 2004; O'Loughlin and Coenders, 2004; Ciavolino and Dahlgaard, 2007). Using structural equation modeling, ECSI has been validated across many industries (e.g. retail banking, cable TV, mobile and fixed phones, insurance, and public transportation) and across several European countries (Kristensen *et al.*, 2000; Martensen *et al.*, 2000; O'Loughlin and Coenders, 2004; Ball *et al.*, 2004; Ciavolino and Dahlgaard, 2007). Marketing research conducted during the last years recognizes the importance of brand strength to business success (Doyle, 2001) as well as to the development of brand relationships and loyalty (Veloutsou, 2015). Even though the ECSI model has many variations (see Table I), the construct of brand strength has not been incorporated in the model. Methodologically, in the ECSI model, the latent variables (LVs) are measured with a reflective relationship. Based on the criticisms for reflective measurements, researchers suggest that formative measurements should be used (Hair *et al.*, 2012).

The ECSI model is clearly appropriate for the prediction of loyalty in the grocery industry, but it has not been used in markets during recession. Using established models in new contexts and conditions advances our understanding and generalizability of these models (Martensen *et al.*, 2000; Bou-Llusar *et al.*, 2001; Ball *et al.*, 2004). Therefore, testing the ECSI model in markets during recession is an appropriate approach to study the determinants of retail loyalty. In addition, measuring the LVs in a formative manner is of value from a methodological perspective. Therefore, this study attempts to: introduce and investigate the role of brand strength as a potential predictor of loyalty, investigate the role of CS in the brand strength and loyalty, extend the investigation in the grocery store setting and in a market under recession, and use a formative approach to measure the LVs.

The remaining of the paper is structured as follows. It first reviews the existing literature on ECSI and identifies specific shortcomings of the existing approaches. It then presents the study focus and hypotheses and the methods used for the data collection and analysis. Finally, the results are presented and discussed as well as the practical and methodological contributions of this study.

2. Conceptual framework

2.1 The ECSI

The ECSI methodology has been developed by European experts based on a set of requirements (ECSI, 1998). The initial ECSI model consists of seven LVs; the five exogenous variables (customer expectations, perceived product quality, perceived service quality, perceived value, and image) that are seen as the antecedents of the two endogenous variables of satisfaction and loyalty (Bayol *et al.*, 2000; Kristensen *et al.*, 2000). A review of previous studies that used the ECSI methodology revealed that there are variations from the initial model in the constructs, the mode of measurement, and in the scales that were used (Table I). Researchers have made changes to the initial model to adapt it to their specific study. In some models loyalty is explained by CS and image (Kristensen *et al.*, 2000; Martensen *et al.*, 2000; Ciavolino and Dahlgaard, 2007). Other models have also included the construct of complaints as an outcome of satisfaction and as a determinant of loyalty (Bayol *et al.*, 2000; Ferreira *et al.*, 2010). Other researchers have added the construct of trust (Askariazad and Babakhani, 2015). While in some models loyalty is explained also by trust, complaints, and communication in addition to CS and image (Ball *et al.*, 2004; Revilla-Camacho *et al.*, 2017). Furthermore, there is no consistency in how perceived quality was measured. In some models, perceived quality is conceptually divided in perceived product quality ("Hard ware") and in perceived service quality ("Human ware") while in others there is no such distinction (Kristensen *et al.*, 2000; Martensen *et al.*, 2000; Vilares and Coelho, 2003; Ciavolino and Dahlgaard, 2007; Ferreira *et al.*, 2010).

Table I.
Methodology review
of the ECSI model

Author	Year	Context	Country	Sample	Loyalty	CS	Expect.	PPQ	PSQ	PQ	PV	Image	Constructs			Mode	Scale
													Other constructs	Other constructs	Other constructs		
Revilla-Camacho <i>et al.</i>	2017	Hotel	Spain	629	x	x	x	-	-	x	x	x	Trust, complaints, communication, CR	R	1-5		
Askarizad and Babakhani	2015	B2B: construction and mining	Iran	90	x	x	x	-	-	x	x	x	Trust, complaints	R ^a	1-5		
Turkyilmaz <i>et al.</i>	2013	Telecommunications	Turkey	266	x	x	x	-	-	x	x	x	-	R ^a	1-5		
Coelho and Hensele	2012	Banking and cable TV	Portugal ^b	1,583	x	x	x	-	-	x	x	x	Trust, customization	R	1-10		
Ferreira <i>et al.</i>	2010	Mould industry	Portugal	108	x	x	x	x	x	x	x	x	Complaints	R	? ^b		
Chitty <i>et al.</i>	2007	Youth Hostels	Australia	281	x	x	x	-	-	-	x	x	Technical dimension, Price functional dimension, Price	R ^a	1-7		
Giavolino and Dahlgaard	2007	Auto industry, service industry, motor vehicle industry, other industry, other manufacturing, remaining industry	Sweden	89	x	x	x	x	x	-	x	x	-	? ^b	1-5		
Ball <i>et al.</i>	2006	Banking industry	Portugal	2,500	x	x	x	-	-	x	x	x	Trust, complaints, communication, personalization	R ^a	? ^b		
Aydin and Ozer	2005	Mobile phone users	Turkey	1,662	x	-	-	-	x	-	-	x	Trust, switching cost	R ^a	1-5		
Ball <i>et al.</i>	2004	Banking	Portugal	2,826	x	x	x	-	-	x	x	x	Trust, complaints, communication	R ^a	?		
Vilares and Coelho	2003	Super markets	? ^b	547	x	x	x	x	x	-	x	x	Perceived employee satisfaction, perceived employee commitment, perceived employee loyalty	R ^a	? ^b		
Kristensen <i>et al.</i>	2000	Postal service	Denmark	3,000	x	x	x	x	x	-	x	x	-	R	? ^b		
Bayol <i>et al.</i>	2000	Mobile phone	? ^b	250	x	x	x	-	-	x	x	x	Complaints	R	1-10		
Martensen <i>et al.</i>	2000	Telecommunications, soft drinks, fast food restaurants, banks, super markers	Denmark	8,000	x	x	x	x	x	-	x	x	-	? ^b	1-10		

Notes: "X" represents the presence of the corresponding variable; "-" the absence for each of the studies reviewed; ^aIdentified based on the method of analysis; ^bnot provided

In addition to the variations in the LVs, it was also revealed that there is no consistency in the scale used (Table I). It is noteworthy that quite many models do not provide a description of the constructs' measurement modes and where possible this was identified based on the method of analysis. All of the models reviewed are based exclusively on reflective measures except one that used both formative and reflective measures (Revilla-Camacho *et al.*, 2017). These findings are consistent with an extensive research conducted by Hair *et al.* (2012).

2.2 Conceptual model

The theoretical review enables the proposing of the conceptual model depicted in Figure 1. The model includes a new construct, brand strength, aiming to better explain loyalty in the grocery store context. In this section, I develop the conceptual model and hypotheses based on the literature.

Loyalty has received a great deal of attention among researchers. However, there is no agreement over the conceptualization and operationalization of the construct. Traditionally, customer loyalty has been measured as a behavioral attitude and loyal customers were identified based on their actual purchases. In the retailing context some of these measures of customer behavior commonly used in the industry are: repurchase, share of purchase, and share of visits (Mittal and Kamakura, 2001; Magi, 2003). All these measures assist managers in evaluating and monitoring behavioral loyalty through the customer's purchase behavior (Zeithaml *et al.*, 1996; Sirohi *et al.*, 1998). However, the behavioral loyalty approach was challenged as it does not explain the reasons of loyalty and criticized as insufficient to capture the "true" brand loyalty. Thus, researchers have argued that loyalty should be captured as a combination of both behavioral and affective attitude (Kumar and Shah, 2004; Aksoy, 2013). This study conceptualizes loyalty as a multi-dimensional construct. Therefore, both behavioral loyalty (the degree to which consumers intend to repurchase) and attitudinal loyalty (recommending the store to others, and positive word of mouth) are considered in measuring loyalty (Ball *et al.*, 2004; Lam *et al.*, 2004).

CS is considered by many researchers as the most important determinant of loyalty (Lam *et al.*, 2004; Rust *et al.*, 2004; Chandrashekar *et al.*, 2007). On the other hand, recent

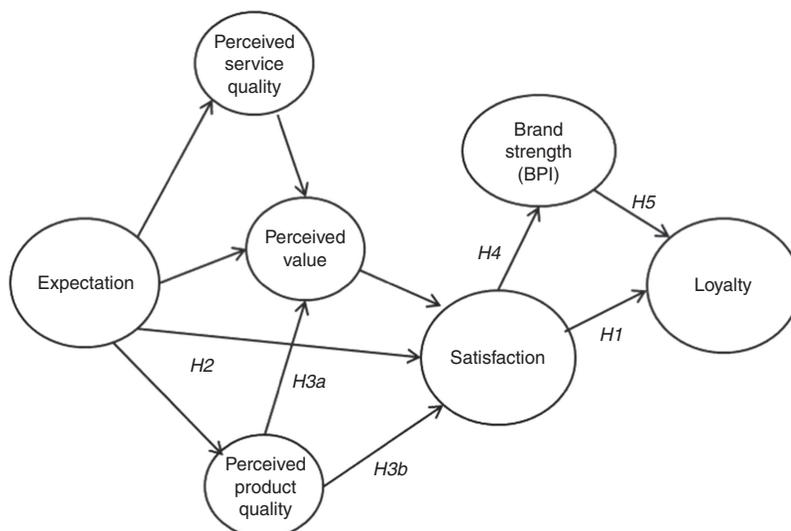


Figure 1.
Proposed model

research suggests that the CS-loyalty relationship is not so straight forward and that CS is inadequate in predicting and/or explaining loyalty. Overall, researchers suggest that there is a positive relationship between CS and loyalty but the variance explained by CS is rather small (Kumar *et al.*, 2013). Additionally, they found that there are variations on the impact of CS due to industry differences (Kumar *et al.*, 2013; LariviÈre *et al.*, 2016). It is noteworthy that only few studies address the impact of CS in the grocery retail sector (Davies *et al.*, 2001). The nature of grocery shopping is characterized as task oriented, with frequent visits to the store. Due to these differences, it can be implied that the specific context might be dominated by utilitarian concerns. Thus, there are different mechanisms that determine CS and the strength of the retail brand in this setting compared to other retail settings that hedonic experiences are more important (Kozinets *et al.*, 2002).

Researchers have agreed that CS is an antecedent of loyalty. This is because CS is an outcome of the subjective evaluation that the chosen alternative – the store – meets or exceeds expectations (Bloemer and de Ruyter, 1998). Thus, the customer's positive evaluation is a requirement for repeat purchase behavior and an important pillar to sustain loyalty (Anderson and Mittal, 2000; Veloutsou, 2015). However, there is disagreement among researchers on the strength and the shape of this relationship; some of the studies indicate a linear while others a non-linear relationship (Kumar *et al.*, 2013). Some of the past research suggests that the strength of satisfaction and the context affect the relationship with loyalty (Chandrashekar *et al.*, 2007; LariviÈre *et al.*, 2016). Therefore, it is hypothesized that:

H1. CS positively influences retail loyalty.

According to Szymanski and Henard (2001), the role of expectations in satisfaction can be modeled either as an outcome of comparison or of anticipation. In the traditional expectancy disconfirmation satisfaction model, satisfaction is the outcome from the comparison of expectations with perceived performance (Oliver, 1980). Thus, when product perceived performance exceeds expectations (positive disconfirmation) consumers are satisfied and when expectations exceed perceived performance (negative disconfirmation) consumers are dissatisfied (Oliver, 1980). In addition, expectations can be modeled as the level of quality that customers anticipate to receive and is formulated through prior experience/interactions with the product or service (O'Loughlin and Coenders, 2004; Ciavolino and Dahlgaard, 2007). Expectations reflect the image the customer has developed of the store, through previous shopping trip experiences (Theodoridis and Chatzipanagiotou, 2009; Esbjerg *et al.*, 2012). It can also be formulated prior to the purchase from knowledge acquired through word of mouth, publicity, opinion leaders, and through all elements of the product's marketing mix (Oliver, 1980; Boulding *et al.*, 1993). Because grocery shopping occurs frequently, consumers have many interactions with the retailer. Therefore, it is hypothesized that:

H2. Expectations positively influence CS.

Perceived quality is defined as the consumer's judgment about a product's overall excellence or superiority (Zeithaml, 1988). Perceived quality affects loyalty (Das, 2014) and CS mediates this relationship (Frank *et al.*, 2014). The perception on quality for retailers can be derived from both tangible and intangible attributes (Pappu and Quester, 2006; Maggioni, 2016). Thus, similar to the ECSI model, perceived quality is based on the evaluation of performance on different attributes related with the grocery retail industry (Churchill and Surprenant, 1982; Maggioni, 2016). The construct was broken down to perceived product quality and to perceived service quality. The first contains perceptions related with the tangible elements of the retailer's marketing strategy and the second perceptions related with the intangible elements such as the store atmosphere, the friendliness of the personnel, etc., perceived customer

value has been defined as the trade-off between the customer's evaluation of all the benefits derived and all the costs of acquiring those benefits (Lam *et al.*, 2004). This definition treats perceived value as a multi-dimensional construct which includes "give" (e.g. cost, effort) and "take" (e.g. functional benefits, hedonic benefits). Thus, perceived value is created during the consumption experience (Grönroos, 2011) and it should be especially important in the grocery retail context which is characterized with frequent direct interaction of the consumer with the retailer. This construct was measured by rating the quality of products and services (in terms of the variety of products, the customer service, the quality of products, and the store atmosphere along with the overall buying experience) given the prices that consumers paid. Because grocery shopping is associated with utilitarian product beliefs, it is hypothesized that:

H3a. Perceived product quality positively influences perceived value.

H3b. Perceived product quality positively influences CS.

Researchers suggest that trying to explain loyalty through CS alone is not enough and that there is a need for models that will include other variables as mediators, moderators or other predictors and thus increase the explained variance (Szymanski and Henard, 2001; Kumar *et al.*, 2013). A lot of research in marketing attempts to find the antecedents of loyalty, and some of the significant predictors are CS, trust, communication, customer factors, and the view toward the brand (Chaudhuri and Holbrook, 2001; Ball *et al.*, 2004; Baltas *et al.*, 2010). However, as the marketing thinking evolves and the environment changes, some new concepts introduced in the marketing thinking are increasingly gaining interest and may be better predictors of loyalty, such as the strength of the brand, the consumer-brand relationship, and the engagement with the brand (Hollebeek, 2011; Veloutsou, 2015; Dessart *et al.*, 2016). The above researchers suggest that cognitive and affective elements can strengthen the relationship between the brand and the customer and thus affect the strength of the brand. Thus, there is a need to investigate the relevant importance of the constructs that are recognized for a long time as predictors of loyalty and the new constructs simultaneously and in particular in contexts that are somewhat idiosyncratic, such as retailing. Consequently, any improvement in identifying the factors that affect retail loyalty could be a value to managers, researchers, and investors who use satisfaction surveys to predict behaviors and based on that allocate the company's resources (Morgan and Rego, 2006).

A very important trend in retailing is the rise of the retailer as a brand and retailers have realized the need to develop a strong brand name (Grewal *et al.*, 2004; Kumar and Youn-Kyung, 2014). The literature review shows a plethora of ways of interpreting brand strength and performance in a product brand context. Brand image, trust, brand relationships, brand attachment, and engagement have been used as a basis of brand strength (Chaudhuri and Holbrook, 2001; Hollebeek, 2011; Veloutsou, 2015). In this study, brand strength is conceptualized as the outcome of the overall evaluation and attitudes toward the retailer's brand which is formulated from multiple direct and indirect interactions/experiences with the retailer (Möller and Herm, 2013). Through internal processes consumers assess the retailer's brand based on various tangible and intangible cues (Kumar and Youn-Kyung, 2014). The way the retailer's brand is perceived and evaluated affects their behavior. A positive brand evaluation has a positive effect on brand loyalty (Veloutsou, 2015). The development of trust with the brand is positively related to both behavioral and attitudinal loyalty (Chaudhuri and Holbrook, 2001; Veloutsou, 2015). Furthermore, several studies found that positive emotions impact the evaluation toward a brand which influences purchase intention (Shim *et al.*, 2001; Brakus *et al.*, 2009). This finding was recently confirmed in a utilitarian setting (Ladhari *et al.*, 2017). Although, the link between brand strength and loyalty has been

studied in product branding context (Veloutsou, 2015), no study has explored the same in the grocery retailing context. This gap leads to propose the following hypotheses of this study:

H4. CS positively influences brand strength.

H5. Brand strength positively influences retail loyalty.

2.3 ECSI measurement approach: formative vs reflective

The model consists of the structural or inner model and the measurement model. The measurement model describes the relationships between the observable variables, which are called manifest variables or indicators, and the unobservable LVs or constructs. In respect to the direction of the relationship between a construct and its indicators, Diamantopoulos *et al.* (2008) identified the reflective and the formative measurement models. Misspecification of the measurement model can bias inner model parameter estimation and lead to incorrect conclusions on tested relationships (Jarvis *et al.*, 2003; Diamantopoulos *et al.*, 2008). Thus, it is important for researchers to select the appropriate measurement model. The reflective model is the most common type used in SEM and particularly in the business field (Cenfetelli and Bassellier, 2009; Hair *et al.*, 2012). According to Diamantopoulos and Winklhofer (2001, p. 274), there is “an almost automatic acceptance of reflective indicators in the minds of researchers”; they believe that in many cases, constructs are operationalized with reflective indicators instead of the more appropriate formative indicators.

In order to help researchers determine the appropriate measurement model Jarvis *et al.* (2003); Coltman *et al.* (2008) suggested that both theoretical and empirical considerations should be considered. Jarvis *et al.* (2003) suggested four primary decision rules: the direction of causality, the interchangeability of the indicators, the intercorrelation among the indicators, and the relationship of the indicators with the construct. Using these rules, the formative measurement was selected for this study and thus the appropriate type of analysis was followed.

3. Methodology

3.1 Empirical context

Grocery retailing in Greece was selected as the empirical context of the study for several reasons. First, the nature of grocery retailing is characterized as task oriented with short sales cycle. Second, the specific setting is very competitive with low loyalty levels with consumers patronizing multiple chains. Also, due to the economic crisis consumers have become more price-sensitive (IRI Topline Report, 2017). Third, there is little research on retail loyalty and its antecedents. Fourth, the study is supported by a large grocery retailer that wants to investigate the determinants of loyalty.

3.2 Sampling and description of data

Data were collected through a telephone survey. The target population was those responsible for the household grocery shopping, had made their purchases from a super market recently, and they were inhabitants of all regions in Greece. Respondents were asked to respond to the questions for the grocery retailer that they visit more often and the one that they make most of their purchases. The questionnaire was pretested, using a small convenience sample, to ensure that the questions are understood and to check the sequence of questions. A total of 2,000 respondents completed the questionnaire based upon a quota of 250 respondents from each of the seven leading grocery retailers in Greece and an additional 250 from the “all others” super market category. Of the respondents 31 percent were men and 69 percent were women while 76.5 percent were in the 25-55+ age group.

Comparing the demographic characteristics of the sample with the National Statistics, we note that women and the 25-55+ age group are over represented in the sample. However, this is to be expected since participants in the survey were those responsible for the household grocery shopping.

3.3 Method of analysis

The model was estimated using partial least squares-structural equation modeling. Partial least square (PLS) was selected as an appropriate method of analysis since the objective of this research is theory development and prediction (Hair *et al.*, 2011, Table I, p. 144). For the execution of the analyses the SmartPLS 3.0 software was used (Ringle *et al.*, 2015).

3.4 Measures and instrument design

A questionnaire survey was designed to empirically validate the model (Figure 1) and test the hypotheses. In line with the widely recognized methodology of the ECSI model (Ciavolino and Dahlgaard, 2007), which is central to the conceptual development of this study, the questionnaire asked respondents to assess their main grocery retailer.

The model of this study links CS to its determinants (expectations, perceived product quality, perceived service quality, and perceived value) and to its consequences (brand performance and loyalty). These seven LVs are seen as latent, i.e. non-observable. Each of the LVs is operationalized by three to eight measurement variables (indicators) which were observed by survey questions to customers (see Table AI). Thus, the LV CS is conceptualized and operationalized as a multi-dimensional aggregate construct. As it is indicated in Table II, the four first-order constructs were combined to produce CS the second-order construct (Diamantopoulos *et al.*, 2008).

Contrary to the ECSI model, in this study all variables measuring CS were specified as formative rather than reflective for the following reasons: the nature of the constructs is not independent from the indicators, i.e. any change in any of the indicators will cause a change in the construct (e.g. a decrease in the expectations regarding the service offered will decrease the overall expectations), we do not expect covariation among the indicators, i.e. a drop in any of the indicators measuring each of the constructs is not expected to necessarily bring a change on the other indicators (e.g. when measuring the construct of perceived product quality, a drop in the product freshness is not expected to have a drop in the cleanliness of the store). Thus, I view indicators as causing rather than being caused by the measured LV (Diamantopoulos and Winklhofer, 2001; Coltman *et al.*, 2008). Therefore, all constructs are conceptualized as aggregate constructs and they are operationalized by summing scores on their dimensions, meaning that the dimensions combine to produce the construct (Edwards, 2001). However, a major concern of formative measurement models is how to establish statistical identification to enable their estimation. In order to enable their estimation, it is necessary to place formative measurement models “within a larger model that incorporates consequences (i.e. effects)” of the CS (Diamantopoulos *et al.*, 2008, p. 1213). Thus, three reflective indicators were added to the formatively measured construct of CS (see Table AI).

First-order construct	Second-order construct
Customer expectations	Customer satisfaction
Perceived product quality	
Perceived service quality	
Perceived value	

Table II.
Emergent
measurement model

Even though the study was mainly quantitative, a qualitative phase was used for the creation of a brand performance index (BPI) for measuring the construct of brand strength. The index is based on formative indicators and its construction is based on the guidelines provided by Diamantopoulos and Winklhofer (2001). Because a formatively measured construct is more abstract than a LV measured with reflective indicators, the specification of the scope of the LV (brand strength) is important; it provides us with the domain of content the index is intended to capture (Diamantopoulos and Winklhofer, 2001). In this study, we specify the domain of content of the brand strength construct as the outcome of the overall evaluation and attitudes toward the retailer's brand. The indicators were selected to capture the scope of the construct based on a review of the literature, ten focus groups with consumers, and five interviews with retail marketing managers, and a research analyst. The rest of the questionnaire was drafted using existing scales to ensure content validity. The scales were translated to Greek and back translated to English. Where necessary, the items were adapted to fit the grocery store context. The items used to capture all constructs of the model are presented in Table AI. The number of items used to measure the constructs is: expectations five items, perceived value four items, perceived product quality seven items, perceived service quality eight items, brand strength seven items, and CS and loyalty three items each. All the variables were measured using a ten-point Likert scale, i.e. there is no midpoint so the respondents had to make a choice (O'Loughlin and Coenders, 2004). In addition, respondents had an option to select a category of "don't know"/"will not tell" in case of lack of knowledge and/or indifference.

4. Data analysis and results

The measurement model and the structural model were assessed following the suggested procedure by Hair *et al.* (2017). Overall, the construct measures of both the measurement model and the structural model proved to be valid and reliable.

4.1 Analysis of the measurement model

In formative measurement models, it is required to assess collinearity before analyzing outer weights for their significance and relevance (Cenfetelli and Bassellier, 2009). To assess collinearity, the variance inflation factor (VIF) was computed (Table AII). All 31 indicators that are used to measure the respective constructs have a VIF below the threshold value of 5, thus collinearity is not an issue. Furthermore, in order to assess the contribution of the indicators to forming the constructs, the bootstrapping procedure (5,000 samples) was followed. Looking at the significance levels (Table AII), we find that the weights of all formative indicators are significant at a 5 percent level ($\alpha = 0.05$ two tailed test), except for PSQ_2 one of the indicators of the perceived service quality construct. Even though the outer weight for this indicator is not significant, I retain the indicator due to its outer loading (0.497), to better capture the perceived service quality construct and to possible managerial input.

In terms of assessing the two reflective constructs of CS and loyalty both demonstrate internal consistency reliability, convergent validity, and discriminant validity. Composite reliability values are above 0.7; AVE is higher than the minimum of 0.5; outer loadings are above 0.708 with the exception of one of the indicators in the construct of loyalty (LOY_1) that has an outer loading of 0.521; (Table III). The indicator LOY_1 was retained for its contribution to content validity. Furthermore, the outer loadings (are indicated in bold) of all indicators measuring CS and loyalty are greater than the cross-loadings on the other constructs thus exhibiting discriminant validity.

4.2 Analysis of the structural model

The structural model provides us with measures of the relationships between the constructs. Assessing the structural model, the results indicate that the VIF values of all combinations are below the threshold value of 5 (Table V), thus collinearity is not an issue in the structural model and all constructs are retained.

In terms of the relationships among the constructs, all structural path coefficients are significant at a 5 percent level but in some cases their size is small (Table IV); for instance, expectations to perceived value (0.064) and expectations to CS (0.079). This can be attributed to the large sample size. In this case, the analysis and interpretation of the results can be based on the relative importance of the relationships, i.e. perceived product quality has the highest effect to CS (0.297) than the other three constructs (expectations: 0.070, perceived service quality: 0.204, and perceived value: 0.202), also perceived product quality has the highest effect to perceived value (0.565) than expectations and perceived service quality, also the BPI has a higher effect to loyalty (0.388) than CS (0.261).

The results of the PLS (SmartPLS 3.0) analysis, the path coefficients (β), variance (R^2) are also summarized in Figure 2.

As suggested by Hair *et al.* (2017), the structural model is also assessed by examining the coefficient of determination (R^2 value). The results indicate that a moderate amount of variance is explained for loyalty ($R^2 = 0.334$), CS ($R^2 = 0.464$), and brand strength ($R^2 = 0.329$). This means CS and brand strength explain 33.4 percent of loyalty; expectations, perceived service quality, perceived product quality, and perceived value explain 46.4 percent of CS; CS explains 32.9 percent of the brand strength. Thus, the fit of the modified model in the grocery store setting is shown (Hair *et al.*, 2017).

		Composite reliability	AVE
Customer satisfaction (CS)		0.778	0.540
Customer loyalty (LOY)		0.746	0.503
	CS	Loyalty	
CS_1	0.792	0.394	
CS_2	0.700	0.294	
CS_3	0.709	0.368	
LOY_1	0.241	0.521	
LOY_2	0.387	0.780	
LOY_3	0.380	0.792	

Table III.
Assessing the
measurement model

	VIF	Path coefficients	t-Values	p-Values	95% Bca confidence interval	Significance ($p < 0.05$)
BPI → LOY	1.491	0.388	16.711	0.000	[0.345, 0.436]	Yes
EXPECT → PPQ	1.000	0.631	31.638	0.000	[0.592, 0.671]	Yes
EXPECT → PSQ	1.000	0.512	21.038	0.000	[0.464, 0.560]	Yes
EXPECT → PV	1.683	0.064	2.492	0.013	[0.014, 0.115]	Yes
EXPECT → SATISF	1.692	0.079	3.460	0.001	[0.034, 0.124]	Yes
PPQ → PV	2.560	0.565	20.344	0.000	[0.509, 0.619]	Yes
PPQ → SATISF	3.270	0.297	7.895	0.000	[0.224, 0.370]	Yes
PSQ → PV	2.087	0.173	6.447	0.000	[0.122, 0.226]	Yes
PSQ → SATISF	2.153	0.204	6.662	0.000	[0.145, 0.265]	Yes
PV → SATISF	2.222	0.202	7.308	0.000	[0.147, 0.254]	Yes
SATISF → BPI/BS	1.000	0.574	31.985	0.000	[0.540, 0.610]	Yes
SATISF → LOYALTY	1.491	0.261	10.833	0.000	[0.212, 0.306]	Yes

Table IV.
Assessing the
structural model

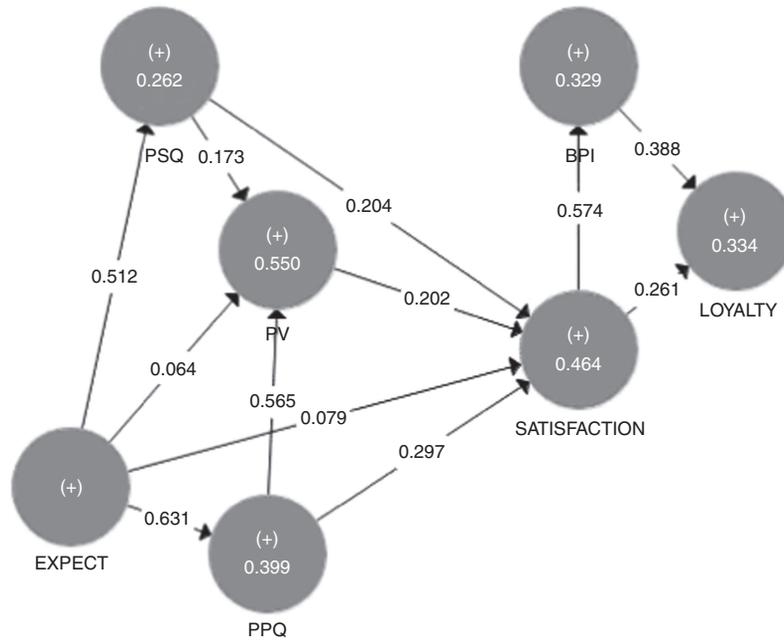


Figure 2. Structural model

In addition, the impact of each exogenous construct on the associated endogenous construct in the model was calculated with the effect size f^2 . In assessing f^2 , values of 0.02, 0.15, and 0.35 represent small, medium, and large effect, respectively (Henseler *et al.*, 2009). The f^2 values in the structural model are shown in Table V. The path between brand strength and loyalty has a medium effect size ($f^2 = 0.151$); which means that removal of the path from the model has a moderate effect on the loyalty construct. The path between CS and loyalty indicates a small effect size ($f^2 = 0.068$), i.e. the path has a low predictive value and removal of the path from the model will have a small effect on the loyalty. However, the path between CS and brand strength has a large effect size ($f^2 = 0.491$), so brand strength is a mediating construct in the impact of CS on loyalty.

5. Discussion

The objective of this study was to incorporate brand strength into the ECSI model and to investigate its role as a potential predictor of loyalty. Furthermore, this study attempts to investigate the role of CS to the retailer’s loyalty and its impact on the brand strength in

Table V. Summary of the hypotheses and results

Hypothesis	f^2	β -value	t -Value	Decision
H1: Customer satisfaction positively influences retail loyalty	0.068	0.261	10.833	Supported
H2: Expectations positively influence customer satisfaction	0.007	0.079	3.460	Supported
Total effect of expectations to customer satisfaction		0.474	20.717	
H3a: Perceived product quality positively influences perceived value	0.277	0.202	7.308	Supported
H3b: Perceived product quality positively influences customer satisfaction	0.050	0.297	7.895	Supported
H4: Customer satisfaction positively influences brand strength	0.491	0.574	31.985	Supported
H5: Brand strength positively influences retail loyalty	0.151	0.388	16.711	Supported

the grocery store setting and in a market under recession. To explore these relationships five hypotheses have been developed and empirically tested. Results of this study (Table V) revealed that CS (*H1*; $\beta = 0.261$, $t = 10.833$) and brand strength (*H5*; $\beta = 0.388$, $t = 16.711$) significantly influence loyalty. Also, CS significantly influences brand strength (*H4*; $\beta = 0.574$, $t = 31.985$). In relation to the determinants of CS, perceived product quality has a significant influence on both CS (*H3b*; $\beta = 0.297$, $t = 7.895$) and perceived value (*H3a*; $\beta = 0.202$, $t = 7.308$).

However, when comparing the differential impact of several driver constructs on a criterion construct, the total effects need to be considered. Table VI presents the results for the total effects as well as their significance at a 5 percent level. In our case, even though the direct effect of CS to loyalty ($\beta = 0.261$, $t = 10.833$) is not very strong, the total effect is moderate via the mediating construct of brand strength ($\beta = 0.483$, $t = 22.852$); indicating the relevance of CS in explaining loyalty. Expectations have a weak direct effect on CS (*H2*; $\beta = 0.079$, $t = 3.460$). However, expectations have a significant indirect effect via the mediator variables of perceived product quality and perceived service quality; overall expectations have the highest total effect on CS ($\beta = 0.474$, $t = 20.717$). This can probably be attributed to the influence of expectations on perceived product quality ($\beta = 0.631$, $t = 31.638$) and perceived service quality ($\beta = 0.512$, $t = 21.038$). Thus, *H2* is supported.

Furthermore, perceived product quality has the greatest direct effect on CS since it has the larger coefficient ($\beta = 0.297$) than expectations, perceive service quality, and perceived value. But there is also an indirect effect between the two constructs via the moderating construct of perceived value and the total effect is 0.411. Thus, even though the direct effect in some cases is not very strong, the total effect is moderate indicating the relevance of the constructs in explaining the criterion constructs.

6. Theoretical and managerial implications

This study provides some significant contributions to the marketing theory. Previous research has examined the direct relationship of CS on loyalty and most loyalty programs are based on the satisfaction-trust-loyalty paradigm. However, even though the effect of CS on loyalty is evident, there are variations in the level of impact and thus hard to predict loyalty. This research confirms that this cause-effect relationship is more complex. To better understand this relationship, the construct of brand strength is added as a mediator variable in the model. This study confirmed that the strength of the retailer's brand has a direct positive impact on loyalty and it is consistent with previous studies (Das, 2014; Veloutsou, 2015). In addition, this study identified that the most important determinants of

	Total effect	t-Values	p-Values	95% Bca confidence interval	Significance ($p < 0.05$)
BPI/BS → LOYALTY	0.388	16.711	0.000	[0.345, 0.436]	Yes
EXPECT → PPQ	0.631	31.638	0.000	[0.592, 0.671]	Yes
EXPECT → PSQ	0.512	21.038	0.000	[0.464, 0.560]	Yes
EXPECT → PV	0.509	21.338	0.000	[0.461, 0.556]	Yes
EXPECT → SATISF	0.474	20.717	0.000	[0.429, 0.519]	Yes
PPQ → PV	0.565	20.344	0.000	[0.509, 0.619]	Yes
PPQ → SATISF	0.411	11.894	0.000	[0.341, 0.477]	Yes
PSQ → PV	0.173	6.447	0.000	[0.122, 0.226]	Yes
PSQ → SATISF	0.239	7.732	0.000	[0.180, 0.300]	Yes
PV → SATISF	0.202	7.308	0.000	[0.147, 0.254]	Yes
SATISF → BPI/BS	0.574	31.985	0.000	[0.540, 0.610]	Yes
SATISF → LOYALTY	0.483	22.852	0.000	[0.442, 0.526]	Yes

Table VI.
Significance testing results of the total effects

brand strength (see Table AII) are the emotional closeness and familiarity with the store (0.341), the perceived superiority (0.302) as well as the reputation of the retailer (0.274). Also, the study confirmed the direct positive impact of CS to retail loyalty but the size of the effect is small ($f^2 = 0.068$). So, CS alone has a low predictive value to loyalty toward the grocery retailer. However, this study has also found the indirect impact of CS on retail loyalty through the mediating construct of brand strength. The mediating role of the brand strength construct can be explained by the strong effect of CS (the predictor variable) to brand strength (the dependent variable). Another theoretical contribution of this study is the identification of the most influential determinants of CS. The results showed that the indirect impact of expectations to CS is greater than the direct impact. Thus, the study has found the mediating roles of perceived product quality and perceived service quality in the relationship between expectations and CS. Furthermore, the study has proved the importance of the functional store attributes to CS and loyalty in the grocery store setting; the expectations and the perceptions toward the retailer's product offering are the most important drivers of CS and loyalty.

The intense competition in the grocery retail market emphasizes the need for loyalty and for retaining existing customers. Thus, for retail managers improving loyalty is a strategy to maintain a competitive advantage and to improve profitability. The results of this study will help them in developing and implementing effective strategies aiming to retain customers. Given that the strength of their brand has a positive impact on loyalty, retail managers should try to engage in activities that will strengthen their brand. This study revealed that the most important determinants of brand strength are the reputation, the superiority as well as the emotional closeness and familiarity with the store. Therefore, their managerial actions and communication should be directed toward this direction; they should be aimed to create the specific perceptions toward their brand. In terms of the determinants of CS, this study has found that perceived product quality has a higher influence to both perceived value and CS than perceived service quality. Thus, retailers should focus their marketing strategies on the tangible elements, i.e. to invest in the quality and variety of products offered as well as the availability of the products in their store.

7. Limitations and further research

This study has few limitations. First, the study was focused on grocery retailers. Thus, in order to generalize these results, further testing across other retail segments (non-food retailers) is required. Second, respondents were asked to respond to the questions for their favorite grocery retailer. This may have influenced the strength of the relationships between the respondents and the selected grocery retailer. In addition, even though their responses were for the retailer, it is expected that their responses were influenced by their experience with a specific store of the retailer.

Some suggestions for future research: further analysis should be made in order to identify if there are significant differences among the different grocery retailers that were included in the sample; the construct of brand strength should be conceptualized as a second-order construct since it will facilitate understanding of the formation process; and future research should investigate the role of the retailer's image to brand strength and to evaluate whether the brand strength is a better predictor of loyalty than the retailer's image.

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Appendix

Model construct and items	Measurement
<i>Customer satisfaction (CS)</i>	Fornell <i>et al.</i> (1996)
(1) Overall satisfaction with the super market	
(2) Fulfillment of expectations	
(3) Performance vs the customer's ideal super market	
<i>Customer expectations (EXPECT)</i>	Fornell <i>et al.</i> (1996)
(1) Expectations regarding the variety of products offered	
(2) Expectations regarding the service offered	
(3) Expectations regarding the quality of products offered	
(4) Expectations regarding the value for money offered	
(5) Expectations regarding the overall buying experience offered	
<i>Perceived product quality (PPQ)</i>	Fornell <i>et al.</i> (1996)
(1) The quality of products offered	Parasuraman <i>et al.</i> (1988)
(2) The cleanliness of the store	
(3) Product freshness	
(4) The variety of products offered	
(5) The promotions of the store, discounts, gifts, bonus points	
(6) The availability of products on the shelves	
(7) The value for money prices	
<i>Perceived service quality (PSQ)</i>	Fornell <i>et al.</i> (1996)
(1) The quality of personal service and friendliness of personnel	Parasuraman <i>et al.</i> (1988)
(2) The time you had to wait at the cashier and at the fresh products	
(3) Convenience of locating products at the store	
(4) Knowledge and advice offered by the personnel	
(5) The availability of personnel	
(6) The overall store atmosphere and decoration	
(7) The care for hygiene and better quality of life	
(8) How modern and contemporary/up to date is the store	
<i>Perceived value (PV)</i>	Fornell <i>et al.</i> (1996)
Rating the quality of products and services given the price that is paid in terms of	
(1) The variety of products offered	
(2) The service	
(3) The quality of products offered	
(4) The overall purchase experience offered	
<i>Brand performance index/brand strength (BPI)</i>	Items chosen during the qualitative phase of the project – Likert scale (level of agreement)
(1) The super market has better reputation from the other super markets	
(2) The super market is better than the other super markets	
(3) Feel emotionally closer than the other super markets	
(4) I trust the super market more than the others	
(5) I feel that the super market suits me better	
(6) Shopping at the SM gives me so much pleasure that I would not change it with another	
(7) Is a place that gives me pleasure to do my shopping	
<i>Customer loyalty (LOY)</i>	Lam <i>et al.</i> (2004)
(1) Repurchase from the super market	
(2) Saying positive things about the super market to friends	
(3) Recommendation of the super market to a friend or colleague	

Table AI.
Measurement items

Formative constructs	Formative indicators	VIF	Outer weights (outer loadings)	t-Value	p-Value	95% Bca confidence interval	Significance ($p < 0.05$)
Expectations	EXPECT_1	1.656	0.234 (0.693)	5.715	0.000	[0.152, 0.310]	Yes
	EXPECT_2	1.342	0.287 (0.662)	8.265	0.000	[0.218, 0.356]	Yes
	EXPECT_3	1.198	0.375 (0.695)	10.842	0.000	[0.310, 0.445]	Yes
	EXPECT_4	1.296	0.155 (0.544)	4.814	0.000	[0.092, 0.217]	Yes
	EXPECT_5	1.813	0.378 (0.801)	9.254	0.000	[0.296, 0.458]	Yes
Perceived product quality	PPQ_1	1.236	0.459 (0.761)	17.634	0.000	[0.407, 0.507]	Yes
	PPQ_2	1.627	0.102 (0.584)	3.659	0.000	[0.051, 0.163]	Yes
	PPQ_3	1.858	0.145 (0.653)	5.147	0.000	[0.092, 0.202]	Yes
	PPQ_4	1.740	0.263 (0.697)	9.320	0.000	[0.208, 0.319]	Yes
	PPQ_5	1.142	0.169 (0.491)	8.716	0.000	[0.132, 0.209]	Yes
	PPQ_6	1.249	0.233 (0.603)	11.383	0.000	[0.193, 0.273]	Yes
	PPQ_7	1.154	0.180 (0.500)	9.082	0.000	[0.141, 0.218]	Yes
Perceived service quality	PSQ_1	1.202	0.174 (0.492)	6.280	0.000	[0.121, 0.230]	Yes
	PSQ_2	1.669	0.046 (0.497)	1.456	0.146	[-0.015, 0.109]	No
	PSQ_3	1.627	0.215 (0.552)	6.331	0.000	[0.152, 0.284]	Yes
	PSQ_4	1.216	0.147 (0.517)	4.846	0.000	[0.087, 0.204]	Yes
	PSQ_5	1.479	0.237 (0.629)	7.367	0.000	[0.175, 0.300]	Yes
	PSQ_6	1.270	0.249 (0.627)	7.805	0.000	[0.190, 0.317]	Yes
	PSQ_7	1.426	0.086 (0.556)	2.804	0.005	[0.028, 0.147]	Yes
	PSQ_8	1.209	0.467 (0.734)	13.678	0.000	[0.400, 0.534]	Yes
Perceived value	PV_1	1.288	0.148 (0.575)	5.880	0.000	[0.097, 0.194]	Yes
	PV_2	1.273	0.188 (0.590)	7.488	0.000	[0.138, 0.237]	Yes
	PV_3	1.323	0.619 (0.868)	20.269	0.000	[0.557, 0.675]	Yes
	PV_4	1.224	0.384 (0.695)	12.668	0.000	[0.329, 0.449]	Yes
Brand performance index	BPI_1	1.828	0.274 (0.699)	7.252	0.000	[0.200, 0.347]	Yes
	BPI_2	1.309	0.302 (0.674)	10.366	0.000	[0.245, 0.359]	Yes
	BPI_3	1.328	0.341 (0.721)	10.498	0.000	[0.279, 0.408]	Yes
	BPI_4	1.412	0.121 (0.607)	3.613	0.000	[0.056, 0.185]	Yes
	BPI_5	3.741	0.137 (0.700)	2.653	0.008	[0.035, 0.239]	Yes
	BPI_6	1.883	0.086 (0.636)	2.166	0.030	[0.010, 0.163]	Yes
	BPI_7	3.636	0.197 (0.685)	3.985	0.000	[0.099, 0.294]	Yes

Table AII.
Formative constructs collinearity, outer weights, and significance testing results

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Agent-based simulation in management and organizational studies: a survey

Agent-based
simulation

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Abstract

Purpose – The purpose of this paper is to provide a comprehensive survey of the literature about the use of agent-based simulation (ABS) in the study of organizational behavior, decision making, and problem-solving. It aims at contributing to the consolidation of ABS as a field of applied research in management and organizational studies.

Design/methodology/approach – The authors carried out a non-systematic search in literature published between 2000 and 2016, by using the keyword “agent-based” to search through Scopus’ business, management and accounting database. Additional search criteria were devised using the papers’ keywords and the categories defined by the divisions and interest groups of the Academy of Management. The authors found 181 articles for this survey.

Findings – The survey shows that ABS provides a robust and rigorous framework to elaborate descriptions, explanations, predictions and theories about organizations and their processes as well as develop tools that support strategic and operational decision making and problem-solving. The authors show that the areas that report the highest number of applications are operations and logistics (37 percent), marketing (17 percent) and organizational behavior (14 percent).

Originality/value – The paper illustrates the increasingly prominent role of ABS in fields such as organizational behavior, strategy, human resources, marketing and logistics. To-date, this is the most complete survey about ABS in all management areas.

Keywords Complexity, Agent-based simulation, Decision making, Organizational simulation, Simulation as a method, Organizational studies

Paper type Research paper

1. Introduction

Today’s markets and organizations are complex systems (CS). CS are made up of heterogeneous elements that interact with each other and the environment, generating interdependencies across multiple spatial and temporal scales that are difficult to understand, predict and control (Boisot and Child, 1999). A distinctive feature of CS is their ability to exhibit complex emergent properties, i.e. counterintuitive aggregate properties

JEL Classification — C63, L00

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(Mitchell, 2009). Their environment is characterized by dynamic, fast-paced changes across different domains that make them prone to uncertainty, systemic risks and networked effects (Helbing, 2013). To be able to cope, organizations must create mechanisms to learn, adapt and coevolve under such circumstances.

Most phenomena relevant to current organizations entail uncertainty and complexity. Understanding and managing the intrinsic complexity in organizations requires strategies that go beyond intuition (Bonabeau, 2003) and traditional analytical methods (Andriani and Mckelvey, 2007). Therefore, new theoretical and methodological frameworks are needed.

Over the past two decades, agent-based simulation (ABS) has emerged as a new research and management paradigm within organizational theory (Wall, 2016). However, ABS has not been as widely adopted in management as in other domains, leaving its potential to manage organizations far from realized. We believe that this is in part due to a lack of knowledge about what has been done in the field or what are the most promising areas for future application. Hence, the goal of this paper is to provide a comprehensive survey of the literature about ABS in business and management. Such overview contributes to the establishment of a dialogue among scholars and the consolidation of ABS as a field of research in management and organizational studies. To help demarcate this field, we use the term agent-based organizational simulation (ABOS) to refer to any of the applications of ABS in business and management.

ABS allows researchers to recreate interactions between individuals in an organization or between organizations in a market to evaluate the aggregate outcome of their behavior (Fioretti, 2012). As a result, SBA can be used to study organizational behavior (Secchi and Neumann, 2016) and manage complexity within organizations and their environments (Terna, 2008).

ABS provides a robust framework that enables elaborate descriptions, explanations, predictions and theories about organizations and their processes (Fioretti, 2012). It also aids in the development of tools that support strategic and operational decision making and problem-solving (North and Macal, 2007).

2. The paradigm of ABS

Understanding ABS requires distinguishing between three interrelated concepts: agent-based complex systems (ABCS), agent-based models (ABMs) and ABSs. An ABCS (Grimm *et al.*, 2005) is a portion of reality in which basic components interact with each other and the environment in non-linear ways producing emergent, global patterns. These patterns could be structural, behavioral or functional (Gómez-Cruz, 2013). Examples of ABCS are the brain, ant colonies, organizations and economies (Mitchell, 2009).

ABCSs are tightly coupled with their environments. They display sensitivity to initial conditions and path-dependence. These elements cause network effects and interdependency at different scales, often leading to cascading failures that limit our ability to control and predict these systems (Helbing, 2013). Models help us overcome such limitations.

An ABM is an abstraction of a system's components, their actions, interactions and environment (Wilensky and Rand, 2015). An ABM architecture, therefore, includes three components: agents, an environment and agent-agent/agent-environment interactions.

An agent is an autonomous computational entity that has its own behavior and attributes (Rand, 2013). Agents represent social actors or institutions that make up the system. In the context of organizations and markets, agents can be consumers, employees, companies, clusters or countries. Agents can be simple or complex – their intricateness depends on the problem at hand.

Each agent can be modeled with a different set of properties that include perception, communication, reactivity, proactivity, flexibility, learning and adaptation (Crooks and Heppenstall, 2012). There are different ways to model the cognitive ability underpinning decision making in agents (Balke and Gilbert, 2014). These include simple probabilistic models;

if-then decision rules; decision trees; reasoning and planning mechanisms derived from cognitive science and artificial intelligence, and bio-inspired (meta)heuristics.

The most distinctive feature of ABMs is that they explicitly model the interactions among agents and between agents and the environment (Macal, 2016). These interactions make the system inherently dynamic and can be direct, i.e. agent-agent, or indirect, i.e. mediated by the environment or artefacts. The communication through chemicals that takes places in ant colonies is an instance of indirect interaction mediated by the environment. An example of indirect interaction mediated by artefacts is the communication that occurs in social networks like Facebook and Twitter.

Modeling interactions between agents requires the specification of who is linked to whom and the definition of interaction strategies. The first task refers to the model topology; the second, to the mechanisms of interaction. Diverse interaction topologies are used in the literature (Macal and North, 2009): rigid topologies, Euclidean spaces, network topologies, non-spatial models or realistic geospatial landscapes using GISs. Rand (2012) highlights the implications of this last topology in business.

Regardless of the topology, interactions and information transmission are local – agents have limited visibility of the system as a whole. In ABS there is no global communication or information. This allows a more realistic representation of the complex nature of organizational and economic systems.

Finally, the environment is the space within which agents “live” and interact. ABS can depict natural and artificial environments (Cioffi-Revilla, 2014). Natural environments may include topological, climatic, biological and hydrological elements while artificial ones encompass manmade systems like roads, and power and telecommunications networks.

ABS links agents’ micro-behaviors to macro-patterns that emerge from their interactions. The transition between local and global is achieved through computational simulation (Gómez-Cruz, 2017). ABS is, therefore, the computational implementation of the system and the “visualization” of its dynamics over time.

Several frameworks and platforms have been developed for this end. Some of the most widely used are NetLogo, Repast, Symphony, Swarm and MASON (Railsback *et al.*, 2006). For methodological details of ABS see Wilensky and Rand (2015).

ABS can be considered an approach to modeling, a computational tool, a methodological framework or an analytic method. However, it is better understood as a new paradigm of computational thinking that is decentralized, interactive, dynamic, generative and emergent (Wilensky and Rand, 2015; Epstein, 2007). Its foundations are not so much technical or technological, but scientific and philosophical. In consequence, ABS is technically simple but conceptually deep (Bonabeau, 2002).

3. ABOS: scope and applications

The use of simulation in management and organizational studies is not new (Berends and Romme, 1999). The novelty of ABOS derives from the use of agents for understanding and managing complexity and uncertainty in organizations. ABOS uses ABMs and simulations in the domain of organizations, their problems and environment. From the conceptual and epistemological point of view, ABOS is rooted in computational social science (Cioffi-Revilla, 2014), generative social science (Epstein, 2007), computational organization theory (Frantz *et al.*, 2013) and computational management[1].

ABOS overlaps with growing fields like agent-based computational economics (Tesfatsion and Judd, 2006) and agent-based computational sociology (Squazzoni, 2012). ABOS’s specificity relies on the use of ABS in domains of organizational life that lend themselves to management and control. While other fields emphasize the comprehension and explanation of systems and processes, ABOS emphasizes decision making and problem-solving.

We present a non-systematic survey of the main areas in ABOS encompassing articles published between 2000 and 2016. Paper selection was conducted following two strategies: First, articles were filtered using the “agent-based” keyword in Scopus’ business, management and accounting database. Then, additional search criteria were devised using the articles’ keywords and the categories defined by the Academy of Management (AOM, 2017) (See Table I). Selected books and conference proceedings were included as well. From 436 articles, 181 were selected, based on titles, abstracts and keywords (see Table I). Figure 1 shows that most applications are in operations and logistics (37 percent), marketing (17 percent) and organizational behavior (14 percent).

3.1 Organizational behavior

The study of organizational behavior underscores the versatility of ABS. It has been used to understand behavior of organizations in a market and the behavior of agents within an organization. Thus, organizations can be considered agents or environments.

Organizations as agents have been studied in business networks and innovation. Prenkert and Folgesvold (2014), for instance, found that in an international business network the topology of the net affects the intensity of commercial relationships. Other publications focused on innovation found that companies with similar technological conditions can occupy very different market positions. Particularly, Ciarli *et al.* (2007) showed that companies focusing on specific innovations over long periods of time increased their short-term competitiveness, but faced long-term technological lock-in.

Literature on organizations as agents encompasses areas such as analysis of market conditions, the knowledge society (Mollona and Hales, 2006) or the study of populations of companies. Odehnalová and Olsevcová (2009) addressed development processes in family business, and Wu *et al.* (2009) examined organizational adaptability in terms of agility, robustness, resilience and survival.

Application field	Subfield	Number of papers reviewed
Organizational behavior	Organizational change	4
	Organizational learning	3
	Organizational design	5
	Organizational psychology	1
	Unclassified	12
Strategic management and decision making	General topics	13
Research and development	General topics	15
Operations and logistics	Operations	9
	Healthcare logistics	3
	Production	11
	Supply networks	32
	Transportation	11
Marketing	Traditional marketing	4
	Digital marketing	4
	Social marketing	1
	Diffusion of innovations	12
	Other topics	10
Human resources	General topics	4
Education in management	General topics	6
Other categories	Examples: project management, public administration, social responsibility, entrepreneurship	21

Table I.
SBA applications in organizations and management

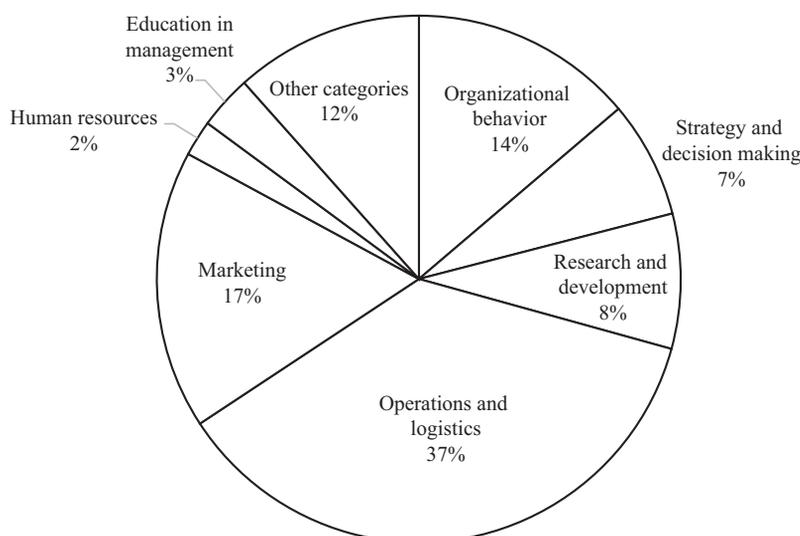


Figure 1.
Percentage of identified works by application area

The use of ABS to study interactions within organizations has been centered around the diffusion of knowledge (Wang *et al.*, 2009) or opinions (Rouchier *et al.*, 2014) among institutional actors. It has also been used to study the result of these diffusion processes, for example, the emergence of a changing organizational identity (Rousseau and Van der Veen, 2005). Jiang *et al.* (2010) explored the link between employees' behavior and task assignment. They implemented a simulation that allowed them to determine that a collaborative environment in which learning is encouraged and tasks are dynamically assigned, employees' capabilities can be increased.

Contributions in organizational psychology (Hughes *et al.*, 2012), organizational design (Heyne and Mönch, 2011) and organizational architecture (Rodríguez *et al.*, 2011) we also found.

3.2 Strategic management and decision making

We found several applications on organizational decision making. Sun and Naveh (2004) computationally recreated organizational dynamics that have been studied empirically for decades. The simulation showed that decisions made in non-hierarchical teams have better outcomes than those made in hierarchical structures. Similarly, they show that organizations with free access to information perform better than those with restricted access.

Forkmann *et al.* (2012) studied the link between strategic decision making and the position of power held by an agent. They found that although dominant strategies are favored by CEOs, these strategies do not necessarily yield the best results over time. This shows that the mismatch between empirically derived decisions made by managers and the effect that these strategies have on their businesses. These results underscore the need for decision-making tools. Kodia *et al.* (2010), on the other hand, study the impact of local interactions and cognitive behavior of investors in stock markets. Under different market conditions, the simulations show the effect of the investors' decision making on the price fluctuation in the market.

North *et al.* (2010) discuss the need to develop holistic models that represent interdependences between consumers, retailers and producers in consumer markets to aid in decision making. This is exemplified by an ABM that addressed different organizational problems in Procter & Gamble. The model helped guide organizational decisions leading to

significant savings in operation costs. Other areas of applications of ABS in decision-making systems include the value chain (Hilletofth and Lättilä, 2012), logistic and manufacturing systems (Nilsson and Darley, 2006) and the integration of technical and business aspects in the oil sector (Hu *et al.*, 2012).

3.3 Research and development

ABS has been used in R&D to understand innovation as a collective process that emerges from the interaction of different actors. It has provided some evidence of some pitfalls in previous approaches to the process of innovation, such neglecting human subjectivity.

Mild and Taudes (2007) presented a model that showed that guided-search methods in which the companies decide hierarchically the features of a new product, are less successful than decentralized strategies such as trial and error. The model suggests that a larger knowledge-base of prototypes or alternatives, the more likely it is to develop new products. Similarly, Zhong and Ozdemir (2010) claimed that group structure affects the speed of innovation processes.

Zhang *et al.* (2013) used a task assignment model based on agents' preferences to provide important insights regarding the effect of human elements in the innovation process. Finally, Maisenbacher *et al.* (2014) exemplified the use of ABS in product-service systems (products that also provide services). They also laid out the most promising lines of research regarding the use of ABS for product development.

3.4 Logistics and operations

Applications in logistics are some of the earliest used of ABS. The first models date back to the early 1990s (Santa-Eulalia *et al.*, 2012). Then, perhaps unsurprisingly, most ABS in business and management are to-date in this area.

ABS used to add dynamism to the implementation of the productive processes. The work of Renna (2011) proved that, in a dynamic context, an ABS performs better than traditional methods regarding throughput time, throughput, work in process, machines average utilization and tardiness. Rolón and Martínez (2012) incorporate dynamicity from the perspective of production automatization. Their work determined that agents' ability to learn provided significant advantages in the new era of automatization of manufacturing systems.

ABS has increased its popularity in the transportation. Currently, there are some ABS platforms built exclusively to deal with transport tasks. The most popular, according to Zheng *et al.* (2013), are: TRANSMISMS; Multi-Agent Transport Simulation Toolkit (MATSim); Sacramento Activity-Based Travel Demand Simulation Model (SACSIM); Simulator of Activities, Greenhouse Emissions, Networks, and Travel (SimAGENT); Open Activity-Mobility Simulator (OpenAMOS) and Integrated Land Use, Transportation Environment (ILUTE).

ABS had a great impact in this area because traditional approaches do not capture the complexities of current logistic markets. They are unable to account for external perturbations, such as changes in policy or traffic flows (Cavalcante and Roorda, 2013). ABS provide a way to overcome these problems, thanks to its flexibility (Kavicka *et al.*, 2007) and its ability to deal with diversity –a feature that is common in freight transportation around the world (Holmgren *et al.*, 2013).

In air logistics, Bouarfa *et al.* (2013) use a hybrid ABS and a Monte Carlo simulation to identify uncommon emergent behaviors in air transport systems. Their work showed that some high-level risks in air safety cannot be identified or managed with traditional warning systems. Other applications in transportation and logistics are cross-docking optimization (Suh, 2015) and the implementation of shared parking strategies to reduce traffic and pollution in a food transport network (Boussier *et al.*, 2011).

Risk management in supply networks is also a common topic in the literature. Chen *et al.* (2013) elaborated a review of ABS applications for the management of value chain risks. According to these authors, the volatility of the environment and its increasing complexity has made that up to 75 percent of the operation costs depends on the management of the supply network.

Analogously, some authors have studied the impact of local processes on global economic behavior, focusing on dynamics and systemic risks that affect the value chain (Mizgier *et al.*, 2012). Others suggest that ABS helps increase value chain visibility and improve communication between different actors (Hilletoft and Lättilä, 2012).

There are also several ABS applications in healthcare logistics. Friesen and McLeod (2014) describe the most common application in this domain and also provide some suggestion regarding its use. In turn, Denton (2013) surveys several case studies and provides a more comprehensive review of ABS and other methods used in healthcare logistics. Most ABS in this direction focuses on optimization. There are, however, many other applications. Liu and Wu (2016), develop a model about a payment model that increases accountability in health organizations.

Finally, some of the most recent applications seek to provide common logistic frameworks. Long and Zhang (2014) implemented a model to analyze the global behavior of the supply network. This model integrates production, inventory and transportation, enabling the exploration of the system at different levels and granularity. The model is reusable and scalable, reducing computational costs and computing time.

3.5 Marketing

ABS has been used in marketing, both inside and outside academia (Rand, 2013). Hence, there are two major trends in the literature: case studies documented by consultants and academic research encompassing theory and practice.

Case studies published by consultants (e.g. Icosystem or Ignite Technologies) include organizations in different economic sectors. Most studies are made for large organizations, such as Procter & Gamble, Telecom Italia, Urban Outfitters or Toyota. The former has used simulation to quantify the release of several products on media and social networks. In order to protect clients, consultants often restrict access to sensitive information but publish most of their results. Concentric – an ABS consulting firm – claims that it was able to predict the number of subscriptions for a video streaming website with less than 1 percent error. It used detailed data from previous years to calibrate the model. The company has also implemented a simulation for a coffee firm experiencing a decrease in sales in which market dynamics were replicated with less than 2.2 percent error. With this model, it was able to determine that the best strategy was to improve the product experience and increase marketing in stores. Similarly, Ignite Technologies increased the return on investment of a packed goods company by 15 percent using the same principle.

A literature review by Negahban and Yilmaz (2014) included 80 articles, out of 11,200, in which ABS was used. It discusses emergent phenomena and the overall results of using ABS for market research. According to these authors, the ABS literature in marketing can be divided in three categories: conventional marketing, digital marketing and diffusion of innovations. We add social marketing as fourth category.

Conventional marketing focuses on scenarios in which clients find out about new products through conventional channels, like catalogues or at the store. Hassan and Craft (2012) evaluated the effectiveness of market segmentation based on the customers' perception. The authors concluded that basic market features, such as consumer decision-making rules and preference variability determine the performance of segmentation strategies, even in cases in which those strategies are closely linked. Roozmand *et al.* (2011) also built a model focused on segmentation dynamics. The model addresses the processes of decision making,

validating the results with information from European countries. It sought to overcome the lack of realism in the decision-making heuristics of traditional models. Therefore, they included element like identity, extroversion, affability and openness in the agents' cognitive structure. They also included the social status and social responsibility. This shows that ABS allows for agents as complex and realistic as the problem demands. Even though there is not a full correspondence between the results of the model and the empirical data, the model was able to determine that the cultural dimension of agents is particularly relevant for the purchase of vehicles.

The digital market category studies scenarios in which the clients are influenced through non-traditional means, such as online reviews, blogs or social networks (Negahban and Yilmaz, 2014). Chang *et al.* (2010), for example, analyze the effect of a strategic alliance between two small search engines to better compete with the company with the largest market share. The model assumes that the decision to advertise in a search engine depends on the advertiser's individual preferences and the disposition to follow others' decisions. Even though market share of the biggest company is larger than the share of the two small companies, the simulation reveals that the alliance allows the two companies to take over the bigger markets. This category also involves digital markets in which producers and clients meet and interact online. ABS could be used, for instance, to study the impact of e-commerce on organizational structures (Siggelkow and Levinthal, 2003) or supply chains (Zhang and Bhattacharyya, 2010).

Diffusion of innovations pertains to the uptake of new products and innovations. Most applications found by Negahban and Yilmaz (2014), 37 articles, are on this topic (here we consider 12). Diffusion models study adoption behavior and social influences to understand the role of heterogeneity, interaction dynamics, network effects and promotion strategies. Recent models analyze the effect of word-of-mouth on the perception of product attributes (Goldenberg *et al.*, 2001). Other applications include models that provide time-price strategies for new products releases in the mobile phone market (Lee *et al.*, 2014).

The last category, social marketing, is less developed than the other three and is not considered by Negahban and Yilmaz. Nonetheless, it is an important category that should be included in this survey. Marketing goods or services is different from "marketing" a cause or idea.

The model by Pérez-Mujica *et al.* (2014) about an ecotourism campaign for a zone of wetlands conservation is an instance of these kind of models. Results suggested that the ecological state of the wetlands depends on the design of the social marketing campaign.

3.6 Human resources

ABS is not commonly used in human resources. Yet, there are applications that focus mostly on the performance of teams. Rojas and Giachetti (2009), for example, explored collaboration processes in teams that carry out non-structured tasks. The model implements a shared and distributed mental model among agents, according to which each agent has only partial understanding of the skills, knowledge and role of other members. The model provides insights into collaboration dynamics in teams.

Singh *et al.* (2012) study social learning and its impact on team performance. Their results show that the success of different social learning strategies partially depends on how familiar members are with each other, and that the contribution of social learning to team performance is higher in personal interactions, followed by interactions about completed tasks.

SBA has recently been used to study team configurations that were uncommon until recently, due to technological limitations. Some simulations explore the behavior of teams working remotely through complex technological systems. According to Sullivan *et al.* (2015), the operation of these teams requires new structures of shared leadership. The authors

suggest, however, that there is not enough knowledge about the time-space interaction that leads to the emergence of such structures. Hence, they develop a model that integrates current knowledge about leadership, networks and innovation, to specify the generative mechanisms through which decentralized forms of leadership emerge. Finally, Siebers *et al.* (2011) move away from team work dynamics, seeking instead to research the practices of personnel management in a wholesale chain.

3.7 Teaching in management

In comparison to other simulation approaches, ABS gives students a wider perspective of market dynamics (Baptista *et al.*, 2014). Simulations allow students to create and generatively identify behavioral patterns exhibited by social systems (Wilensky, 2014).

According to Baptista *et al.* (2014), ABS increases the transparency of a simulation, because it provides students with more information about the workings of the model. Similarly, the work of Tanabu (2010) concluded that ABS does not only improve learning in subjects such as value chain management, it also facilitates the role of teachers managing the simulation. Tanabu's conclusions were drawn after an ABS was implemented as an alternative to traditional simulators in more than 70 Japanese universities.

4. The scope of ABOS

ABS cannot answer all research questions. Problems with features like linearity, causality, statistical averages, and controlled environments are better tackled with analytic methods. Problems involving the comprehension, prediction and control of complex phenomena must be approached with alternative techniques that are better suited for this task (Sayama, 2015). Game theory, network theory, Monte Carlo simulations or Dynamic Systems theory are a few examples. In general, ABS is useful when (Gómez-Cruz, 2017; Wilensky and Rand, 2015; Rand, 2013; Bonabeau, 2002):

- The system under study has multiple autonomous and heterogeneous components.
- Agents act in a local, parallel and distributed manner, without global knowledge. Interactions are non-linear, discontinuous and asynchronous. Small actions can propagate through the entire system, triggering network effects and amplifying fluctuations (Helbing, 2013).
- The system is structured in spatial-temporal scales.
- The system's global dynamic is self-organizing and emergent, i.e. it exhibits properties such as memory, path-dependence, temporal correlations, learning, adaptation and evolution (Bonabeau, 2002). Such dynamics cannot be understood through normal distributions, or by using law of large numbers or as the sum of the parts (Andriani and Mckelvey, 2007).
- The environment is uncertain and often includes a non-reducible spatial component.

4.1 General purposes of ABOS

Theory and practice of organizational studies can be divided in two: the meta scale, which includes academic and scientific aspects of organizations and management and the specific or pragmatic scale, which supports decision making and problem-solving. Fioretti's (2012) work is a good introduction to ABOS on the meta scale. To-date, the use and impact of ABOS is increasing on the pragmatic scale. We outline the main goals of the pragmatic scale using Davidsson and Verhagen's (2013) categories.

Understanding observed dynamics, processes and systems. ABS is often used to deepen understanding where no theory is available. In organizations, it is particularly useful in the

development diagnostic or risk management models. In all these scenarios, decision making critically depends on the available knowledge about the problem at hand. Thus, an ABS could provide new insights about the phenomenon of interest.

Designing or engineering of processes or systems. ABS can be used to identify design criteria or to test engineering concepts in *in silico* experimental environments. The design and implementation of an engineering system could have potential negative ethical, economic, social and legal implications that are not easy to predict for an organization. Testing under diverse conditions is supported by ABS enabling managers to better estimate their impact. It also helps to evaluate complex man-machine interactions, typical of socio-technical systems.

Managing a system or process. ABS is able to answer what if questions that can significantly support strategic and operational decision making. It can be used to identify failures, underutilized resources, bottlenecks and the design of organizational policies.

Formulating theory and explanatory models. ABS is an operational platform in which assumptions, theories and models can be translated into testable hypotheses. It is also an experimental laboratory in which, through the manipulation of pre-specified parameters, it is possible to develop theories, models or new hypotheses about the world (Conte and Paolucci, 2014).

Prediction. ABS explores the structural, dynamic and functional possibilities of a system. This approach does not aim at long-term prediction, as it happens with classical methods, but acknowledges the irreducible limitations of predicting the behavior of CS (Nicolis and Nicolis, 2012). Agent-based monitoring systems working on real time help managing organizational uncertainty.

Optimizing resources, capabilities and processes. ABS has been used in areas where traditional and heuristic methods are limited. Particularly, problems that are distributed, heterogeneous and unstable. There are several hybrid applications combining ABS with heuristic and metaheuristic methods. These combined models have been used to solve problems in scheduling, logistics, supply chain planning, manufacturing and packing (Barbati *et al.*, 2012).

4.2 Advantages of ABS

Interaction is a fundamental feature of complex economic and organizational systems. Complexity is not possible without interaction. In this regard, ABS significantly departs from other analytical techniques because it is able to model agents' interactions independently (Macal, 2016). It does not establish links between fundamental variables, rather it directly models interacting agents that influence each other. Recreating the interactions between members of an organization, between organizations or economies, enables researchers to uncover the effects of individual decisions on the global system. Due to its interaction-based approach to modeling, using ABS has several advantages.

Unlike equation-based models, ABS provides descriptions that closely resemble the system under study (Squazzoni, 2012). Thinking in terms of actors, their features and interactions makes ABS more suitable for the description of markets or organizations.

ABS captures the logic of emergence (Wilensky and Rand, 2015). Agent-based systems exhibit patterns at a global scale that result from interaction of the micro-components, yet are not easily deducible, reducible or predictable from these micro-components alone (Gómez-Cruz, 2013). The price dynamics in a stock market, for instance, are an emergent pattern resulting from the actors' decisions to buy and sell.

A large part of socio-technical systems can be conveniently modeled as networks of interconnected elements. Production and supply networks, organizational clusters, social networks and international trade networks are a few common instances. ABS is the bridge between ABMs and network-based models (Namatame and Chen, 2016). In an ABM, agents

represent nodes and interactions represent edges. Therefore, ABS is useful not only for the study of structural, but also functional aspects of complex networks in the organizational domain (Skvoretz, 2002).

Another distinctive aspect of ABS is its flexibility (Helbing and Balmelli, 2012). ABS makes it easy to add or delete agents without a need to re-program the model. It is also possible to alter agent and environmental properties to see the effect of such changes. Time can be compressed or expanded to manipulate the speed of the phenomenon simulated.

Finally, ABS can be articulated with other methods (Helbing and Balmelli, 2012) to improve realism, explanatory power or problem-solving capabilities. Among the long list of methods that have been paired with ABS is network analysis, fuzzy logic, genetic algorithms, neural networks, swarm intelligence and GIS (Rand, 2012).

4.3 Limitations of ABS

ABS is not without limitations. The validity of a model depends on the assumptions built into the model. Given the inherent complexity of organizational systems, it is not possible to abstract these assumptions completely or univocally. ABS can have programming errors or might not adequately capture the essence of the target system. There are no standardized models that guarantee verification and validation in ABS, in spite of recent efforts (Yilmaz, 2006). Also, interpreting the results of an ABS is hard when they are counterintuitive or when there is stochasticity involved. Finally, the acquisition of technical skills by managers and organizational researchers is still not widespread, and outside academia ABS is rather uncommon.

Despite its limitations, ABS is one of the most promising and generalized approaches to study complexity and emergence (Sayama, 2015).

5. Conclusions

In this paper we provided an overview of impact of ABOS with the intent to consolidate its standing as a field of research. ABOS proved to have a rich variety of practical and theoretical approaches to management and organizational studies (Secchi and Neumann, 2016; Wall, 2016; Fioretti, 2012; Chang, 2006).

There have been many independent efforts to build ABS frameworks and agent architectures focused on organizations (Moise or Thomas); create consultancy firms that make use of ABS (Icosystem, Concentric or ABM Analytics); develop simulation platforms (AnyLogic) and publish academic literature and patents that use this method. We believe the time is ripe to embark on an agenda-setting endeavor and promote an effective dialogue among scholars. We hope that this paper is a step in that direction.

ABOS gives way to a generative view of organizations and their processes. It supports high-level abstractions, aimed at explaining and formalizing organizational dynamics. Further, it gives managers and decision-makers detailed models that can be empirically calibrated to support decision making, prediction and optimization in strategic, tactical or operational scenarios.

From a theoretical point of view, ABS is a third way of approaching reality, along with induction and deduction (Axelrod, 1997). From the practical point of view, integrating ABOS with data science, machine learning, complex network analysis and bio-inspired computation will become increasingly common. We believe that the development of hybrid technologies mediated by ABS is the future of decision making and organizational problem-solving tools.

Note

1. See the journal *Computational Management Science* and the series *Advances in Computational Management Science*, both published by Springer-Verlag.

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Reputation of multinational companies

Corporate social responsibility and internationalization

Reputation of
multinational
companies

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Abstract

Purpose – The purpose of this paper is to use stakeholder theory as the theoretical reference framework to study the influence of internationalization (geographic international diversification) and social performance on multinational companies' (MNCs) reputation.

Design/methodology/approach – The authors confirm the research hypotheses using a sample of 113 US MNCs in the chemical, energy and industrial machinery sectors during the period 2005-2010.

Findings – This study contributes to the literature in three ways. First, it incorporates literature on internationalization to study the possible connection between geographic international diversification and social performance in MNCs. Second, it sheds light on the debate between corporate social responsibility (CSR) and the reputation of MNCs in a very diverse transnational context in which MNCs must meet the needs of stakeholders at both local and global levels. Third, it incorporates the mediating role of social performance in the relationship between geographic international diversification and the firm's reputation.

Originality/value – Prior studies have hardly analyzed this relationship, which becomes especially relevant for MNCs, since their implementation of advanced CSR practices in the different markets in which they operate will gain them a good reputation, not only in specific local contexts but also globally, benefitting the organization as a whole and enabling it to gain internal consistency (improvement in internal efficiency), transparency and legitimacy.

Keywords Reputation, Stakeholder theory, Corporate social responsibility, International diversification, Multinational companies

Paper type Research paper

1. Introduction

Corporate social responsibility (CSR) has acquired great relevance in the academic world and in firm management in recent years (Barrena *et al.*, 2016; Madorran and Garcia, 2016). Defined as organizations' commitment to contribute to sustainable economic development, CSR includes issues such as employee labour conditions, improvements in products and

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services, progress that seeks to satisfy the needs of the local community and advances in environmental management, among others (World Business Council for Sustainable Development, 2004).

Since multinational companies (MNCs) are organizations that can incorporate advances and improvements in social issues in the different areas in which they operate, the literature increasingly considers them as precursors of economic and social progress (Porter and Kramer, 2011). One of the main reasons these firms invest in advanced CSR practices is to improve their reputation. While one definition of reputation is the perception that stakeholders have of the firm's willingness and capacity to satisfy stakeholders' interests (Fombrun, 1996), some studies argue against considering reputation as the aggregate perception of the set of stakeholders, primarily for two reasons (Walker, 2010). First, reputation depends on the issue to which it refers – for example, reputation with respect to behaviour in environmental, social, employee or corporate governance matters and product quality, among other issues. Second, reputation can vary for each specific interest group – for example, consumers, investors or the government (Lewellyn, 2002). Based on these assumptions, having an excellent reputation does not necessarily imply satisfying the different stakeholders; that would require determining what type of reputation we mean and for which specific group.

Previous studies have analyzed the relationship between CSR and the firm's results, but findings are not conclusive (Madorran and Garcia, 2016) due to mediating and moderating variables such as the context (country and region) of stakeholders' locations (Gardberg and Fombrun, 2006). The literature has paid little attention, however, to how MNCs, which must typically negotiate the needs of very heterogeneous stakeholders (both local and international), can increase their reputation by improving their social performance (Musteen *et al.*, 2013). In fact, MNCs should manage relations in social issues with all stakeholders in the different contexts in which they operate. All of these issues can affect their reputation directly.

MNCs often operate in different countries and regions with varied institutional profiles (Kostova *et al.*, 2008). Through internationalization, they can attend to the demands of stakeholders in the different contexts and markets in which they operate, there by achieving the image of responsible, legitimate, transparent entities committed to the environment (Christmann, 2004). Further, they can strengthen their internal organizational framework by extending their business model outside their boundaries (Aguilera-Caracuel *et al.*, 2013), efficiently transferring their best practices, policies and business models (Hitt *et al.*, 1997) by means of management standards (Aguilera-Caracuel *et al.*, 2012). All of this activity can have very positive repercussions for both their social performance and significant improvement in their reputation driven by this social performance.

This study uses stakeholder theory as the theoretical reference framework to study the influence of internationalization (geographic international diversification) and social performance on MNCs' reputation. We confirm the research hypotheses using a sample of 113 US MNCs in the chemical, energy and industrial machinery sectors during the period 2005-2010. The results show that the MNCs with the highest levels of social performance that can fulfil the expectations of stakeholders in both local and global contexts obtain a better reputation, as their stakeholders come to see them as responsible, consistent organizational entities. The results also support the relationship between geographic international diversification and reputation through the mediating role of social performance.

This study contributes to the literature in three ways. First, it incorporates literature on internationalization to study the possible connection between geographic international diversification and social performance in MNCs. Second, it sheds light on the debate between CSR and the reputation of MNCs in a very diverse transnational context in which MNCs must meet the needs of stakeholders at both local and global levels.

Third, it incorporates the mediating role of social performance in the relationship between geographic international diversification and the firm's reputation. Prior studies have hardly analyzed this relationship, which becomes especially relevant for MNCs, since their implementation of advanced CSR practices in the different markets in which they operate will gain them a good reputation, not only in specific local contexts but also globally, benefitting the organization as a whole and enabling it to gain internal consistency (improvement in internal efficiency), transparency and legitimacy.

2. Theoretical foundations

2.1 Stakeholder theory in MNCs

The term "stakeholder" refers to the individual or group that can affect or be affected by the firm's action in pursuit of its objectives (Freeman, 1984). Stakeholder theory is especially useful for explaining why firms decide to put into practice socially responsible management, such as promotion of social progress in the local community, protection of disadvantaged groups, improvement of workers' labour conditions or commercialization of ecological products and services. According to this theory, negative actions in social issues such as polluting the environment or abusing employees have a very negative effect on stakeholders' perception of the firm (Freeman, 1984). For Porter and Kramer (2006), firms and society complement each other and should act jointly. Companies should thus make decisions related to the formulation and implementation of CSR initiatives in active and continuous dialogue between the company and its different interest groups (Christmann, 2004). Actions oriented to satisfying stakeholders' needs should be a priority goal for firms, impacting them positively in the medium and long term (Valenzuela-Fernández *et al.*, 2015). Whereas some studies assimilate the concept of the firm's "social performance" with "stakeholders' satisfaction level" (e.g. Clarkson, 1995; Post *et al.*, 2002; Zagenczyk, 2004), others hold that the two terms are related but should not be confused. The complexity of the relationship between the firm and stakeholders grounds separation of the two concepts, due fundamentally to the diversity of the socially responsible initiatives and heterogeneity of the interests of each specific interest group. To determine the effect of social performance on stakeholder satisfaction, it is thus necessary to analyze the type and intensity of the firm's social actions, as well as their impact on each specific group of stakeholders (Luna and Baraibar, 2011).

Stakeholder theory is especially relevant to MNCs, since they are in contact with a multitude of interest groups due to their operation in numerous countries and regions (Jamali, 2010). Each stakeholder has its own needs and expectations, some more specific and others more extendable to different contexts (Aguilera-Caracuel *et al.*, 2015). Compared to local firms, MNCs are under more pressure because they face very relevant, diverse, strong interest groups in the local and global environments, groups that will grant them legitimacy and the power to act (Kang, 2013). For example, stakeholders in certain countries consider gender equality at work as essential, whereas those in others do not see it as a real priority (Connell, 2005). The same duality emerges on environmental issues, especially if we compare developing countries with developed ones (Becker and Henderson, 2000).

Finally, for the firm to benefit from relationships with its stakeholders, it is important to distinguish appropriately between them and to capture their needs. By responding appropriately to stakeholders' expectations, firms can obtain licence to operate in foreign markets (Park *et al.*, 2015).

2.2 Geographic international diversification and social performance in MNCs

We can define international diversification as "the number of markets in which the firm operates and their respective importance" (Hitt *et al.*, 1997). International diversification of MNCs involves interacting with different cultures and levels of economic and legal

development, including satisfying the needs of diverse interest groups – governments, political parties, unions, NGOs and customers, among others (Crane and Matten, 2010; Rodríguez *et al.*, 2006). Although international diversification involves some risk due to operation in new markets with diverse institutional, political, environmental and cultural profiles (Aguilera-Caracuel *et al.*, 2013), organizations can also benefit from economies of scale and overcome entry barriers in specific markets by having the right response to their stakeholders' demands (Kang, 2013).

Different reasons drive internationally diversified MNCs to develop socially responsible initiatives. First, greater visibility and exposure to these firms' pressures from interest groups can make socially responsible behaviour a priority (Christmann, 2004; Crane and Matten, 2010; Kang, 2013; Rodríguez *et al.*, 2006; Yang and Rivers, 2009). Greater visibility can motivate MNCs to be more proactive in social and environmental issues and ultimately strengthen relationships with the societies in which they operate (Garriga and Mele, 2004). The demands of the different stakeholders can vary, however, depending on the country in which the firm operates – demands on issues such as gender equality (Connell, 2005), corruption (Transparency International, 2004) or workers' rights (Ahmadjian and Robinson, 2001). To achieve positive effects derived from these actions and to satisfy stakeholders, firms must make an effort to inform their stakeholders adequately of the social responsibility initiatives the firm performs (Sen *et al.*, 2006). Strike *et al.* (2006) affirm that MNCs with a high level of international diversification can communicate more effectively with the different interest groups, capture their needs and play an active role in the design of national and international regulations in the social and environmental arenas. For example, MNCs can have stable, trust-based relationships with governments and public powers that grant them privileged access to subsidies and licences to act in different markets (Luo and Bhattacharya, 2009).

Second, response to social demands enables MNCs to reduce specific risks significantly (Deckop *et al.*, 2006): failure to comply with legislation, pressures from firms in the same sector and from business associations, negative reactions from public opinion and consumers' associations, problems with activists and NGOs and possible consumer boycotts. Along these lines, various studies show a positive relationship between high level of social responsibility and cost reduction. For example, some studies show that investing in environmental issues can help firms to avoid penalties (Aguilera-Caracuel *et al.*, 2013; Hart, 1997) or pressure from civil and consumers' associations (Henriques and Sadorsky, 1996; Russo and Fouts, 1997).

Third, in contrast to firms with little geographic diversification, MNCs that operate in diverse markets can redistribute the costs and benefits of investing in CSR among their subsidiaries, an economic incentive to invest in these topics (McWilliams and Siegel, 2001). For example, the MNC can use the positive image it derives from high involvement in socially responsible behaviour efficiently in different markets and cultures (Lichtenstein *et al.*, 2004). Some studies show that MNCs standardize specific CSR activities that they consider as universal in such social responsibility issues as workplace health and safety, human rights, corruption and climate change (Bondy *et al.*, 2012). MNCs can also adapt some CSR activities depending on the specific rules and values of the country or region in which they operate. Other studies, in contrast, hold that there are no absolute or universal CSR practices and that companies should fit these practices to each area (Ang and Maasingham, 2007; Mooij and Hofstede, 2010). Kakabadse *et al.* (2005) hold that CSR means different things in Europe, the USA and developing countries and that MNCs should adapt their levels of social responsibility to each area (Arthaud-Day, 2005; Wang and Juslin, 2009). MNCs in developing countries, for example, can orient specific actions to compensating for the inefficiency of public resources (Valente and Crane, 2010) and to making up for the lack of government resources to satisfy basic needs (Eweje, 2006) in areas such as

environmental protection, labour rights and anticorruption and antidiscrimination policies (Barkemeyer, 2011).

In sum, the literature identifies various reasons that can drive MNCs with a high degree of geographic diversification to develop social responsibility initiatives. These firms are more visible and thus generally more subject to pressure from different interest groups. The right response to such pressures from these stakeholders can reduce the risks that affect the firm negatively (e.g. from consumers' associations, activists, NGOs and customers). Further, MNCs can redistribute costs and their investments in social issues. Based on these arguments, we propose that greater geographic international diversity of MNCs will contribute to implementation and development of socially responsible initiatives that result in improvement in their social performance:

H1. Geographic international diversification of MNCs is positively related to their social performance.

2.3 Social performance and reputation of MNCs

MNCs' efforts to develop socially responsible initiatives have grown significantly in recent years (Park *et al.*, 2014), and the literature in this field argues that these initiatives can enable firms to improve their reputation (Melo and Garrido-Morgado, 2012; Valenzuela-Fernández *et al.*, 2015). As a result, reputation has become an extrinsic motivation to develop socially responsible activities (Fombrun, 2005). Having a good reputation helps to improve interest groups' trust in the firm, while also enabling it to improve its competitive position (Fombrun, 1996). In contrast, damage to the reputation can seriously jeopardize the firm (Bertels and Pelozo, 2008).

Some studies support viewing social initiatives as a strategic investment in maintaining and improving reputation (Valenzuela-Fernández *et al.*, 2015). Along these lines, firms use CSR as a strategic tool to satisfy the demands of the different stakeholders – such as NGOs and consumers – in order to create a good corporate image (Jones, 2005) and achieve competitive advantage (Fombrun *et al.*, 2000). According to Klein and Dawar (2004), developing social initiatives is a source of differentiation for firms and helps to create good brand image (Gardberg and Fombrun, 2006); consumers tend to reward firms that behave ethically by paying higher prices for their products (Creyer and Ross, 1997).

Other studies show a positive effect of philanthropic initiatives on reputation (e.g. Lange *et al.*, 2011). Fombrun and Shanley (1990) find that firms that have established a foundation and make more contributions to charity have better reputations. Analyzing determinants of reputation in large corporations in the UK, Brammer and Millington (2005) find that people perceive firms with more philanthropic behaviour as socially more responsible and that these firms enjoy a better reputation than firms that do not follow such behaviour. In general, this group of studies shows that greater involvement in the local community has a positive effect on reputation, suggesting that the different stakeholders expect the firm to behave well towards the community (Brammer and Pavelin, 2006). According to Gugler and Shi (2009), MNCs that operate in developing countries usually understand the concept of CSR in an ethical and philanthropic sense, for example, in terms of monetary contribution to the community. MNCs that operate in these markets sometimes develop ethical and philanthropic activities that enable improvement of sustainability and economic development in these countries (Kolk and van Tulder, 2010; Porter and Kramer, 2011). Through direct investment, MNCs can provide much-needed resources in the Third World, such as technology and work skills. Dickson (2003) holds that philanthropic initiatives are especially welcome when governments do not have sufficient resources to undertake social welfare projects. Through these activities, MNCs can drive sustainability and economic development in developing countries (Moon *et al.*, 2005) to improve their reputation.

MNCs can also improve their reputation by developing socially responsible behaviour with their customers and employees (Park *et al.*, 2014). Customers constitute an interest group that exerts significant pressure on the firm if it detects that the firm is behaving in a socially irresponsible way, as customers have instantaneous information and a multitude of alternatives (Lindgreen *et al.*, 2009). To avoid loss of customers, some MNCs make an effort to develop CSR initiatives, taking into account the ethical standards of the markets in which they operate (Yang and Rivers, 2009). Further, firms with management practices oriented to encouraging workers' well-being at work can simultaneously improve workers' productivity and morale (McWilliams and Siegel, 2001), reduce the level of absenteeism (Berman *et al.*, 1999) and generally have a more consistent workforce (Branco and Rodriguez, 2006). All of the foregoing enables the firm to have a comparative advantage over other firms in the same sector and geographic area (Berman *et al.*, 1999; Heikkurinen, 2010), positively influencing its reputation (Melo and Garrido-Morgado, 2012).

Implementing CSR initiatives is especially important for MNCs' reputation and public image (Fombrun, 1996). More specifically, loss of reputation for MNCs may be one of the greatest problems it can face (Levis, 2006), since MNCs are more visible and subject to greater stakeholder scrutiny (Christmann, 2004). Some studies suggest that institutional pressures have pushed MNCs to increase their social initiatives at both global and local level (Aguilera *et al.*, 2007). Global CSR initiatives include establishing standards related to safe working conditions, protection of minorities (Jamali, 2010) and preservation of the natural environment (Aguilera-Caracuel *et al.*, 2012). It is also important that MNCs' social commitment be in accord with local stakeholders' demands (Pedersen and Neergaard, 2009), that is, with the specific needs and circumstances of the territories in which they operate. For example, in South Africa it is essential to involve stakeholders in the fight against unemployment and AIDS (De Jongh, 2004). All such initiatives, at local and global level, enable stakeholders to protect and even improve their reputation (Kolk and van Tulder, 2010).

As a result, we can see reputation as an intangible resource (Heikkurinen, 2010) that organizations use to improve their image and reinforce their brand (Porter and Kramer, 2006). Improvement in reputation can result from implementing practices connected to CSR that can facilitate achievement of a sustainable competitive advantage (Melo and Garrido-Morgado, 2012). Based on the foregoing arguments, we propose that implementation and development of initiatives that improve MNCs' social performance and that attend to the demands of the different stakeholders will contribute to improving MNCs' reputation:

H2. Social performance of MNCs is positively related to their reputation level.

2.4 Mediating role of the MNC's social performance

As we argued above, MNCs with a high level of geographic international diversification operate in the presence of a broader group of stakeholders and thus suffer greater public scrutiny. Operating in many markets can create an opportunity to extend their social initiatives throughout their organizational framework (McWilliams and Siegel, 2001). Other studies show that one of the strategies most relevant for MNCs consists of developing ethical management practices linked to social development and very closely linked to obtaining a sustainable reputation – practices such as improving labour conditions, organizational climate and other measures outside the firm with repercussions in the areas of the environment and cultural and socioeconomic progress in specific regions (Park *et al.*, 2015; Park and Ghauri, 2015). All of the foregoing can give these organizations strong credibility, especially in their social sphere, greatly benefitting their reputation.

Based on these arguments, and considering the hypotheses presented above, we propose that social performance plays a mediating role between geographic international diversification and the MNC's reputation. That is, social performance is the way in which highly diversified MNCs can improve their reputations in the different markets in which they operate:

H3. MNCs' social performance mediates the relationship between geographic international diversification and reputation level.

3. Sample and variables

3.1 Sample

We tested the hypotheses on a sample of US MNCs from the chemical (SIC 28), energy (SIC 29) and industrial machinery (SIC 37) sectors. These three activity sectors typically have great environmental impact, with significant repercussions in the social arena. In fact, they are activity sectors relevant for analyzing the impact of CSR practices on organizations with international presence (Christmann, 2004). The choice of firms with headquarters in the USA is especially relevant in this study because we analyze firms that usually have a significant impact on social, environmental and international issues.

Starting from the information available in Standard & Poor's (Capital IQ) database, we perform simple random sampling to select a total of 100 firms from the chemical sector, 100 from the energy sector and 100 from the industrial machinery sector. The final sample included a total of 113 MNEs and 672 observations over a period of six years (2005-2010). We also obtained the financial information from Standard & Poor's (Capital IQ) and draw the information on social performance from the KLD database. Table I presents the methodology used in the study.

3.2 Variables

Social performance of the firm. We obtained the different CSR policies and practices in the sample of firms in this study from the KLD database, created by the firm Kinder, Lydenberg, Domini. KLD provides a ranking of firms based on evaluation of a series of dimensions in the social arena. This study includes the social dimensions that play an essential role in establishing relationships with the different interest groups (McWilliams and Siegel, 2001). Based on the proposal of Waddock and Graves (1997), we used the following indicators: relationships with the local community, relationships with women and disadvantaged groups, relationships with employees, impact on the natural environment and socially responsible characteristics of the products that the organizations offer. KLD assigns each of the five indicators of CSR a point value ranging from +2 to -2, where +2 is evident strength, 0 a neutral position and -2 evident weakness. They then calculate the

Methodology	Panel data: linear regression (fixed effects model)
Country of firm headquarters	USA
Activity sectors	3 sectors: chemical, energy and industrial machinery
Study sample	113 MNCs and 672 observations
Distribution of MNCs by sector	53 MNCs from the industrial machinery sector (279 observations) 40 MNCs from the chemical sector (260 observations) 20 MNCs from the energy sector (113 observations)
Period of analysis	2005-2010 (6 years)
Information sources	Financial and sales information by region: Standard & Poor's (Capital IQ) database Information on corporate social responsibility (social performance): KLD database

Table I.
Summary of methodology

overall value of the variable “social performance of the firm” using the arithmetic means of the values of the five practices for each observation in the sample. A broad range of prior studies use KLD (Servaes and Tamayo, 2013; Waddock and Graves, 1997). KLD uses a great variety of sources to measure and evaluate the socially responsible behaviour of the firm. On the one hand, it includes annual information from the firm drawn from a questionnaire on the firm’s social responsibility practices. It also gathers information on annual accounts, quarterly reports and other reports related to the responsible initiatives that the firm develops. Further, KLD obtains information from external sources, such as articles from the economics and business press (*Fortune*, *Business Week*, *Wall Street Journal*, among others), surveys and internet. Based on this information, we believe that KLD’s measure does not evaluate firms starting from either stakeholders’ or managers’ perceptions but uses internal and external sources to increase objectivity.

International diversification. Prior studies conducted in the area of international business use the regional entropy index (REI) to measure the degree to which a firm operates in different markets (Hitt *et al.*, 1997). The following equation defines this index:

$$REI_j = \sum_{i=1}^n P_{i,j} \times \left(\text{Ln} \frac{1}{P_{i,j}} \right)$$

where $P_{i,j}$ refers to the percentage of sales of firm j in a region i , and $\text{Ln}(1/P_{i,j})$ represents the weight assigned to each region. The recent literature on international diversification widely accepts this measure from Hitt and colleagues (e.g. Yeoh, 2004).

Reputation of the MNC. To measure the MNC’s reputation, we used the “Fortune Corporate Reputation Index”. We obtained the data on reputation from the survey *Fortune* “American’s Most Admired Corporations”, based on the responses of approximately 10,000 executives, directors and financial analysts who evaluate firms in their sector in eight dimensions – use of assets, financial solvency, respect for environment and community, people development, degree of innovation, value of investment, management quality and product quality. A broad range of previous studies use *Fortune*’s measure of reputation (e.g. Philippe and Durand, 2011).

In addition, we incorporated three control variables – activity sector, firm size and financial performance.

Activity sector. To consider the possible effect of industry type on the sample of firms, we incorporated two dichotomous variables for two of the three activity sectors – industrial machinery and chemical.

Size. Size can positively influence reputation (Deephouse and Carter, 2005), visibility and relationship to the environment (Deephouse, 1996). We use the figure for total sales (operating revenue) from each MNC, including all of its business units.

Financial performance of the MNC. Implementing initiatives on social issues can affect the firm’s reputation not only directly but also indirectly; good reputation can drive good financial performance (e.g. Berman *et al.*, 1999; Berrone *et al.*, 2007). We use the ratio of profitability over total assets (Bansal, 2005).

Table II shows the variables used in the empirical analysis.

4. Results

We performed static analysis of the panel data. This analysis takes into account unobservable heterogeneity, determining whether to include fixed or random effects in the model. Whereas the fixed effects estimator assumes that unobservable individual effects are fixed parameters to calculate using correlations with regressors, the random effects model considers the firms chosen to constitute a representative sample, incorporating the

Variable name	Measures
<i>Control variables</i>	
Industrial machinery sector	Dichotomous variable (0 = does not belong to sector; 1 = belongs to sector)
Chemical sector	Dichotomous variable (0 = does not belong to sector; 1 = belongs to sector)
Firm size	Sales volume (billing) of MNC
Financial performance	Profitability over total assets (Bansal, 2005)
<i>Independent variables</i>	
Social performance of the MNC	Indicators obtained from the KLD database, considering criterion proposed by Waddock and Graves (1997): Relations with the local community Relations with women and disadvantaged groups Relations with workers Impact on the environment Socially responsible characteristics of the products the firm offers
Geographic international diversification	Regional entropy index (Hitt <i>et al.</i> , 1997)
<i>Dependent variable</i>	
Reputation	Overall point value assigned by the <i>Fortune</i> database

Table II.
Description of variables used

unobservable individual effects as stochastic and not correlated to the regressors included in the error term (Hausman, 1978).

We performed the Hausman test to determine whether to apply fixed or random effects. The null hypothesis supports the conclusion that there is no difference between the fixed and random estimators. Cases that reject the null hypothesis thus use fixed effects (Hausman, 1978). Based on this logic and our rejection of the null hypothesis, we chose the fixed effects model.

Table III presents the descriptive statistics and correlations among all variables used in the analysis.

Finally, Table IV shows the regression analysis using the fixed effects model. The resulting variance inflation factors (VIF) below 5 indicate that there are no problems of multicollinearity among the variables used. We standardized the values of the variables to facilitate the analysis (Hair *et al.*, 2009). The model shows good fit, which the R^2 within value and the F-statistic support.

As we observe in Table IV, international diversification has a positive and significant effect on the firm's reputation in Model 1 ($b = 0.31$, $SE = 0.07$; $p < 0.01$). This direct effect does not, however, consider one of the key aspects analyzed in this study: the mediating role of social performance.

	Mean	SD	1	2	3	4	5	6
1. Social performance of MNC	0.11	0.5	1					
2. Industrial machinery sector	0.43	0.50	-0.01	1				
3. Chemical sector	0.41	0.49	0.01	-0.72***	1			
4. Firm size	21.45	45.34	0.05	-0.04	-0.01	1		
5. Financial performance	0.24	0.36	0.06*	-0.10**	0.10**	0.10**	1	
6. Geographic international diversification	0.6	0.43	0.26***	0.03	0.03	0.02	0.15***	1
7. Reputation	0.29	0.39	0.32***	0.02	0.03	0.02	0.17**	0.35***

Notes: Number of observations (n) = 672; number of groups (MNCs) = 113. * $p < 0.055$; ** $p < 0.01$; *** $p < 0.001$

Table III.
Descriptive statistics and correlations

Dependent variables (horizontal)	Model 1 Reputation (direct effect)	Model 2 Social performance (<i>H1</i>)	Model 3 Reputation (<i>H2</i>)	Model 4 Reputation (<i>H3</i>)
Constant	1.57 (2.23)	1.24 (1.80)	1.11 (1.93)	1.21 (2.11)
Industrial machinery sector	2.46 (4.24)	1.21 (3.22)	2.13 (3.36)	2.23 (3.12)
Chemical sector	-16.17 (9.56)	-18.37 (9.67)	-12.11 (9.87)	-13.67 (9.97)
Firm size	-0.24 (0.30)	-0.14 (0.30)	-0.17 (0.28)	-0.14 (0.20)
Financial performance	0.09* (0.07)	0.08* (0.07)	0.09 (0.07)	0.09* (0.07)
Geographic international diversification (indep. var.)	0.31** (0.08)	0.42*** (0.07)		0.10* (0.08)
Social performance (indep. var.)			0.29*** (0.06)	
Social performance (mediating var.)				0.21** (0.08)
Hausman Test	9.55*	10.05*	9.55*	9.55*
Number of observations	672	672	672	672
Number of groups (MNCs)	113	113	113	113
R^2 within	0.18	0.27	0.19	0.24
F	10.71**	12.36**	10.85**	11.34**

Table IV.
Results of the fixed
effects linear
regression model

Notes: The table includes coefficients of the regression model (estimators); Standard deviations are included in parentheses. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Model 2 shows that greater geographic international diversification improves the firm's social performance, fulfilling *H1* ($b = 0.31$, $SE = 0.07$; $p < 0.001$).

Model 3 shows that the firm's social performance has a positive effect on improving reputation levels, likewise confirming *H2* ($b = 0.42$, $SE = 0.09$; $p < 0.001$).

Finally, *H3* predicts that social performance mediates the relationship between geographic international diversification and firm reputation. Model 4 confirms this mediating effect through the PROCESS macro, installed in the programme SPSS (Hayes, 2013). We can thus determine the direct effect (geographic international diversification – reputation) and the mediating effect of our model (geographic international diversification – social performance – reputation) independently. The results support mediation if the indirect effect is significant. To determine this, we use the Sobel test under conditions of normality. The direct effect is 0.10 ($b = 0.10$, $SE = 0.10$, $p < 0.055$), and the indirect effect is significant, yielding the value 0.21 ($b = 0.21$, $SE = 0.10$, $p < 0.01$). The total effect is thus 0.31 (see Model 1: $b = 0.31$, $SE = 0.07$; $p < 0.01$).

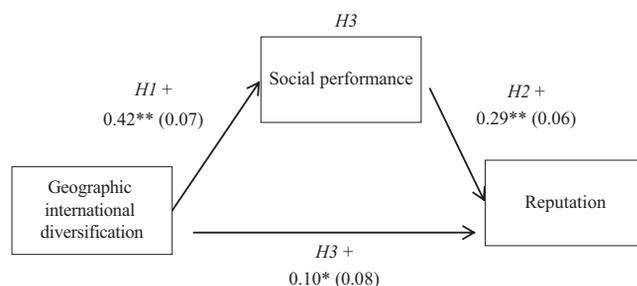
As to the indirect effect, we observe that the parameters BootLLCI (0.05) and BootULCI (0.23) do not include the value 0 in this interval, indicating the significance of the other indicator that supports the indirect effect (Preacher and Hayes, 2004, 2008).

Based on these data, we can conclude that social performance mediates the relationship between geographic international diversification and reputation. In Model 4, however, the direct relationship between international diversification and reputation continues to be significant, although to a lesser degree ($b = 0.10$, $SE = 0.10$, $p < 0.055$). Finally, social performance partially (not totally) mediates the direct relationship mentioned. Using the procedure developed by Frazier *et al.* (2004, p. 231), we see that the firm's social performance mediates approximately 67.7 per cent of the total effect of international diversification on reputation.

Figure 1 provides a summary of the mediation model explained above.

5. Conclusions

Using stakeholder theory, this study analyses whether a high degree of international diversification in the MNC (in terms of presence in different countries and regions) encourages improvement in its social performance. The study also sheds light on the debate



Notes: Standard deviations in parentheses. * $p < 0.055$; ** $p < 0.01$

Figure 1. Mediator model

concerning CSR and MNCs' reputation. Finally, we analyze the effect of international diversification on reputation, taking into account the mediating role that the firm's social performance plays.

First, we find that a high degree of geographic international diversification enables the MNC to improve its social performance. Improvement in its visibility through contact with a heterogeneous group of stakeholders with diverse needs located in markets with different institutional profiles motivates such diversification (Aguilera-Caracuel *et al.*, 2013). MNCs must take this fact into account when performing management practices that bring credibility and respect from stakeholders (Park *et al.*, 2015). Second, the MNC will be able to decrease risks that derive from failure to comply with legislation and from conflicts with associations and firms in the sector (Deckop *et al.*, 2006) and, ultimately, to improve its corporate image, a result that translates to the other organizational units (headquarters and subsidiaries) (McWilliams and Siegel, 2001).

Second, the results show that improvement in the MNC's social performance positively affects its reputation. The literature shows that MNCs, in contrast to local firms, are more sensitive to socially responsible and irresponsible behaviour (Mahmood and Humphrey, 2013). MNCs sometimes receive accusations of opportunistic behaviour for locating their factories in countries with questionable respect for human rights and for exploiting the natural resources of the most disadvantaged countries and those with laxer regulations. Yet others consider MNCs as pioneers in establishing ethical and moral standards (Engle, 2007). The current study highlights the mutual benefits involved in implementing CSR activities, both for MNCs and for the communities in which they operate, since the MNCs can improve their reputation and public image, while the communities obtain support for sustainable development of their territory.

Third, we conclude that internationalization of the MNC, which we understand as the number of countries and regions in which the MNC has a presence, positively influences the MNC's reputation, to a large extent through the mediating role that social performance exerts. In other words, the primary way for MNCs to gain in reputation is through local and/or global social initiatives in the different markets in which they operate and by interacting with the various stakeholders. This gain in reputation occurs primarily because the MNC can meet the expectations on social issues of numerous stakeholders from different contexts (local, national and global) and can thus both attend to the needs of a specific local community and create its own standards, which it can extend to different contexts (Jamali, 2010). While they can definitely encounter difficulty in initiating relationship with specific stakeholders (Strike *et al.*, 2006), MNCs can minimize all of these efforts by managing the different relationships correctly, fostering the MNC's communication capability (Hah and Freeman, 2014). The MNC's internal organizational structure may be quite complex in many cases, especially if it has numerous organizational units located in markets with very

different institutional profiles. The MNC can overcome this issue, however, if it is sufficiently flexible to adapt, when necessary, to specific local contexts and specific social demands. Finally, considering that MNCs increasingly receive more pressure from stakeholders to perform responsible behaviours, especially in the social and environmental spheres (Kang, 2013), a high degree of geographic international diversification establishes an ideal scenario to enable reflection of their social initiatives in significant increase in their reputation, in both local and transnational contexts. In sum, social performance constitutes the main vehicle by which highly diversified MNCs can improve their reputations in the different markets in which they operate.

Our paper has implications for management and public powers. Managers of MNCs should pay attention to capturing the different needs and expectations of the stakeholders in the different markets in which the organization operates. They should distinguish the needs of more specific local environments rather than more global needs that they can satisfy by creating standards internal to the MNC itself (Aguilera-Caracuel *et al.*, 2013). They should also particularly stress the social and environmental spheres, as MNCs can play a significant role in this domain, perhaps becoming precursor-drivers of economic and sustainable development for the regions (Valente and Crane, 2010). Finally, they should both make an effort to ensure that all organizational levels and workers at the MNC develop communication capabilities that permit a fluid relationship with stakeholders and that can obtain a licence to operate in foreign markets (Rugman and Verbeke, 1998) to overcome institutional barriers (legal and cultural, among others).

Public and regulatory powers should be able to create certain common game rules for all organizations in the different countries, independently of their degree of economic, legal and cultural development (Aguilera-Caracuel *et al.*, 2013). All of the foregoing is very useful when avoiding opportunistic behaviour from organizations, particularly international ones, in the social and natural environments. In addition to the more specific ongoing local needs in some individual communities, other communities tend increasingly to become standardized (e.g. relative to human and minority rights or minimal international environmental standards that protect against abusive practices), making it easier to satisfy these requirements at the global level. By way of example, we would highlight the United Nations Global Compact, based on ten international principles on issues of human rights, labour regulations, environment and anticorruption, to which over 2,500 firms adhere.

This study has a series of limitations. First, all MNCs in our sample have their headquarters in the USA. Since some of the directives from company headquarters influence some MNCs' policies and management practices (Kostova *et al.*, 2008), it would be interesting to incorporate MNCs that have sites in other countries to take this possible effect into account. Second, we measure social performance using the KLD database, widely used in the prior academic literature (McWilliams and Siegel, 2001). Future research could complement and contrast our these measures with questionnaires and surveys addressed to managers and workers in the MNCs. Research could also consider objective measures of CSR, such as those developed by the United Nations World Treaty based on four fundamental pillars – human rights, labour regulations, environment and fighting corruption. Third, we measure the firm's reputation using the *Fortune* database, based on the perceptions that managers and other expert sector agents have of the firm's visibility and importance in society. Future research can complement this measure with construction of an index that includes the number and type of news items that firms in our sample received in order to capture the repercussions of this news in society and to strengthen the indicators of reputation (Carter, 2006; Philippe and Durand, 2011).

Finally, performing this study opens a path to new and interesting lines of research with greater utility for the academic community, managers and businesspeople, as well

as public institutions. First, it would be interesting to undertake studies using theories from social psychology as the reference framework. These theories have great capability to explain why specific stakeholders become involved in socially responsible initiatives, the motivational structures that foster socially responsible and irresponsible behaviour and analysis of the processes by which CSR shifts from being a set of organizational practices that develop as the result of pressure from interest groups to become a set of practices that represent values that the firms and their stakeholders share (Aguinis and Glavas, 2013; Rupp *et al.*, 2013). Second, it could be important to take into account the role that MNCs perform in developing countries and regions (Hitt *et al.*, 1997) and the differing impact of these roles on both local and global reputation (that of the entire MNC as a whole). Third, future studies could take into consideration in the context of MNCs the internal management of human resources in the different locations and their influence on improvement of the MNCs' levels of social performance and reputation.

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Marketing and social networks: a criterion for detecting opinion leaders

Marketing and
social
networks

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Abstract

Purpose – The purpose of this paper is to use the practical application of tools provided by social network theory for the detection of potential influencers from the point of view of marketing within online communities. It proposes a method to detect significant actors based on centrality metrics.

Design/methodology/approach – A matrix is proposed for the classification of the individuals that integrate a social network based on the combination of eigenvector centrality and betweenness centrality. The model is tested on a Facebook fan page for a sporting event. NodeXL is used to extract and analyze information. Semantic analysis and agent-based simulation are used to test the model.

Findings – The proposed model is effective in detecting actors with the potential to efficiently spread a message in relation to the rest of the community, which is achieved from their position within the network. Social network analysis (SNA) and the proposed model, in particular, are useful to detect subgroups of components with particular characteristics that are not evident from other analysis methods.

Originality/value – This paper approaches the application of SNA to online social communities from an empirical and experimental perspective. Its originality lies in combining information from two individual metrics to understand the phenomenon of influence. Online social networks are gaining relevance and the literature that exists in relation to this subject is still fragmented and incipient. This paper contributes to a better understanding of this phenomenon of networks and the development of better tools to manage it through the proposal of a novel method.

Keywords Social network analysis, Marketing, Influencers

Paper type Research paper

1. Introduction

Consumer opinions and behaviors are affected by complex sources of social influence, where online social networks become a new field in which brands and companies must redefine their relationship with their consumers, forcing marketing and advertising professionals need to rethink the paradigms of conventional marketing (Benedetti, 2015).

Prominent leaders and figures naturally emerge within these networks and gain special relevance and interest from a marketing perspective because they have the potential to influence buying behavior in both their first-order contacts and their broad network. The usefulness in identifying these prominent actors and being able to selectively act on them is undoubted and opens new possibilities for the relationship of a brand with its target public. Traditional marketing is complemented by the possibility of operating directly on these actors and generating a multiplier effect based on electronic word of mouth (WOM).

JEL Classification — M31, L86

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As a relatively new and constantly evolving phenomenon, the study of online social networks involves several areas of study. Literature reviewed is incipient in relation to the approach of online social networks from the perspective of social network analysis (SNA) and this work aims to contribute to the understanding of diffusion in online social networks by using the tools provided by marketing and SNA.

In that sense, through exploration, and using concepts and tools from SNA, a method to detect individuals that can potentially influence the behavior, brand perception or purchase decision of other actors within an online social network is suggested.

The first part of this contribution reviews theoretical concepts that relate marketing and SNA, including the study of WOM diffusion, the role of influence in the purchase decision, in the context of online social networks in particular.

In the second part, a method to detect individuals with the potential to efficiently spread a message in relation to the rest of the community based on SNA, particularly a combination of centrality metrics, is proposed.

Then, a case study is presented. The proposed method is applied to a real online community with the objective of detecting actors with potential influence. This selection is then analyzed by variety of tests to determine the effectiveness of the proposed model.

2. Literature review

2.1 WOM in marketing

Consumer rationality in the decision making of buying a product or service is limited by the available information, the individual limitations in processing that information and the time available to do so. This is why people often make purchase decisions that may not be optimal given the circumstances, but satisfy them to some extent (Simon, 1982).

Potential consumers of products and services have sought and valued recommendations through references and acquaintances that have previously made a purchase. Likewise, those who offer these products have turned and validated the role of tools as advertising in all its forms in an effort to generate awareness and influence a purchase decision.

Traditionally the communication of a brand with its potential consumers has been done in a unidirectional way, seeking the transmission of an advertising message with a persuasive purpose, but neglecting feedback and interaction among its consumers. This latter role that has been reserved at best, to market research and intelligence or niche practices (Bacile *et al.*, 2014; Benedetti, 2015).

WOM has been extensively studied and is recognized as a key influencing factor in consumer decisions (Lang and Hyde, 2013; King *et al.*, 2014). WOM has a positive effect on the consumer's relationship with the brand, and on other marketing outcomes (Hudson *et al.*, 2016; Wang and Gon Kim, 2017). Traditional advertising has recognized its effectiveness and it is a key reason for the recruitment of celebrities or opinion leaders to endorse products and services, seeking an emotional or rational connection with a target audience.

Individual propensity and motivation to engage in WOM have been extensively studied and at least eight motives have been identified. Four of them are positive, and the rest are negative (Sundaram *et al.*, 1998).

The relationship between traditional advertising and WOM and its effects on sales have not yet been extensively studied, but at least one work suggests that there is great interdependence between both platforms, having both complementary and non-substitutive roles in consumer behavior (Stephen and Galak, 2010). Hewett *et al.* (2016) postulate that the nature of brand communication has changed with the advent of online technologies, and quantifies the mutual influence in communication between companies, consumers and traditional media, in terms of volume and value, and its effect on consumer sentiment and business results.

2.2 Online social networks

The advent of internet, hyperconnectivity, and Web 2.0 has generated a paradigm shift. A dialogue emerges within the community of potential consumers of a brand instead of simply being the recipient of a message. This interaction profoundly affects the perception and purchasing decisions of the individuals (Benedetti, 2015).

Thanks to internet, consumer markets are becoming better informed, smarter and more demanding of the qualities that are missing in most business organizations (Weinberger *et al.*, 2000).

Online social networks are a novel and transformational phenomenon in the way we relate, think and exchange experiences as a human group. Nowadays the penetration and online time dedicated to the use of networks is massive and has become naturalized, favored by the ubiquity and variety of technological platforms that support these networks, the improvement in communications and the technification of society. Facebook, for example, has 1.71 billion active users worldwide, more than 90 percent of them connected through mobile platforms (Facebook Newsroom, 2016).

Albeit the wide variety of online social networks that exist both in terms of characteristics and purpose, they all have a common feature being that they depend fundamentally on user generated content. This content is often related to brands and has the potential to influence consumers' perception of the brand (Smith *et al.*, 2012; Nam and Kannan, 2014).

The reach of a campaign in social networks happens through replication amid the network users. The price to pay is that the original message is likely to be altered and increased (Peters *et al.*, 2013). Given the right conditions, a message can become viral, implying that it will be replicated and disseminated quickly and without control (Berger and Milkman, 2012). Several models have been elaborated to predict the scope of a message once it takes viral characteristics based mainly on time series analysis and stochastic processes (Subbian *et al.*, 2017).

In any case, the engagement of a social network user through a like, a comment, a share or a retweet amplifies the relationship of the user with the brand. How to increase the chance of an online publication to generate engagement and interaction with the brand has been studied from the perspective of communication design (de Vries *et al.*, 2012) and parasocial interaction (Labrecque, 2014) among other techniques.

Propensity to interact in online media has been defined as a personal trait and scales have been developed to measure it (Blazevic *et al.*, 2014; Hollebeek *et al.*, 2014). Personal attachment to online social media has also been positively related to consumer behaviors and brand advocacy. This makes some people a desirable target to maximize the effectiveness and efficiency of campaigns designed for social media (VanMeter *et al.*, 2015).

The concept of electronic WOM becomes paramount. Social networks become hubs in which users engage through comments and expressing attitudes and feelings that they are willing to share on topics of interest. This has a critical impact in brand image and awareness of a brand (Jansen *et al.*, 2009).

Several previous studies suggest a greater strength of user generated content in generating interest in a topic, surpassing commercially generated content (Bickart and Schindler, 2001; Gauri *et al.*, 2008), as well as the effect of WOM on trust, loyalty and purchase intent (Awad and Ragowsky, 2008; Chen *et al.*, 2011; Pavlou and Ba, 2002), and the importance of user communities in the generation of brand value (Nambisan and Baron, 2007).

People trust on disinterested online opinions. They have the effect of generating knowledge about products and services, suggesting that companies should focus on mechanisms that facilitate WOM (Duan *et al.*, 2008).

According to a Nielsen study on 30,000 internet users in 60 countries around the world, eight out of ten people rely on product or service recommendations made by acquaintances,

and two-thirds of respondents rely on third party reviews posted online. Trust in traditional paid media, such as TV spots, newspapers, magazines and even online media such as sponsored online videos, search advertising or social networks advertising fall well below (The Nielsen Company, 2015).

2.3 *Influencers and opinion leaders*

Within these networks, some individuals stand out and gain interest from a marketing perspective because they have the potential to influence buying behavior in both their first-order contacts and in the rest of their network.

Influence has been studied in marketing literature from various perspectives. Seminal works as the two-step flow communication model, postulates that people follow opinion leaders who in turn are influenced by the media (Katz and Lazarsfeld, 1955). More recently, a model of influence networks was proposed that extends the original two-step model proposing that influence is not unidirectional but can flow in any way, and also ponders the role of easily influenced individuals as multipliers in the diffusion of innovations (Watts and Dodds, 2007).

Influential individuals have been categorized as hubs, as they have a large number of social links, and classified into innovators or followers. Both classes have a significant role in the diffusion of an innovation, and the rate of adoption of an innovation by these hubs allows to make predictions about the success of a campaign in its early stages (Goldenberg *et al.*, 2009).

The diffusion of innovations model studies and classifies individuals in relation with their permeability and speed to adopt innovations. Early adopters have a high degree of opinion leadership in social systems and facilitate the diffusion of a product or message (Rogers, 1983).

It is also relevant to the definition of the market maven, as an individual who willingly seeks, owns and shares general information about products and markets. This makes them an attractive target of marketing efforts to accelerate the diffusion of a message (Feick and Price, 1987).

In modern marketing a company's communication cannot depend solely on its own efforts and must take advantage of the power of WOM. To generate and maintain influence within social networks, brands must identify themselves and attract user groups that connect with the brand and act on their behalf. These groups do not necessarily have to be large but they should be influential (Peters *et al.*, 2013; Risselada *et al.*, 2014). Therefore, it is essential to generate relevant content for alpha consumers who are the ones who will propagate the message through the network (Vaz, 2011).

Due to the variety of approaches that address this phenomenon in literature, the terms used to designate individuals that can generate contagion efficiently are different. These terms are often used interchangeably and to refer to individuals who share totally or partially the same set of features.

The advantages of identifying and engaging influential actors within a complex social network include, among others:

- Market research: it may be a good idea to involve influencers in testing concepts or products, as they will influence future adoption by other users or consumers.
- Product testing: likewise, product sampling to these actors can provide support in a new product launch through electronic WOM.
- Direct advertising (Hawkins *et al.*, 1995).

Other advantages include:

- Public relations events: involving opinion leaders in these activities is generally accepted as a good source for positive WOM, keeping the budget for these actions under control.

- Damage control: it may be useful to engage the most influential players in order to moderate and minimize damages to the brand in a crisis scenario.

The process of engaging a group of individuals picked by some particular criterion with the purpose of achieving a multiplier effect in a broader network is known as seeding. Seeding strategies have been used to accelerate the diffusion of information and adoption of products by generating contagion toward potential consumers. The value of seeding programs derives from the interaction of two mechanisms: market expansion and consumption acceleration (Libai *et al.*, 2013).

Various methods to optimize the selection of individuals for a seeding strategy have been proposed. Chen *et al.* (2010), Aral *et al.* (2013), Kempe *et al.* (2015) and Aghdam and Navimipou (2016) address the issue as an optimization problem from an experimental approach. For certain networks, metrics derived from users' attributes and activities have been developed to estimate indicators of popularity and influence (Grosseck and Holotescu, 2009).

This paper proposes a methodology to identify influential actors in online social networks, which is determined by the engagement of these actors through comments. The content of the comments is not analyzed, beyond a simple semantic analysis. Nor it is tried to assess if these individuals exerted influence in the sense to affect the behavior of other actors through their interventions. For this reason these individuals will be referred to as "potential influencers."

To this effect, potential influencers are defined in the context of this work as "those individuals located in a position within the online social network from which they could potentially achieve greater outreach of the diffusion of a message deriving out of their connection structure."

2.4 SNA

Online social networks are themselves social entities that function as an aggregate of the behaviors of their undivided components. SNA has been applied in many fields of science (Molina, 2004) and the potential of its use in marketing studies is enormous. Networks can be classified according to their morphology into at least six regular structures varying in number of clusters, cohesion and interconnectivity (Smith *et al.*, 2014). Likewise, each of the members of the network can be analyzed individually from metrics that describe their position within the network relations structure, such as centrality metrics (Hansen *et al.*, 2011).

Previous studies suggest that the structural situation of an actor within a network is a good indicator of opinion leadership. SNA can detect the central actors of a network and these actors will tend to be opinion leaders within that network (Van der Merwe and van Heerden, 2009).

Despite the importance of these individuals, the bulk of research in relation to influence has focused on their personal, social and behavioral traits but not on the relationships they have within a social network (Balkundi and Kilduff, 2006; Tucker, 2008).

The application of SNA to marketing in online social networks is still incipient. Because it is a relatively new phenomenon, the specific literature of this particular point is still scarce (Paquette, 2014).

This contribution explores the possibility of detecting potential influencers in online social networks through the use of tools derived from traditional SNA, in particular centrality metrics.

3. Methodology

3.1 Model of detection of potential influencers

SNA provides several methods that can be used to describe and weigh different characteristics of the network in general, the individuals that make it up, and the

connections or links between these individuals. The most relevant in relation to this work are metrics that refer to attributes of individuals in relation to the rest of the network:

- Degree centrality, which counts how many direct connections each individual has with other actors within the same network. It is a local measure of the importance of a node.
- Eigenvector centrality, also ponders the quality of these connections: an actor with the same degree centrality that another can be more influential within a network if its connections are with actors who are in turn well connected. Information about the whole structure of the network is required for its estimation as eigenvalues and eigenvectors associated to the network adjacency matrix are estimated, obtaining information on the direct and indirect importance of each node in particular. It is a global measure of the importance of that actor in the network.
- Betweenness centrality measures the number of paths that pass through a node to reach any other node in the network with respect to the total number of paths in the network that allow these same nodes to connect, showing the extent to which an actor is on the shortest path between two other nodes. It can be thought of as a “bridge” within the network, in which the actor takes a strategic position in the flow of communication between different groups. An individual with a high betweenness centrality can present the shortest path for the diffusion of a message through an extensive network. It is also a global measure of the importance of that actor in the network.

Figure 1 shows clearly the difference between these metrics, pointing out the individuals with the best score for each of them:

The highest degree centrality individual is “j” because it has the most connections to other vertices (total of 7). Highest eigenvector centrality is achieved by “d” because it has quality connections with actors who in turn are well connected. The individual with the highest betweenness centrality is “h.” It has few connections, but it plays a vital role as the only link between three separated clusters: If “h” disappeared, groups “a, b, c, d, e, f, g,” “i, j, k, l, m, n, o, p, q, s” and the individual “r” would lose contact with each other.

Betweenness and eigenvector centralities have very desirable properties for the location of an influencing potential. A combination of both features would simultaneously include those actors who connect dispersed groups through highly connected actors. *A priori*, the potential for diffusion is very large. Modern social networking theory suggests that individuals who are central to their close networks and have links to outside networks

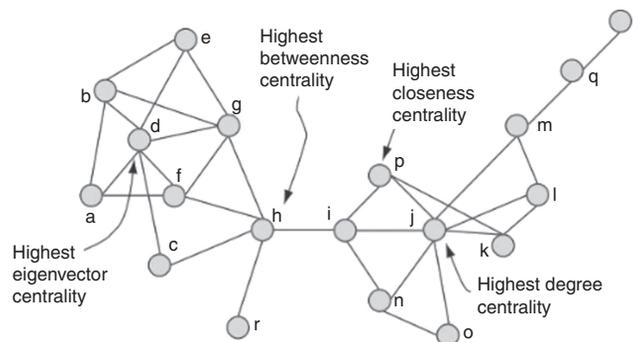


Figure 1.
Different measures of centrality applied over an example network

Source: Ortiz-Arroyo (2010)

usually acquire a combination of power and superior knowledge. Leaders do not necessarily have to be central to of each important network as this would be at expense of a marginal position in another network. There is a trade off in the construction of this social capital (Balkundi and Kilduff, 2006).

Our proposal is an adaptation of the matrix model presented by Scoponi *et al.* (2016) to classify the actors of a social network in terms of their level of influence through two complementary metrics. Members of the network that simultaneously meet the highest values of both betweenness and eigenvector centrality should be classified as potential influencers as shown in Figure 2.

This matrix represents a two-dimensional scatter plot in which the individual components of a network are plotted according to their betweenness centrality (x -axis) and their eigenvector centrality (y -axis). Then, according to a relevant criterion to determine thresholds in each dimension, this plane is divided into quadrants, allowing classifying every actor into four different groups:

- (1) potential influencers with a high degree of betweenness and eigenvector centrality;
- (2) brokers or individuals with high betweenness centrality and low eigenvector centrality;
- (3) actors with important connections, their low score in betweenness centrality suggesting a limited outreach to groups outside their local community; and
- (4) secondary actors.

For the case study, thresholds were defined in the 95th percentile of each one of these two dimensions. Consequently, 5 percent of the cases were selected in each one of the independent metrics, which when combined yield approximately 2.5 percent of the cases, as represented in Figure 3.

The selection criterion seeks to select users who can be considered a minority or elite in terms of their ability to efficiently diffuse a message within the network. The selection of too small group of influencers can make a marketing action lack the desired outreach or diffusion speed. Conversely, the selection of a very large group of influencers can produce decreasing and in some cases negative results (Aral *et al.*, 2013; Sela *et al.*, 2016).

It is important to clarify that when applying this method, thresholds should be adjusted according to the purpose of the analysis, the size and characteristics of the network, operational and budgetary constraints.

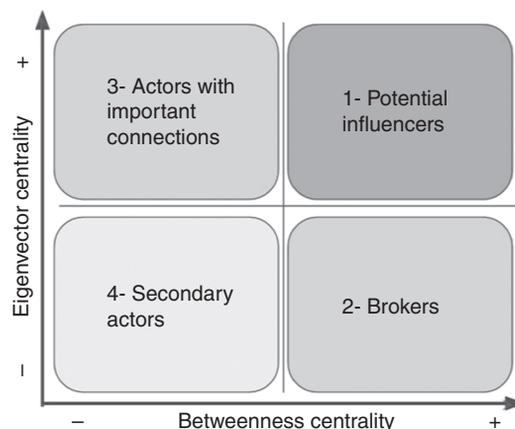


Figure 2.
Matrix to detect potential influencers within a social network based on the work of Scoponi *et al.* (2016)

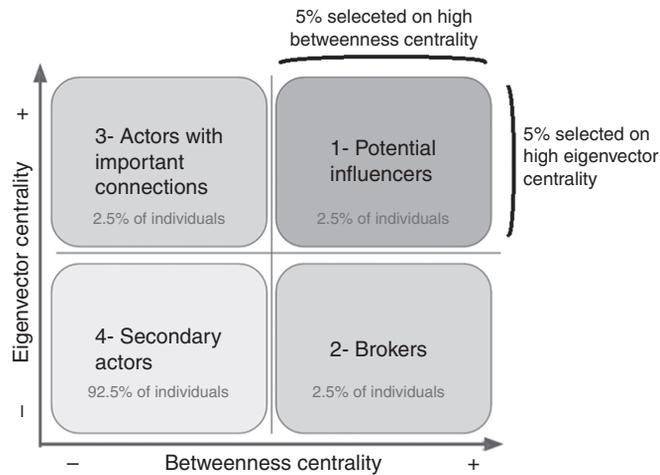


Figure 3. Matrix to detect potential influencers within a social network based on the work of Scoponi *et al.* (2016) with 5 percent thresholds

3.2 Selection of a SNA software and a case study

NodeXL (Smith *et al.*, 2010) was selected as the main tool to analyze the proposed case study over other SNA applications available in the market due to its versatility, analysis possibilities and import of popular social networks. NodeXL is an open source Excel template that features data import directly from the main social networks (Hansen *et al.*, 2011). NodeXL Pro version 1.0.1.354 was used for the development of this case.

For the selection of the case study, Facebook was selected among other online communities as being the most popular social network globally. In Argentina, Facebook has a penetration close to 50 percent of the total population (eMarketer, 2016) surpassing the regional average.

Facebook is a social network created in 2004 by Mark Zuckerberg and others. As of June, 2016, there were 1,710 million active users worldwide, more than 90 percent of them connected through mobile platforms (Facebook Newsroom, 2016).

As unit of analysis, the official Facebook fan page of the entity that organizes the “Maratón de Buenos Aires” (www.facebook.com/maratonbuenosaires/) was chosen. The Buenos Aires marathon is a sporting event that takes place annually in October in its full version of 42 kilometers and in September in the half marathon modality. Both races are very popular and the number of runners grows annually. In total, 27,822 runners registered in both events combined in 2015 (Frieni, 2016).

Fan page counted more than 58,000 followers in July 2016, and although it generates content and interaction with its community throughout the year, activity peaks occur on dates close to the main races. For this reason, it was defined as date range for the case study all the content generated in the page by the organizers and users between August 31, 2015 (one week before the half marathon) and October 17, 2015 (one week after the full marathon).

One of the reasons this community was chosen is the high level of community engagement and activity, allowing capturing as much activity as possible between users and user generated content regardless of the level of activity of the community administrator.

It was also chosen because of the potential utility of this research on the marketing of products and services generated around such an event for different stakeholders:

- The event organizer himself, to promote the event, expands his network of contacts, assess attitudes, opinions and feelings of their own community.
- Competing or similar events, to broadcast or promote their own activities efficiently through high potential diffusion actors in the running community.

- Manufacturers and marketers of sports apparel, to focus on promotional or merchandising campaigns ensuring maximum outreach with a limited budget, detect niches; boost the development of brands and product lines.
- Lodging providers and transportation services to detect and engage communities of foreigners attending the event, who may potentially require their services.

Facebook as an online social networking platform offers several interaction alternatives, each reflecting a different type of relationship between user and content. When analyzing a social network, each one of these interactions or the aggregation of them can be seen as links between people of different direction and intensity.

The interaction of this network par excellence is the “like,” which indicates that the user liked or considered interesting some content. The like is specially designed for mobile devices, allowing the user to reflect a reaction to content quickly and efficiently, both through the traditional “thumb up” icon and the “emojis” introduced in February 2016. The usefulness of Facebook’s organic likes as an indicator of an attitude or purchase intention toward a brand is challenged in recent publications (Mochon *et al.*, 2017; John *et al.*, 2017). The same ease of use that makes it so popular determines that likes are abused and are not generally considered as an indicator of a strong link (PewResearch Center, 2014). An additional problem is that its polarity cannot be analyzed: it does not indicate a positive or negative value, nor it does contain text that allows making that analysis.

“Shares” and “comments” on the other hand are more complex forms of interaction and indicate a greater engagement of the user with the content. Sharing involves replicating the content through the user’s own page, with the potential to replicate in turn to other users and grow exponentially (Subbian *et al.*, 2017). Commenting implies generating a text in the form of an opinion directly addressed to that content, or to comments generated previously in that content.

In many cases comments are trivial and will not generate dialogue among users. On the other hand, there are occasions in which users engage with content, giving it visibility, replicating, and augmenting by adding reactions and opinions. When that content becomes electronic WOM, and by analyzing the underlying structure of connections generated by the transmission of the message, potential influencers can be detected.

While NodeXL allows importing likes, shares and comments, it was observed that using the likes significantly increased the volume of imported data without adding value to the analysis. Therefore, in this case it was defined to use only comments as indicators of links between the individuals. Likes could potentially be added to the analysis by giving them a low weighting to reflect their lower information quality without completely discarding them. Surely this may be an aspect of this work to be developed in the future.

4. Results

4.1 Network analysis

A graph with 977 vertices or actors including the page administrator was obtained. These vertices are linked through 25,613 unique edges between them corresponding to comments, as seen in Table I.

Betweenness and eigenvector centralities are both measures of the individual nodes of the network and relate to the diffusion potential of a node. The values of the results obtained are shown in Figures 4 and 5.

The resulting graph, visualized with NodeXL according to a Harel-Koren Fast Multiscale layout (Harel and Koren, 2000) is presented in Figure 6, where each circle corresponds to a node or user of the network. The size and opacity of each user is proportional to their eigenvector centrality value, and the color corresponds to subcommunities automatically identified. These communities represent groups of nodes highly related to each other in communities or clusters technically referred to as modules. Specifically the algorithm used is

the one proposed by Clauset *et al.* (2004). The communities themselves are not studied in our work, although they could be addressed on future research.

From the application of the model of detection of influents proposed with quadrant thresholds defined, according to the detailed criterion, in 1,744.97 for betweenness centrality and 0.0035 for eigenvector centrality, 26 influential actors were obtained. This number does not include the user “Marathon of Buenos Aires (Official Group)” that belongs to the community manager.

Table I.

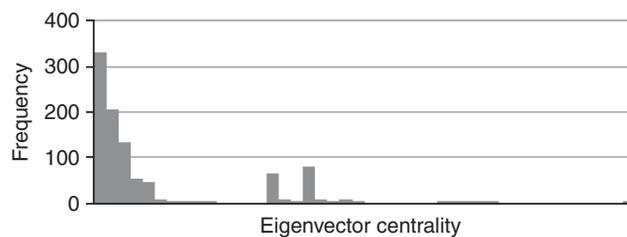
Oficial Maratón de Buenos Aires Facebook fan page analysis overall graph metrics for comments generated between August 31, 2015 and October 17, 2015

Graph metric	Value
Graph type	Directed
Vertices	977
Unique edges	25.613
Duplicate edges	17.774
Total edges	43.387

Source: Made with NodeXL www.smrfoundation.org/nodexl/

Figure 4.

Distribution of eigenvector centrality values for users of Oficial Maratón de Buenos Aires Facebook fan page based on comments generated between August 31, 2015 and October 17, 2015



Minimal eigenvector centrality	0.00008
Maximum eigenvector centrality	0.00868
Average eigenvector centrality	0.00102
Median eigenvector centrality	0.00046

Source: Made with NodeXL www.smrfoundation.org/nodexl/

Figure 5.

Distribution of betweenness centrality values for users of Oficial Maratón de Buenos Aires Facebook fan page based on comments generated between August 31, 2015 and October 17, 2015

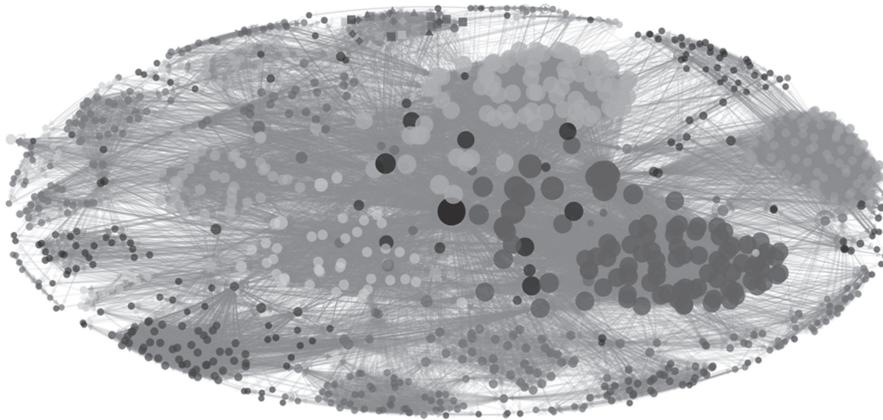


Minimal betweenness centrality	0.000
Maximum betweenness centrality	582,594.081
Average betweenness centrality	913,711
Median betweenness centrality	0.000

Source: Made with NodeXL www.smrfoundation.org/nodexl/

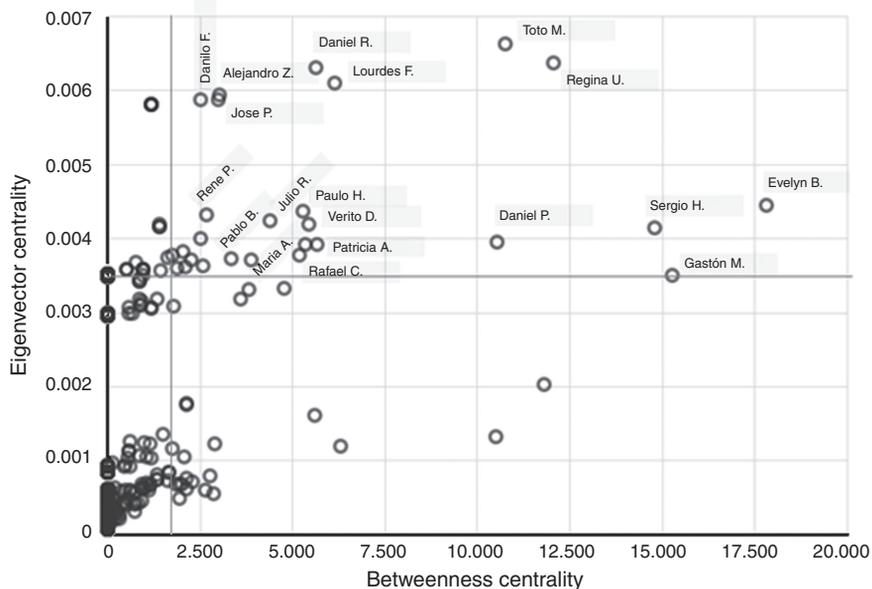
Figure 7 shows the results of the application of the model through the scatter diagram representing all the individuals that compose this network (except for the community manager), and the quadrant thresholds represented by red lines.

Figure 8 shows again a graph representing all the actors in this network with their relationships. Potential influencers are highlighted in red, whereas the rest of the users of the network are shown in light gray.



Source: Available at: www.smrfoundation.org/nodexl/

Figure 6. Oficial Maratón de Buenos Aires Facebook fan page graph made with NodeXL from comments generated between August 31, 2015 and October 17, 2015



Notes: Signs are shown indicating first name and first letter of the surname for several potential influencers. Quadrant thresholds are indicated with red lines. The fan page administrator is excluded. Elaborated in Microsoft Excel

Figure 7. Scatter plot representing users of the official Buenos Aires marathon fan page on Facebook between August 31, 2015 and October 17, 2015 according to their betweenness centrality (X-axis) and eigenvector centrality (Y-axis)

4.2 Performance of influencer detection model

The model performance was analyzed through different techniques. In a first instance, the average of comments received and issued by individuals selected by the model was compared vs unselected individuals and overall total. This information is presented in Table II.

The high number of comments both received and issued by the selected users is an indicator of the traffic generated by these actors within the network to which they belong and therefore the influence they have or is attributed to them. As shown in Table II, the total of comments in these users is 350 percent higher than the general average, indicating a higher level of activity.

Likewise, the average issued comments/total comments ratio is inferior in selected individuals with respect to the rest of the actors of the network indicating a multiplier effect in their interventions not present in the rest of the users, which is consistent with the definition of influencer proposed at the beginning of this work.

If each of the quadrants of the model is analyzed separately, it can be noted that the average total number of comments (issued plus received) is higher than the average when centrality measures are used to classify individuals separately, but the combination of both dimensions outperforms them separately, which suggests that the model is efficient identifying influential actors, as can be seen in Table III.

This leads to the conclusion that there is a synergistic effect in the use of these two metrics that prove to be complementary as far as the detection of influence traits is concerned.

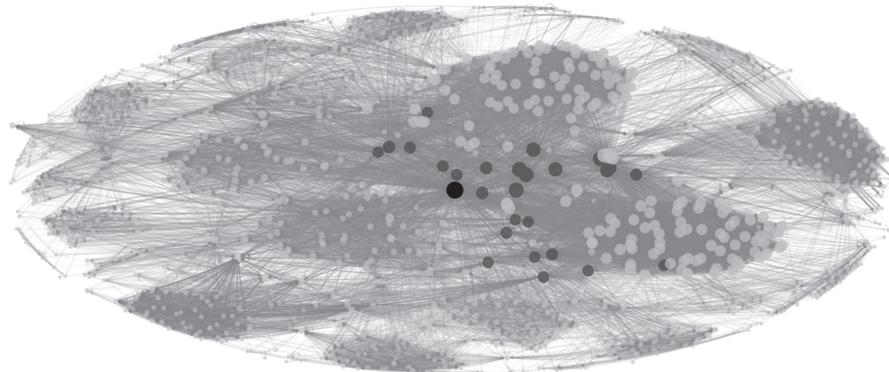


Figure 8.
Oficial Maratón de Buenos Aires Facebook fan page graph made with NodeXL from comments generated between August 31, 2015 and October 17, 2015

Notes: Potential influencers according to the proposed model are shown in red. Page administrator is shown in black

Source: Available at: www.smrfoundation.org/nodexl/

Table II.
Comments received and issued by individuals selected by the model compared vs unselected individuals and overall total analysis

Values	Potential influencers	Unselected individuals	Overall total
Individual count	26	950	976
Received comments (avg)	0.77	0.16	0.17
Issued comments (avg)	5.85	1.6	1.71
Total comments (avg)	6.62	1.76	1.89
Note: Made with Microsoft Excel			

4.3 Sentiment analysis

Sentiment analysis, also known as opinion mining, refers to the application of natural language processing, text analysis and computational linguistics to identify and extract subjective information with the purpose of determining the attitude of an interlocutor or writer regarding a subject or the general contextual valence of a document (Bodendorf and Kaiser, 2009).

NodeXL performs sentiment analysis by counting word frequency on up to three previously defined groups of words (Minqing and Bing, 2004). These groups of words are called “lexicons.” Two groups of words were adapted from a lexicon in Spanish containing words indicative of positive vs negative sentiment (Gravano and Dell’ Amerlina Ríos, 2014) in order to determine if there is polarization toward one or the other end in the comments of the actors detected as influential, in relation to those who are not (Serrano Puche, 2016).

Sentiment analysis did not show significant differences in the frequency counts of comments of potential influential actors with respect to the rest of the community, on the contrary the proportion of words of like and dislike is similar in both groups, as can be seen in Table IV.

This balance proves that though being more influential, polarity in comments and opinions from potential influencers is *a priori* not different than the rest of the community.

Seen in another way, it could be assumed that a contagion effect to the rest of the network of a desired state of mind could be achieved efficiently by operating on the limited group of influencers detected in this network, given the capacity of replication that these particular actors have and the affinity with the rest of the community.

4.4 Simulation of the role of potential influencers

Once the target network was captured, relations were modeled computationally to carry out diffusion tests. Agent-based simulation methodology (Larrosa, 2016) allows, among many other features, to represent agents operating in networks and analyze the resulting diffusion processes. Agent-based simulation has the advantage that it captures the structure of the social network in which the analyzed phenomenon occurs (Libai *et al.*, 2013). It is an area of research that is used by various branches of science. Goldenberg and others (2009) use it for diffusion studies and Bozanta and Nasir (2014) provides a concise contribution of the many contributions of this methodology to marketing. A broad domain programming environment in the academic literature (Larrosa, 2012) that employs this approach is

Selection by eigenvector centrality

True	3.26	6.62
False	1.64	4.35
	False	True

Selection by betweenness centrality

Note: Made with Microsoft Excel

Table III.
Total comments analysis in each separate quadrant

Values	Potential influencers	Unselected individuals	Overall total
Total word count	90,422	672,033	762,455
% Positive valence words	30.8	32.2	32.1
% Negative valence words	30.4	30.9	30.8

Note: Made with NodeXL and Microsoft Excel

Table IV.
Sentiment analysis on comments generated by the model compared vs unselected individuals and overall total

Netlogo (Wilensky, 1999). Specifically, the nodes, their links and the directionality of the nodes were replicated. The resulting directed graph is shown in Figure 9 along with an example of the simple diffusion simulation which is explained below.

A simple simulation exercise in network diffusion was performed. According to the criterion of identification of influential actors in the network presented in Figure 2, data were obtained from ten random agents that fit the criteria of each category. They were named as presented in the four quadrants, i.e. "Potential influencers," "Brokers," "Actors with important connections" and "Secondary actors."

Once the random agents in each group were selected, an attribute was assigned to each node that simulates a piece of information that the node would distribute along its own network of direct connections. This attribute is represented by a color that each agent distributes to its direct outgoing connection network, causing these connections to distribute them to their own direct connections, repeating the process iteratively. Figure 10 represents a graphic example of this diffusion process with the orange color representing the piece of information. It is a basic epidemic model without immunization where information circulates as a contagious virus. It is shown at each step how this information expands quantitatively in the network, from the inception or seeding of the information (step 0). Only ten diffusion steps were simulated. Figure 10 shows markedly higher information penetration profiles for the category of "Potential influencers" as defined by this research.

Table V shows the diffusion reach data of nodes with respect to the category "Potential Influencers" (representing the total of the nodes reached). The "Potential influencers" curve captures 30 percent more nodes on average than the category that follows it, "Brokers," and

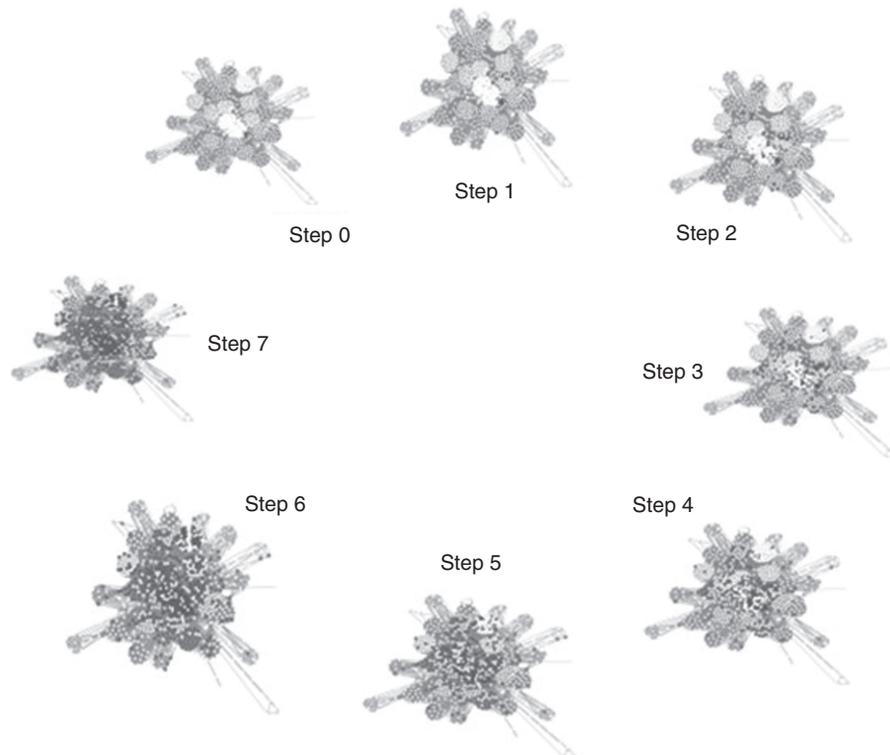


Figure 9.
Model of the target
network and diffusion
simulation example

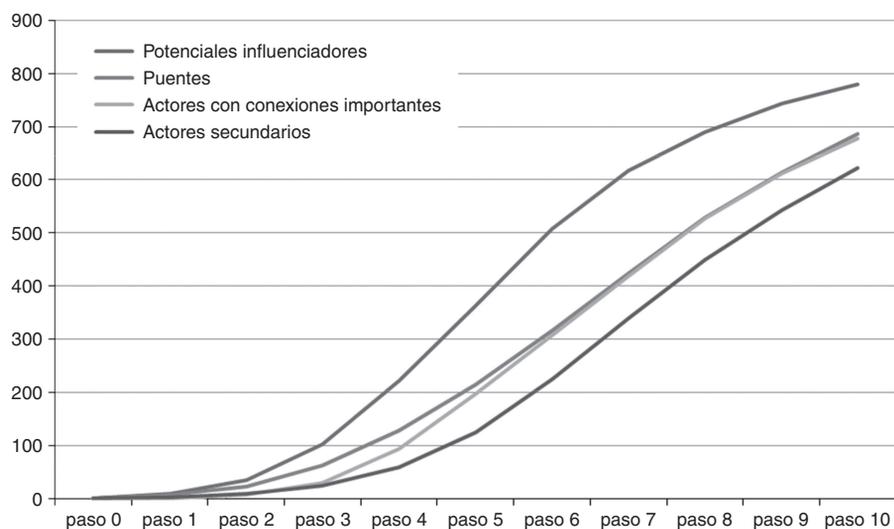


Figure 10. Penetration profile in each category according to the proposed model

	Step 1 (%)	Step 2 (%)	Step 3 (%)	Step 4 (%)	Step 5 (%)	Step 6 (%)	Step 7 (%)	Step 8 (%)	Step 9 (%)	Step 10 (%)	Avg. (%)
Brokers	83.0	68.6	61.3	57.7	59.1	62.4	68.6	76.8	82.6	88.0	70.8
Actors with important connections	21.3	22.3	29.7	42.5	54.5	60.7	67.9	76.4	82.5	87.0	54.5
Secondary actors	25.5	28.0	24.9	27.3	34.5	44.3	54.8	65.2	73.2	79.9	45.8

Table V. Diffusion reach data of nodes with respect to the category "potential influencers"

between 45 and 55 percent more than the categories "Actors with important connections" and "Secondary actors," respectively. Also, it is observed that the "Potential influencers" increase the degree of penetration sharply in the initial steps compared to the rest of the curves in relative terms, situation that tends to reduce only very slowly in the subsequent steps.

This extremely high immediate diffusion rate and its continuity throughout the diffusion period is an expected feature in an influencer.

5. Conclusion

The purpose of this contribution, as mentioned, is to use the tools provided by SNA to achieve instruments that help to identify the different network structures in online social networks and within these the influential actors from a marketing perspective.

A model to detect relevant actors within a social network based on tools from social network theory and taking advantage of specific computer applications of SNA in general and online social networks in particular was proposed.

This model was tested on a real social network and the results show that:

- The proposed model is effective to detect actors with potential to efficiently spread a message, gaining influence from their position within the network.
- The analysis of social networks in general and the proposed model in particular are useful to detect subgroups of components of a social network with particular characteristics that are not evident from other types of analysis.

The proposed method may be particularly useful for marketing and digital marketing managers by facilitating the detection of prominent actors within a social network, with the advantage that it is a simple but powerful method for viewing, analyzing and communicating findings. Knowing the influential potentials, as stated above, can generate savings and advantages in regular marketing department practices as market research activities, product launches, direct marketing and public relations campaigns among others.

This work presents the limitation that the proposed model has only been tested on a very specific domain network such as the community of people following a sporting event, and on a single social network as Facebook. Expanding the experimentation on different networks and on other online social networking platforms would be necessary to strengthen the conclusions of this work.

Another limitation of this work lies in the criteria used to conclude that the individuals detected by the proposed system are influential. Several metrics, sentiment analysis and simulation techniques were applied. It would be desirable to add evidence to support this model through other methods such as direct experimentation on a real social network, and also considering factors as homophilia and characteristics of relations such as frequency and intensity (Aral *et al.*, 2013; Chen *et al.*, 2017).

We also point out as a potential limitation to the proposed method that the way of identifying potential influencers is limited to the analysis and conjugation of two common metrics. It should be mentioned however that it is the simplicity of this method what makes it an adaptable and versatile tool for the analysis of online social networks, where the availability of information may be limited and is continually modified by updates in privacy policies.

In any case, it is clearly exposed that with this conjunction of theoretical knowledge and computational tools it is possible to capture the complexity of the interaction within a social network. Also, this analysis allows the detection the main groups and individual actors of the event. This clarity in the description and analysis, we believe, cannot be found using other more traditional tools.

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