WARWICK

ECONOMICS

CRETA

Centre for Research in Economic Theory and its Applications

Discussion Paper Series

Show me your competitors and I will tell you if you are exposed : Market Structure and Foreign Exchange Exposure

Athanasios Andrikopoulos & Xeni Dassiou

September 2016 No: 25

CRETA
Centre for Research in Economic Theory and its Applications

Department of Economics
University of Warwick, Coventry,
CV4 7AL, United Kingdom

warwick.ac.uk/fac/soc/economics/research/centres/creta/papers

Show me your competitors and I will tell you if you are exposed: Market Structure and Foreign Exchange Exposure

Athanasios Andrikopoulos*, Xeni Dassiou†

September 2016

Abstract.
We examine the impact of exchange rates on profits and prices in differentiated consumable goods markets under imperfect competition. We model the exchange rate exposure of exporting firms operating within price and quantity settings where *between* and *within* competition co-exist. We show that these two forms of competition may act as opposing forces in terms of the impact of the exchange rate on the optimal prices (quantities) and profits in both Bertrand and Cournot models. Real and bilateral exchange rate exposure is empirically tested using stock price and profit data from twenty-two multinational firms from nine markets during 1984-2015.

Keywords: Oligopoly Market Structure; Differentiation; Firm Behaviour; Foreign Exchange; International corporate finance

JEL Classification Numbers: L13, D21, D22, F31, G39

---

* Corresponding Author: Athanasios Andrikopoulos, Location: Hull University Business School, University of Hull, Hull HU6 7RX, UK. Tel. +44 (0)1482 46-3310, A.Andrikopoulos@hull.ac.uk.

†Xeni Dassiou, Department of Economics, City, University of London, Northampton Square, London EC1V 0HB, UK, tel. +44 (0)20 7040 0206, x.dassiou@city.ac.uk.

We wish to thank for valuable comments received on earlier versions of this paper the seminar participants of the IFABS 2015 Corporate Finance Conference, Oxford UK (2015) and the 6th International Ioannina Meeting on Applied Economics and Finance, Corfu Greece (2016). The usual disclaimer applies.

1. Introduction

In a period of increasing globalization, exchange rate movements have considerable effects on firm profitability. Adidas, the second largest firm in sports across the world, attributes the recent downward trend in its profits on the continuing appreciation of euro. (Marketwatch, 2014). Such exchange rate fluctuations have less obvious but equally important effects on the strategic behavior of firms. Notably, the latter affects not just exporting firms but even firms which only operate in their home country (Marston, 2001; Aggarwal and Harper, 2010).

Our objective is to develop simple and more realistic theoretical models of imperfect competition that arise in an international setting to capture the effects of the exchange rates on the strategic behavior of firms offering differentiated consumable goods. We develop two such models to examine exchange rate exposure using specific markets where firms compete in an international oligopoly, under a price (Bertrand) or a quantity (Cournot) setting.

We first look at of competition in a duopoly between two competing firms, one home and one abroad with differentiated products and linear demands; the 1x1 differentiated goods duopoly model as we call it. An example is the Detergent market, dominated by the British-Dutch Unilever and the (US) Procter & Gamble (Economist, 2012a). This allows us to study exchange rate pass-through and foreign economic exposure as simple elasticities of prices and profits with respect to exchange rates.

In the second model there are two home and two foreign firms; the 2x2 differentiated goods oligopoly model. The home (foreign) firm competes with the other home (foreign) firm – *within* countries competition (henceforth *within* competition) and with the foreign (home) firms in the other country – *between* countries competition (henceforth *between* competition). We study a framework that encompasses both elements and look at the impact of exchange rates in these more complicated competition structures. The addition of *within* competition either in a Bertrand or in a Cournot model may reverse the results applied in the 1x1 model regarding the impact of the exchange rate. Whether this happens depends on the intensity of competition among home and foreign firms as measured by the *between* and the *within* cross price parameters which determine the degree to which goods competing in the market are viewed as close substitutes by the consumers.

In the 1x1 Bertrand model a currency appreciation decreases (increases) the optimal price of the appreciating (depreciating) country. Hence, exchange-rate pass-through is in this case profit enhancing (reducing) for home (foreign) goods. The direction of the impact of foreign exposure depends on the price elasticity of the foreign competitor with respect to the exchange rate.

In the 2x2 Bertrand model the introduction of the *within* countries competition may have an opposite sign and if in that case it dominates the *between* countries competition the results will be reversed. In other words, in the 2x2 case, exchange-rate pass-through can be either negative or positive, because of the existence of both *within* and *between* countries competition. Foreign exposure depends on the price elasticity with respect to the exchange rate of the two foreign and the one domestic competitor. The latter model is flexible enough to examine the phenomenon that exchange rates affect even firms which only operate in their home country.

In the 1x1 Cournot model a foreign-currency appreciation decreases (increases) the optimal quantity and profits of the appreciating (depreciating) country. In the 2x2 model we once more find that the *between* and the *within* competition can act as two opposing forces when it comes to the impact of the exchange rates on the equilibrium prices (quantities) and profits. If this is the case, and the *within* effect dominates the *between*, then the results that applied in the 1x1 Cournot model will be reversed in the 2x2 model.

At an empirical level, we contribute to the literature in three main ways. First, we recognize that we need to take consumable products to be consistent with a simple static profit maximizing model where there are no current profit spillovers into future periods. Our sample does not include durable goods producing firms and hence it is free from their resulting dynamic interaction effects.

Second, we examine profits exposure to real and bilateral exchange rates using stock price as well as profit data from a novel sample comprising twenty-two multinational companies (hereafter MNCs) from nine oligopolistic markets during 1984-2015. While existing studies estimate currency exposures of stock prices or cash flows, we study the impact of exchange rates on both profits and stock prices, since as we explain stock price exposure proxies for long run exposure and profit exposure for short run exposure. It is the bilateral exchange rates that are of relevance to our theory but we also use the real exchange rates which as an index captures the economy-wide implications of exchange rates.

Finally, unlike similar studies, we focus on consumable goods producers *engaged in an international price or quantity setting oligopoly* to estimate exchange rate exposure arising from the strategic interactions *between* and *within* countries as a result of mode of competition prevailing. Our sample exclusively includes firms that compete in an international oligopoly, and in this way provides new evidence on the foreign exchange exposure of MNCs that improve our understanding of the effect of exchange rates on MNCs, a key condition for effective hedging. MNCs do not use financial hedging with currency derivatives because they operate in many countries where operational hedging suffices. Operational hedging deals with longer-term foreign exchange exposure by the firm changing the location of its operations (see Hutson and Laing, 2014; and the references therein). However, the use of operational hedging as concerns foreign exchange exposure is beyond the scope of this article.

2. Related Literature

The international oligopoly literature is quite broad. The earliest attempts in modelling the competition between domestic and foreign firms are based on the naive assumption of perfect substitutability: Dornbusch (1987), Krugman (1987), Froot and Klemperer (1989), Feenstra, *et al.* (1996), and Yang (1997). More recent models assume imperfect substitutability (Bodnar *et al*,.2002; Dekle, 2005; Brissimis and Kosma, 2006). However, to our knowledge there is no study in this literature studying the impact of exchange rates under both Bertrand and Cournot competition and the combined effect of the *between* and *within* countries competition.

The 2x2 model captures both *within* and *between* countries competition and studies the exchange rate exposure in more depth. Most of the previous literature studies either Bertrand or Cournot, looking at firms that either both export abroad or one is the exporter and the other is the domestic firm; there is no study for these different market structures in an international oligopoly.[1] Moreover, most of the previous literature looks at pass-through, namely the impact on prices, not on profits; we study the impact on stock prices and profits, i.e. exposure.

[1] Bodnar *et al.* study both Bertrand and Cournot competition but they only discuss *between* competition; home and foreign firms both compete in a third country.

Our 1x1 model closely relates to those of Bodnar *et al.,* and Dekle. Bodnar *et al.,* estimate a two-equation price and quantity competition differentiated model for eight Japanese export industries during 1986-1995. They examine whether the relation between exchange rate exposure and pass-through behavior dictated by their model is consistent with actual behavior. Without distinguishing between consumable and durable goods Bodnar *et al.,* committed a serious mistake and perhaps this is the reason of their poor empirical results: "*In three other industries, namely, Construction Machinery, Motor Vehicles, and Cameras, the estimate of exposure is "too low" to be consistent with the quantity competition model (for any level of pass-through)*", they also write: "*For these three industries, the exposure elasticity is too low to be consistent with a simple quantity-based profit maximizing model*." Moreover, their exposure estimates are too high for the other industries, Film and Electronic Parts to be consistent with a profit maximizing model (despite the former being a consumable good).

Dekle makes a similar mistake by studying automobile, steel, radio-and television-receiver and musical instrument industries using a static profit maximizing model. Dekle studies the impact of foreign competition on exposure in a Cournot setting. Dekle is motivated by his observation that in foreign markets where the foreign and the export good are close substitutes, exporters are hesitant to increase export prices when their home currency appreciates. Dekle tests whether exporters collude in foreign markets.

As we emphasize, the durable goods in the Bodnar *et al.,* and Dekle modelling approach is erroneous. In imperfect competition it is inappropriate to test a static maximization model when using durable goods. To look at durable goods we need to use a dynamic oligopoly framework as Froot and Klemperer and Gross and Schmitt (2000) do.

While Bodnar *et al.,* develop a model that determines pass-through and exposure behavior at the same time, they do not examine the impact of industry structure on exposure. Marston (2011) emphasizes the importance of the competitive structure of the industry in which a firm operates, on its economic exposure. However, he studies only theoretically the following cases: monopoly, a simple Cournot duopoly in which one of the two firms only operates in its domestic country while the other operates in both domestic and exports abroad, and the case of Stackelberg leadership by the exporting or the local firm.

Froot and Klemperer are the first to develop a dynamic oligopoly model, allowing the future product demand of firms to depend on current market shares; future exchange rates affect the current market shares, and thus current international pricing. Their model is the simplest dynamic game, namely a two period one, developed under both Cournot and Bertrand competition. However, their model has a very simple market structure with one foreign and one domestic firm competing in the domestic (U.S.) market only and the goods are homogenous. In their empirical part they test whether prices are affected by the perceived permanence of exchange rate changes by examining foreign firms from the UK, France, West Germany, and Japan competing with the domestic (U.S.) firm in the domestic (U.S.) market; they look at sixty-five industries for each country during 1981-1986.

Gross and Schmitt use the switching cost model of Froot and Klemperer, since switching costs are relevant to the automobile market. They recognize that price decisions have an intertemporal link in a durables good model and maximize the value of the firm, namely the present value of its profits in the simplest two period game. This dynamic model allows the study of the exchange rate pass-through in the long and in the short-run; their result is that price interdependence matters and that exchange rates have significant feedback effects on prices resulting to lower pass-through in the long-run than in the short-run. Here too, the market structure of the model is very simple, with two foreign firms serving a market with no home production under a Bertrand setting studying exchange-rate pass through, but not foreign exposure. In their empirical part they study the Swiss automobile market during 1977-1994 with Belgium, Germany, France and Japan as source-countries.

Finally, we note that Berman *et al.,* (2012) show that the reaction of exporters to currency changes is heterogeneous: using French firm-level data with destination specific export values and volumes during 1995-2005, they find that high-performance firms react to currency depreciation by increasing more their mark-up and less their export volume. They also look at productivity differences *within* and *between* sectors, and they study whether the relation between performance and exchange rates is more a *within* or a *between*-sector phenomenon. While our model emphasizes the mode of competition in specific international markets and its impact on the link between exchange rates and exposure, the addition of a distinction between high and low performance firms is an interesting future direction.

The empirical part of our paper relates to the two-factor model where the dependent variable is either the changes in stock prices (see e.g. Jorion, 1990; Bodnar and Gentry, 1993; He and Ng, 1998; Williamson, 2001) or in cash flows of the firm (Bartov and Bodnar, 1994, Stulz and Williamson, 1997; Oxelheim *et. al.* 1995; Bartram, 2007). Bartram shows that stock price and earnings exposures are similar for short horizons.

3. General Framework

Consumable goods are single- use goods or have a natural life of less than three years; examples consist of cosmetics, food, beer, plastics, clothing, and footwear. We assume that the home market is USA with a seller of athletic shoes like Nike. The price of a pair of shoes is:$P_h = SP_f$; where P_h is the home price, P_f is the foreign price and S is the exchange rate. Hence, S has an impact on the home price of shoes. In the empirical part we look at the impact of foreign exchange rates on profits rather than prices, since it is easier to find data for the former.

3.1 Between Countries Competition

We study the impact of S on prices and profits in the Bertrand and Cournot models in a setting of differentiated goods and linear demands. Since pricing affects profitability, firm pass-through and exposure are linked. Whether firms compete in price or in quantity terms depends on the nature of the good (e.g. degree of product differentiation) as well as on other structural features of the market (e.g. degree of market concentration), which in turn determine the mode of competition. Alternatively, the decision of the firm to choose price or quantity is itself a strategic one (Klemperer and Meyer, 1986; Singh and Vives, 1984).

3.1.1. Bertrand competition

We have two competing firms; the home and the foreign firm, who choose prices P_h and P_f respectively. The demand functions in the home and foreign markets are:

$$\begin{aligned} q_h(P_h, P_f; S) &= \theta_o + \theta_h P_h + \theta_f S P_f \\ q_f(P_h, P_f; S) &= \lambda_o + \lambda_f P_f + \lambda_h \frac{1}{S} P_h \end{aligned} \tag{1}$$

where θ_f>0 and $\lambda_h > 0$ are the substitution terms between home and foreign goods in the home and the foreign market respectively, while $\theta_h, \lambda_f < 0$.

While the firms produce substitutes, we intuitively assume that the own price of each firm has a greater absolute effect on its demand than the price of the other firm. There are no fixed production costs; hence marginal costs are constant for the home and the foreign market and equal to c_h and c_f respectively, such that c_h<θ_o and $c_f < \lambda_o$ while the firms choose prices simultaneously. The payoff function for home and foreign firm is its profits. The optimization problems of the home and foreign firms are:

$$\max_{P_h} \Pi_h(P_h, P_f; S) = \max_{P_h}[\theta_o + \theta_h P_h + \theta_f S P_f][P_h - c_h]$$

$$\max_{P_f} \Pi_f(P_h, P_f; S) = \max_{P_f}\left[\lambda_o + \lambda_f P_f + \lambda_h \frac{1}{S} P_h\right][P_f - c_f]$$

Solving the above problems we get the reaction curves (RCs): $P_h = \frac{1}{2}(c_h - \frac{\theta_o}{\theta_h} - \frac{\theta_f}{\theta_h} S P_f)$ and $P_f = \frac{1}{2}(c_f - \frac{\lambda_o}{\lambda_f} - \frac{\lambda_h}{\lambda_f}\frac{1}{S} P_h)$. Solving the previous pair of equations yields:

$$P_h^{*B} = \frac{\lambda_f\left(2\theta_h c_h - 2\theta_o - S\theta_f c_f + \theta_f \frac{\lambda_o}{\lambda_f} S\right)}{(4\lambda_f\theta_h - \theta_f\lambda_h)}$$

$$P_f^{*B} = \frac{\theta_h(2\lambda_f S c_f - 2\lambda_o S - \lambda_h c_h + \lambda_h \frac{\theta_o}{\theta_h})}{(4\lambda_f\theta_h - \theta_f\lambda_h)S} \tag{2}$$

where $4\lambda_f\theta_h - \theta_f\lambda_h > 0$, for the second order conditions (S.O.C.s) to be satisfied, along with $\lambda_f, \theta_h < 0$. Fig. (1) shows the RCs of the home and foreign firm in the price space; they are upward sloping and the RC of the home firm is steeper relative to the RC of the foreign firm. The equilibrium profits of the home and foreign firm are:

$$\Pi_h^{*B}(P_h^*, P_f^*; S) = \max_{P_h}[\theta_o + \theta_h P_h^* + \theta_f S P_f^*][P_h^* - c_h]$$

$$\Pi_f^{*B}(P_h^*, P_f^*; S) = \max_{P_f}\left[\lambda_o + \lambda_f P_f^* + \lambda_h \frac{1}{S} {P_h}^*\right][P_f^* - c_f]$$

An increase in S, namely a foreign-exchange rate appreciation increases (decreases) the optimal price of home (foreign) goods: $\frac{\partial P_h^{*B}}{\partial S} = \frac{\theta_f(\lambda_o - \lambda_f c_f)}{(4\lambda_f\theta_h - \theta_f\lambda_h)} > 0$ and $\frac{\partial P_f^{*B}}{\partial S} = \frac{\lambda_h(\theta_h c_h - \theta_o)}{(4\lambda_f\theta_h - \theta_f\lambda_h)S^2} < 0$. The positive (negative) derivative of the home (foreign) equilibrium price with respect to S is the result of the fact that in the 1x1 case there is only *between* competition. Fig. (1), shows the effect of a currency appreciation on the RCs of the home and foreign firms. The RC of the foreign firm pivots clockwise when the currency appreciates (and its intercept does not change) while the RC of the home firm becomes more horizontal and its intercept less negative, resulting in a new Bertrand-Nash Equilibrium, with a higher home equilibrium price and a lower equilibrium price for the foreign good as denoted by a shift from E_1 to E_2.

[Insert Fig. 1.]

Proposition 1.

A foreign currency appreciation makes the home firm better (worse) off and the foreign firm worse (better) off if the equilibrium prices of their rivals are inelastic (elastic) to changes in S. In other words, as S increases, unless the foreign country responds with large decrease in its price to offset the appreciation and restore its competitiveness, the home firm will gain.

(a) The derivative of the home firm profit function is: $\frac{\partial \Pi_h^{*B}}{\partial S} = \theta_f(m_h^*)P_h^*P_f^*[1 + \varepsilon_{P_f^*,S}]$, where $\varepsilon_{P_f^*,S} = \frac{\partial P_f^*}{\partial S}\frac{S}{P_f^*}$ <0 is the partial elasticity of the equilibrium foreign price with respect to S and $m_h^* = \frac{(P_h^* - c_h)}{P_h^*}$ is the equilibrium price-cost-margin of the home firm. Hence, the sign of the partial derivative $\frac{\partial \Pi_h^{*B}}{\partial S}$ depends on the price exchange rate elasticity of the rival firm; if the latter is elastic (inelastic) to changes in S, the equilibrium profits of the home firm are decreasing (increasing) in S. In other words, unless the foreign firm reduces its price so that it more than offsets the appreciation of its currency, the home firm will enjoy an increase in its equilibrium profits as a result of an increase in S.

The size of the change in the equilibrium profits of the home firm depends on the cross price substitution parameter θ_f, the price sensitivity of its rival to S, and its own price cost margin.

(b) The derivative of the foreign firm profit function is: $\frac{\partial \Pi_f^{*B}}{\partial S} = \frac{1}{S^2}\lambda_h\left(m_f^*\right)P_h^* P_f^* [\varepsilon_{P_h^*,S} - 1]$, where $\varepsilon_{P_h^*,S} = \frac{\partial P_h^*}{\partial S}\frac{S}{P_h^*}$>0 is the partial elasticity of the home price at its equilibrium point with respect to S and $m_f^* = \frac{P_f^* - c_f}{P_f^*}$ the equilibrium price cost margin of the foreign firm. Again, the sign of the partial derivative $\frac{\partial \Pi_f^{*B}}{\partial S}$ depends on the price elasticity of the rival with respect to S. If the equilibrium price of *h* is elastic (inelastic) to changes in S, the profits of the foreign firm *f* are increasing (decreasing) in *S*. Hence the profits of *f*, *whose* currency appreciates, will decrease unless the home firm *h* more than counteracts its gain in competitiveness through a more than offsetting increase in its equilibrium price. So the magnitude of the change in the equilibrium profits of *f* will depend on its own price cost margin, the degree of substitutability between the two goods parameter λ_h, and the sensitivity of the equilibrium price of *h* to the exchange rate; it is also inversely dependent on the square of S.

Proof.

Please refer to the Mathematical Appendix (henceforth MA).

3.1.2. Cournot competition

In this paragraph we study the impact of foreign exchange rates on equilibrium prices and profits in the Cournot framework with differentiated products, so we need to invert (1) to obtain the prices that will "clear" the markets for given outputs. Hence:

$$P_h\left(q_h, q_f; S\right) = \frac{\theta_f S \lambda_o - \lambda_f \theta_o}{a} + \frac{\lambda_f}{a} q_h - \frac{\theta_f}{a} S q_f$$

$$P_f(q_h, q_f; S) = \frac{\lambda_h \theta_o - \theta_h \lambda_o S}{aS} - \lambda_h \frac{1}{Sa} q_h + \frac{\theta_h}{a} q_f \qquad (3)$$

where, $a = \theta_h \lambda_f - \theta_f \lambda_h > 0$. The payoff function for home and foreign firm is its profits. The optimization problem of the home firm is:

$$\max_{q_h} \Pi_h\left(q_h, q_f; S\right) = \max_{q_h} q_h [\tfrac{\theta_f S \lambda_o - \lambda_f \theta_o}{a} + \tfrac{\lambda_f}{a} q_h - \tfrac{\theta_f}{a} S q_f - c_h].$$

To obtain the reaction function of the home firm, we optimize q_h given q_f : $q_h = \frac{1}{2\lambda_f}\left[ac_h - \left(\theta_f S\lambda_o - \lambda_f\theta_o\right) + \theta_f S q_f\right]$, with a slope $\frac{2\lambda_f}{\theta_f S} < 0$ if we draw the reaction line with $q_f(q_h)$ on the (vertical) horizontal axis. The optimization problem of the foreign firm is:

$$\max_{q_f} \Pi_f\left(q_h, q_f; S\right) = \max_{q_f} q_f [\frac{\lambda_h\theta_o - \theta_h\lambda_o S}{aS} - \lambda_h \frac{1}{Sa} q_h + \frac{\theta_h}{a} q_f - c_f]$$

and the reaction function of the foreign firm is: $q_f = \frac{1}{2\theta_h}\left[ac_f - \left(\frac{\lambda_h\theta_o - \theta_h\lambda_o S}{S}\right) + \lambda_h \frac{1}{S} q_h\right]$, with a slope $\frac{\lambda_h}{2S\theta_h} < 0$. As shown in Fig. (2), the slope of the reaction curve of the *h* firm is more steeply sloped than that of the *f* firm given the S.O.C. $4\theta_h\lambda_f - \theta_f\lambda_h > 0$. Solving the above pair of equations gives the equilibrium quantities:

$$q_h^{*C} = \frac{2\theta_h}{\Delta}[ac_h + \left(\lambda_f\theta_o - \theta_f S\lambda_o\right)] + \frac{\theta_f S}{\Delta}[ac_f + \frac{([\theta_h\lambda_o S - \lambda_h\theta_o])}{S}]$$

$$q_f^{*C} = \frac{\lambda_h}{S\Delta}[ac_h + \left(\lambda_f\theta_o - \theta_f S\lambda_o\right)] + \frac{2\lambda_f}{\Delta}[ac_f + \left(\frac{[\theta_h\lambda_o S - \lambda_h\theta_o]}{S}\right)]$$

where $\Delta = 4\lambda_f\theta_h - \theta_f\lambda_h > \; a = \lambda_f\theta_h - \theta_f\lambda_h > 0$. The optimal home and foreign prices in the Cournot model can be found by substituting the optimal quantities above into (3) (please refer to the MA in the proof of Proposition 2):

$$\begin{aligned} P_h^{*C}\left(q_h^*, q_f^*; S\right) = \; & \frac{\theta_f S\lambda_o - \lambda_f\theta_o}{\Delta a} 2\lambda_f\theta_h + \frac{2\lambda_f\theta_h - \lambda_h\theta_f}{a\Delta} ac_h \\ & - \left[\frac{S\lambda_f\theta_f}{a\Delta}\right]\left\{ac_f + \left[\frac{(\theta_h\lambda_o S - \lambda_h\theta_o)}{S}\right]\right\} \end{aligned} \tag{4}$$

$$P_f^{*C}\left(q_h^*, q_f^*; S\right) = \frac{\lambda_h\theta_o - S\theta_h\lambda_o}{S\Delta a} 2\lambda_f\theta_h + \frac{2\lambda_f\theta_h - \lambda_h\theta_f}{\Delta} c_f - \frac{\lambda_h\theta_h}{Sa\Delta}\left[ac_h + \left(\lambda_f\theta_o - \theta_f S\lambda_o\right)\right]$$

[Insert Fig. 2.]

The equilibrium profits of the home and foreign firm respectively are (for an analytic expression of the profits please refer to the MA in the proof of Proposition 2):

$$\Pi_h^C\left(q_h^*, q_f^*; S\right) = \max_{q_h} q_h \left[\frac{\theta_f S\lambda_o - \lambda_f\theta_o}{a} + \frac{\lambda_f}{a} q_h - \frac{\theta_f}{a} S q_f - c_h\right]$$

$$\Pi_f^C\left(q_h^*, q_f^*; S\right) = \max_{q_f} q_f \left[\frac{\lambda_h\theta_o - \theta_h\lambda_o}{a} - \lambda_h \frac{1}{Sa} q_h + \frac{\theta_h}{a} q_f - c_f\right]$$

or: $\Pi_h^{*C}\left(q_h^*, q_f^*; S\right) = [P_h^{*C} - c_h] q_h^{*C}$ and $\Pi_f^{*C}\left(q_h^*, q_f^*; S\right)=\left[P_f^{*C} - c_f\right] q_f^{*C}$. The proposition below summarizes the impact of a change in *S*, on the optimal prices and corresponding profits of the home and foreign firms.

Proposition 2.

An increase in *S*, increases (decreases) the equilibrium quantity of the home (foreign) goods and makes them more expensive (cheaper) as $\frac{\partial P_h^*\left(q_h^*,q_f^*;S\right)}{\partial S} = \frac{\theta_f\lambda_o}{a}\left(\frac{\lambda_f\theta_h}{\Delta}\right) - \left[\frac{\lambda_f\theta_f}{\Delta}\right] c_f > 0$, $\frac{\partial P_f^*\left(q_h^*,q_f^*;S\right)}{\partial S} = \frac{-\lambda_h\theta_o}{S^2\Delta a}\lambda_f\theta_h + \frac{\lambda_h\theta_h}{S^2\Delta} c_h < 0$, as $\lambda_f\theta_h > 0$ and $\lambda_f\theta_f < 0$. Moreover, a foreign currency appreciation makes the home firm better off and the foreign firm worse off as:

$$\frac{\partial \Pi_h^{*C}}{\partial S} = \frac{\partial q_h^{*C}[P_h^{*C} - c_h]}{\partial S} = \underset{(+)}{\frac{\partial q_h^{*C}}{\partial S}} \underset{(+)}{[P_h^{*C} - c_h]} + \underset{(+)}{\frac{\partial P_h^{*C}}{\partial S}} q_h^{*C} > 0$$

$$\frac{\partial \Pi_f^{*C}}{\partial S} = \frac{\partial q_f^{*C}[P_f^{*C} - c_f]}{\partial S} = \underset{(-)}{\frac{\partial q_f^{*C}}{\partial S}} \underset{(+)}{\left[P_f^{*C} - c_f\right]} + \underset{(-)}{\frac{\partial P_f^{*}}{\partial S}} q_f^{*C} < 0$$

In other words, as the foreign currency appreciates, the home firm will gain at the expense of her overseas rival.

Proof.

Please refer to the MA.

Fig. (2) illustrates the effect of a foreign currency appreciation on the RCs of the home and foreign firm. The RC of the foreign firm pivots counter clockwise and shifts inward when the foreign currency appreciates. The RC of the home firm becomes more horizontal and shifts inward since its intercept goes down, resulting in a new Cournot-Nash Equilibrium point, with a higher quantity of the home good and a lower quantity of the foreign good. Hence a foreign currency appreciation shifts the Cournot-Nash Equilibrium from *E1* to *E2*.

3.1.3. Comparing the Bertrand and Cournot Equilibria

We have found the equilibrium prices for the Bertrand and the Cournot models in (2) and (4) respectively. We next compare the magnitude of the impact of a foreign currency appreciation on the Cournot and Bertrand prices (Proposition 3) and profits.

Proposition 3.

An increase in *S*, has a greater impact on the equilibrium prices of the home and foreign firm in the case of quantity competition as compared to price competition.

a. $\frac{\partial P_h^{*C}\left(q_h^*,q_f^*;S\right)}{\partial S} - \frac{\partial P_h^{*B}\left(q_h^*,q_f^*;S\right)}{\partial S} > 0$ and b. $\frac{\partial P_f^{*C}\left(q_h^*,q_f^*;S\right)}{\partial S} - \frac{\partial P_f^{*B}\left(q_h^*,q_f^*;S\right)}{\partial S} < 0$

Proof.

Please refer to the MA.

In plain English, as the foreign currency appreciates, its positive (negative) impact is greater, in absolute terms, on the home (foreign) equilibrium price in quantity as compared to price competition. It is easy to check that as the degree of substitutability between the home and the foreign goods in the home (foreign) market $\theta_f > 0$ ($\lambda_h > 0$) increases, $\left(\frac{\partial P_h^{*C}}{\partial S} - \frac{\partial P_h^{*B}}{\partial S}\right)$ $\left(\left|\frac{\partial P_f^{*C}}{\partial S} - \frac{\partial P_f^{*B}}{\partial S}\right|\right)$ increase too.

We have shown that an increase in *S* makes the home goods more expensive and their foreign rivals cheaper irrespectively of the competition framework (quantity or price competition), namely: $\frac{\partial P_h^{*B}\left(q_h^*,q_f^*;S\right)}{\partial S} > 0, \frac{\partial P_h^{*C}\left(q_h^*,q_f^*;S\right)}{\partial S} > 0$ and $\frac{\partial P_f^{*B}\left(q_h^*,q_f^*;S\right)}{\partial S} < 0, \frac{\partial P_f^{*C}\left(q_h^*,q_f^*;S\right)}{\partial S} < 0$. We have also proved that this impact is greater in the case of quantity as compared to price competition, namely: $\frac{\partial P_h^{*C}\left(q_h^*,q_f^*;S\right)}{\partial S} - \frac{\partial P_h^{*B}\left(q_h^*,q_f^*;S\right)}{\partial S} > 0$, $\frac{\partial P_f^{*C}\left(q_h^*,q_f^*;S\right)}{\partial S} - \frac{\partial P_f^{*B}\left(q_h^*,q_f^*;S\right)}{\partial S} < 0$. An interesting question is whether the home (foreign) firm passes on more than the full foreign-exchange rate increase (decrease) to consumers. Following Bodnar *et al.* (2002) we define pass through elasticity as $\varepsilon_{P_\ell^{*B} S} = \frac{\partial \ln P_\ell^{*B}\left(q_h^*, q_f^*; S\right)}{\partial \ln(S)}, \varepsilon_{P_\ell^{*C} S} = \frac{\partial \ln P_\ell^{*C}\left(q_h^*, q_f^*; S\right)}{\partial ln(S)}$, for $\ell = h, f$.

Hence if a one percent change in S leads to a higher than one percent change in the same (opposite) direction in P_h (P_f), then this implies that more than the full foreign (home) exchange rate change has been passed through into the price of the home (foreign) goods.

We follow Bodnar *et al.* setting foreign economic exposure as the percentage change in profits induced by a one percent change in the exchange rate, the elasticity of profits with respect to the exchange rate: $\frac{\partial \ln \Pi_h^{B*}}{\partial ln S}, \frac{\partial ln \Pi_h^{C*}}{\partial ln S}, \frac{\partial \ln \Pi_f^{B*}}{\partial ln S}, \frac{\partial \ln \Pi_f^{C*}}{\partial ln S}$. A significant factor of economic exposure is the degree of competition of the market in which a firm operates (Marston, 2001).

As we proved earlier firms differ in both the direction and the sensitivity of their equilibrium profits to exchange rates, depending on the competition framework within which these firms operate. Hence we have shown in the Bertrand model that there is a link between the ability of each firm to pass on the exchange rate change in the price it charges its customers and the direction and magnitude of the impact on the profits of the other firm as result of changes in *S*. Hence in price competition a foreign currency appreciation makes the home firm better (worse) off and the foreign firm worse (better) off if the equilibrium prices of their rivals are inelastic (elastic) to changes in S. On the other hand, in quantity (Cournot) competition the direction of the impact is unambiguous; a foreign currency appreciation makes the home firm better (worse) off and the foreign firm worse (better) off irrespective of the elasticity of the equilibrium prices of their rivals to changes in the exchange rate; of course the size of the impact of changes in S on the home and foreign profits respectively still depends on the parameters λ and θ and the costs in both markets. We note that the above results also cover the cases where one of the two firms is a monopoly in its home market and competes in the foreign market with the domestic firm there i.e. θ_f=0 and $\lambda_h > 0$ or $\theta_f > 0$ and $\lambda_h = 0$. Hence, exchange rate fluctuations affect not just exporting firms but even firms which only operate in their home country (Marston; Aggarwal and Harper).

3.2. Between and Within Countries Competition

We now extend our previous setting to one where there are 2 home and 2 foreign firms. Each home (foreign) firm competes with another home (foreign) firm - *within* competition, and also with the foreign (home) firms in the other market - *between* competition.

We study the impact of foreign exchange rates on profits and prices in a common setting of differentiated products and linear demands, when firms compete in prices or quantities.

3.2.1. Between and Within Countries Bertrand Competition

Both the two home and the two foreign firms choose prices $P_{i,h}$ and $P_{j,f}$,$i = 1,2$, and $j = 1,2$ respectively, and the four demand functions in matrix form are as follows:

$$\begin{bmatrix} q_{1,h}(P_h, P_f; S) \\ q_{2,h}(P_h, P_f; S) \\ q_{1,f}(P_h, P_f; S) \\ q_{2,f}(P_h, P_f; S) \end{bmatrix} = \begin{bmatrix} \theta_{1,o} \\ \theta_{2,o} \\ \lambda_{1,o} \\ \lambda_{2,o} \end{bmatrix} + \begin{bmatrix} \theta_{11,h} & \theta_{12,h} & \theta_{11,f}S & \theta_{12,f}S \\ \theta_{21,h} & \theta_{22,h} & \theta_{21,f}S & \theta_{22,f}S \\ \lambda_{11,h}\frac{1}{S} & \lambda_{12,h}\frac{1}{S} & \lambda_{11,f} & \lambda_{12,f} \\ \lambda_{21,h}\frac{1}{S} & \lambda_{22,h}\frac{1}{S} & \lambda_{21,f} & \lambda_{22,f} \end{bmatrix} \begin{bmatrix} P_{1,h} \\ P_{2,h} \\ P_{1,f} \\ P_{2,f} \end{bmatrix} \tag{5}$$

The four terms: $\theta_{12,h}, \theta_{21,h}, \lambda_{12,f}, \lambda_{21,f}$ are the *within countries* cross-price effects, while the terms: $\theta_{11,f}, \theta_{12,f}, \theta_{21,f}, \theta_{22,f}$,and $\lambda_{11,h}, \lambda_{12,h}, \lambda_{21,h}, \lambda_{22,h}$ are the *between countries* cross-price effects. We assume throughout that the firms produce substitutes, so that all the cross price effects are positive. The direct terms are all negative, i.e. $\theta_{11,h}, \theta_{22,h}, \lambda_{11,f}$,$\lambda_{22,f} < 0$; As before we assume that the own price of the firm has a greater absolute effect on its demand than that of the prices of the firms it competes with, both domestically and abroad; in other words the direct terms are greater in absolute terms from both the corresponding *within* countries cross-price effects, and the *between* countries cross-price effects. There are no fixed production costs and marginal costs are constant, while $c_{1h} < \theta_{1,o}, c_{2h} < \theta_{2,o}$, $c_{1,f} < \lambda_{1,o}, c_{2,f} < \lambda_{2,o}$, while firms act simultaneously. The profit functions for home and foreign firms, and their optimization problem is as follows:

Home Country:

$$\max_{p_{1,h}} \Pi_{1,h}(P_h, P_f; S) = \max_{P_{1,h}} \left[\theta_{1,o} + \theta_{11,h}P_{1,h} + \theta_{12,h}P_{2,h}^* + \theta_{11,f}SP_{1,f}^* + \theta_{12,f}SP_{2,f}^*\right][P_{1,h} - c_{1,h}]$$

$$\max_{p_{2,h}} \Pi_{2,h}(P_h, P_f; S) = \max_{P_{2,h}} \left[\theta_{2,o} + \theta_{21,h}P_{1,h}^* + \theta_{22,h}P_{2,h} + \theta_{21,f}SP_{1,f}^* + \theta_{22,f}SP_{2,f}^*\right][P_{2,h} - c_{2,h}]$$

Foreign Country:

$$\max_{P_{1,f}} \Pi_f(P_h, P_f; S) = \max_{P_{1,f}} \left[\lambda_{1,o} + \lambda_{11,f}P_{1,f} + \lambda_{12,f}P_{2,f}^* + \lambda_{11,h}\frac{1}{S}P_{1,h}^* + \lambda_{12,h}\frac{1}{S}P_{2,h}^*\right][P_{1,f} - c_{1,f}]$$

$$\max_{P_{2,f}} \Pi_f(P_h, P_f; S) = \max_{P_{2,f}} \left[\lambda_{2,o} + \lambda_{21,f}P_{1,f}^* + \lambda_{22,f}P_{2,f} + \lambda_{21,h}\frac{1}{S}P_{1,h}^* + \lambda_{22,h}\frac{1}{S}P_{2,h}^*\right][P_{2,f} - c_{2,f}]$$

In order to obtain the optimal prices we need to set:

$$\left[\frac{\partial \Pi_{1,h}}{\partial P_{1,h}}, \quad \frac{\partial \Pi_{2,h}}{\partial P_{2,h}}, \quad \frac{\partial \Pi_{1,f}}{\partial P_{1,f}}, \quad \frac{\partial \Pi_{2,f}}{\partial P_{2,f}}\right]' = [0, \quad 0, \quad 0, \quad 0]'$$

Solving we get:

$$\begin{bmatrix} P_{1,h}^* \\ P_{2,h}^* \\ P_{1,f}^* \\ P_{2,f}^* \end{bmatrix} = \begin{bmatrix} \frac{1}{2}\left(c_{1,h} - \frac{\theta_{1,o}}{\theta_{11,h}} - \frac{\theta_{12,h}}{\theta_{11,h}}P_{2,h}^* - \frac{\theta_{11,f}}{\theta_{11,h}}SP_{1,f}^* - \frac{\theta_{12,f}}{\theta_{11,h}}SP_{2,f}^*\right) \\ \frac{1}{2}\left(c_{2,h} - \frac{\theta_{2,o}}{\theta_{22,h}} - \frac{\theta_{21,h}}{\theta_{22,h}}P_{1,h}^* - \frac{\theta_{21,f}}{\theta_{22,h}}SP_{1,f}^* - \frac{\theta_{22,f}}{\theta_{22,h}}SP_{2,f}^*\right) \\ \frac{1}{2}\left(c_{1,f} - \frac{\lambda_{1,o}}{\lambda_{11,f}} - \frac{\lambda_{12,f}}{\lambda_{11,f}}P_{2,f}^* - \frac{\lambda_{11,h}}{\lambda_{11,f}}\frac{1}{S}P_{1,h}^* - \frac{\lambda_{12,h}}{\lambda_{11,f}}\frac{1}{S}P_{2,h}^*\right) \\ \frac{1}{2}\left(c_{2,f} - \frac{\lambda_{2,o}}{\lambda_{22,f}} - \frac{\lambda_{21,f}}{\lambda_{22,f}}P_{1,f}^* - \frac{\lambda_{21,h}}{\lambda_{22,f}}\frac{1}{S}P_{1,h}^* - \frac{\lambda_{22,h}}{\lambda_{22,f}}\frac{1}{S}P_{2,h}^*\right) \end{bmatrix}$$

with a gradient vector equal to:

$$\nabla\begin{bmatrix}P_{1,h}^{*}\\P_{2,h}^{*}\\P_{1,f}^{*}\\P_{2,f}^{*}\end{bmatrix}=\begin{bmatrix}-\frac{1}{2}\frac{\theta_{12,h}}{\theta_{11,h}}-\frac{1}{2}\frac{\theta_{11,f}}{\theta_{11,h}}S-\frac{1}{2}\frac{\theta_{12,f}}{\theta_{1,h}}S\\-\frac{1}{2}\frac{\theta_{21,h}}{\theta_{22,h}}-\frac{1}{2}\frac{\theta_{21,f}}{\theta_{22,h}}S-\frac{1}{2}\frac{\theta_{22,f}}{\theta_{22,h}}S\\-\frac{1}{2}\frac{\lambda_{12,f}}{\lambda_{11,f}}-\frac{1}{2}\frac{\lambda_{11,h}}{\lambda_{11,f}}\frac{1}{S}-\frac{1}{2}\frac{\lambda_{12,h}}{\lambda_{11,f}}\frac{1}{S}\\-\frac{1}{2}\frac{\lambda_{21,f}}{\lambda_{22,f}}-\frac{1}{2}\frac{\lambda_{21,h}}{\lambda_{22,f}}\frac{1}{S}-\frac{1}{2}\frac{\lambda_{22,h}}{\lambda_{22,f}}\frac{1}{S}\end{bmatrix}$$

which is positive definite, since its elements are positive. Solving the above system of four equations with four unknowns will obtain:

$$\begin{bmatrix}2\theta_{11,h}+\theta_{12,h}+\theta_{11,f}S+\theta_{12,f}S\\\theta_{21,h}+2\theta_{22,h}+\theta_{21,f}S+\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}+\lambda_{12,h}\frac{1}{S}+2\lambda_{11,f}+\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}+\lambda_{22,h}\frac{1}{S}+\lambda_{21,f}+2\lambda_{22,f}\end{bmatrix}\begin{bmatrix}P_{1,h}^{*}\\P_{2,h}^{*}\\P_{1,f}^{*}\\P_{2,f}^{*}\end{bmatrix}=\begin{bmatrix}\theta_{1,o}-\theta_{11,h}c_{1,h}\\\theta_{2,o}-\theta_{22,h}c_{2,h}\\\lambda_{1,o}-\lambda_{11,f}c_{1,f}\\\lambda_{2,o}-\lambda_{22,f}c_{2,f}\end{bmatrix}$$

The determinant $\Delta=\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{21,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}$ is the equivalent of the expression Δ in the 1x1 model. The four equilibrium prices for the Bertrand model (omitting the B superscripts for simplicity) are:

$$P_{1,h}^{*}=\frac{\begin{vmatrix}\theta_{1,o}-\theta_{11,h}c_{1,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{2,o}-\theta_{22,h}c_{2,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{1,o}-\lambda_{11,f}c_{1,f}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{2,o}-\lambda_{22,f}c_{2,f}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}}{\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{21,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}},\ P_{2,h}^{*}=\frac{\begin{vmatrix}2\theta_{11,h}&\theta_{1,o}-\theta_{11,h}c_{1,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{21,h}&\theta_{2,o}-\theta_{22,h}c_{2,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{1,o}-\lambda_{11,f}c_{1,f}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{2,o}-\lambda_{22,f}c_{2,f}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}}{\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{21,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}}$$

$$P_{1,f}^{*}=\frac{\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{1,o}-\theta_{11,h}c_{1,h}&\theta_{12,f}S\\\theta_{21,h}&2\theta_{22,h}&\theta_{2,o}-\theta_{22,h}c_{2,h}&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&\lambda_{1,o}-\lambda_{11,f}c_{1,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{2,o}-\lambda_{22,f}c_{2,f}&2\lambda_{22,f}\end{vmatrix}}{\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{21,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}},\ P_{2,f}^{*}=\frac{\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{1,o}-\theta_{11,h}c_{1,h}\\\theta_{21,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{2,o}-\theta_{22,h}c_{2,h}\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{1,o}-\lambda_{11,f}c_{1,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&\lambda_{2,o}-\lambda_{22,f}c_{2,f}\end{vmatrix}}{\begin{vmatrix}2\theta_{11,h}&\theta_{12,h}&\theta_{11,f}S&\theta_{12,f}S\\\theta_{21,h}&2\theta_{22,h}&\theta_{21,f}S&\theta_{22,f}S\\\lambda_{11,h}\frac{1}{S}&\lambda_{12,h}\frac{1}{S}&2\lambda_{11,f}&\lambda_{12,f}\\\lambda_{21,h}\frac{1}{S}&\lambda_{22,h}\frac{1}{S}&\lambda_{21,f}&2\lambda_{22,f}\end{vmatrix}}$$

We next study the effect of S on home and foreign prices and profits in a 2-country-2-firm-Bertrand-framework. The impact of a change in S on the prices of home and foreign firms is given by the vector: $\frac{\partial P^{*B}}{\partial S} = [\frac{\partial P^{*B}_{1,h}}{\partial S}, \quad \frac{\partial P^{*B}_{2,h}}{\partial S}, \quad \frac{\partial P^{*B}_{1,f}}{\partial S}, \quad \frac{\partial P^{*B}_{2,f}}{\partial S}]'$. In the 1x1 Bertrand model we proved that a foreign-exchange rate appreciation decreases (increases) the price of the firm in the appreciating (depreciating) country. The proposition below shows that this may not be the case in the 2x2 Bertrand model. The introduction of the *within* countries competition complicates the results. The *within* effect may be in the opposite direction to the *between* countries effect, and if this is the case and the former dominates in size the latter it will lead to an increase (decrease) of the price of the firms in the appreciating (depreciating) country following a foreign-exchange rate appreciation depending on the values of the parameters.

Proposition 4.

A foreign currency appreciation makes:

1. The optimal prices of the home goods more expensive when the following two conditions hold for the first good:

   a. $[(\lambda_{1,o} - \lambda_{11,f}c_{1,f})\lambda_{22,h} - (\lambda_{2,o} - \lambda_{22,f}c_{2,f})\lambda_{12,h}] \begin{vmatrix} \theta_{11,f} & \theta_{12,f} \\ \theta_{21,f} & \theta_{22,f} \end{vmatrix} > 0$

   b. $abs\left\{[(\lambda_{1,o} - \lambda_{11,f}c_{1,f})\lambda_{22,h} - (\lambda_{2,o} - \lambda_{22,f}c_{2,f})\lambda_{12,h}] \left|\begin{matrix} \theta_{11,f} & \theta_{12,f} \\ \theta_{21,f} & \theta_{22,f} \end{matrix}\right|\right\} >$

   $abs\{[(\lambda_{1,o} - \lambda_{11,f}c_{1,f})2\lambda_{22,f} - (\lambda_{2,o} - \lambda_{22,f}c_{2,f})\lambda_{12,,f}] \begin{vmatrix} \theta_{12,h} & \theta_{11,f} \\ 2\theta_{22,h} & \theta_{21,f} \end{vmatrix} -$

   $[(\lambda_{1,o} - \lambda_{11,f}c_{1,f})\lambda_{21,f} - (\lambda_{2,o} - \lambda_{22,f}c_{2,f})2\lambda_{11,f}] \begin{vmatrix} \theta_{12,h} & \theta_{12,f} \\ 2\theta_{22,h} & \theta_{22,f} \end{vmatrix}\}$

   and similarly the following two conditions for the second good:

   c. $[(\lambda_{1,o} - \lambda_{11,f}c_{1,f})\lambda_{21,h} - (\lambda_{2,o} - \lambda_{22,f}c_{2,f})\lambda_{11,h}] \begin{vmatrix} \theta_{11,f} & \theta_{12,f} \\ \theta_{21,f} & \theta_{22,f} \end{vmatrix} < 0$

d. $abs\left\{\left[(\lambda_{1,o}-\lambda_{11,f}c_{1,f})\lambda_{21,h}-(\lambda_{2,o}-\lambda_{22,f}c_{2,f})\lambda_{11,h}\right]\begin{vmatrix}\theta_{11,f} & \theta_{12,f}\\ \theta_{21,f} & \theta_{22,f}\end{vmatrix}\right\}>$

$abs\{\left[(\lambda_{1,o}-\lambda_{11,f}c_{1,f})\lambda_{21,f}-(\lambda_{2,o}-\lambda_{22,f}c_{2,f})2\lambda_{11,f}\right]\begin{vmatrix}2\theta_{11,h} & \theta_{12,f}\\ \theta_{21,h} & \theta_{22,f}\end{vmatrix}-$

$\left[(\lambda_{1,o}-\lambda_{11,f}c_{1,f})2\lambda_{22,f}-(\lambda_{2,o}-\lambda_{22,f}c_{2,f})\lambda_{12,f}\right]\begin{vmatrix}2\theta_{11,h} & \theta_{11,f}\\ \theta_{21,h} & \theta_{21,f}\end{vmatrix}\}$

2. Their optimal prices of the foreign rivals cheaper when the following conditions hold for the first good:

a. $\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})\theta_{22,f}-(\theta_{2,o}-\theta_{22,h}c_{2,h})\theta_{12,f}\right]\begin{vmatrix}\lambda_{11,h} & \lambda_{12,h}\\ \lambda_{21,h} & 2\lambda_{22,h}\end{vmatrix}>0$

b. $abs\left\{\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})\theta_{22,f}-(\theta_{2,o}-\theta_{22,h}c_{2,h})\theta_{12,f}\right]\begin{vmatrix}\lambda_{11,h} & \lambda_{12,h}\\ \lambda_{21,h} & 2\lambda_{22,h}\end{vmatrix}\right\}>$

$abs\{\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})\theta_{21,h}-(\theta_{2,o}-\theta_{22,h}c_{2,h})2\theta_{11,h}\right]\begin{vmatrix}\lambda_{12,h} & \lambda_{12,f}\\ \lambda_{22,h} & 2\lambda_{22,f}\end{vmatrix}-$

$\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})2\theta_{22,h}-(\theta_{2,o}-\theta_{22,h}c_{2,h})\theta_{12,h}\right]\begin{vmatrix}\lambda_{11,h} & \lambda_{12,f}\\ \lambda_{21,h} & 2\lambda_{22,f}\end{vmatrix}\}$

and similarly the following two conditions for the second good:

c. $\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})\theta_{21,f}-(\theta_{2,o}-\theta_{22,h}c_{2,h})\theta_{11,f}\right]\begin{vmatrix}\lambda_{11,h} & \lambda_{12,h}\\ \lambda_{21,h} & \lambda_{22,h}\end{vmatrix}<0$

d. $abs\left\{\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})\theta_{21,f}-(\theta_{2,o}-\theta_{22,h}c_{2,h})\theta_{11,f}\right]\begin{vmatrix}\lambda_{11,h} & \lambda_{12,h}\\ \lambda_{21,h} & \lambda_{22,h}\end{vmatrix}\right\}>$

$abs\{\frac{1}{S^2}\left\{\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})\theta_{21,h}-(\theta_{2,o}-\theta_{22,h}c_{2,h})2\theta_{11,h}\right]\begin{vmatrix}\lambda_{12,h} & 2\lambda_{11,f}\\ \lambda_{22,h} & \lambda_{21,f}\end{vmatrix}-\right.$

$\left.\left[(\theta_{1,o}-\theta_{11,h}c_{1,h})2\theta_{22,h}-(\theta_{2,o}-\theta_{22,h}c_{2,h})\theta_{12,h}\right]\begin{vmatrix}\lambda_{11,h} & 2\lambda_{11,f}\\ \lambda_{21,h} & \lambda_{21,f}\end{vmatrix}\right\}$

Proof.

Please refer to the MA.

We have shown in the 1x1 case, where there is only *between* competition and no *within* competition, that this results to a positive (negative) derivative of the equilibrium price of the home (foreign) firm with respect to *S.* In contrast, we now infer from looking on the LHS of the inequalities in Proposition 4, that in the 2x2 case these derivatives depend on the home and foreign determinants $\begin{vmatrix}\theta_{11,f} & \theta_{12,f}\\ \theta_{21,f} & \theta_{22,f}\end{vmatrix}$ and $\begin{vmatrix}\lambda_{11,h} & \lambda_{12,h}\\ \lambda_{21,h} & \lambda_{22,h}\end{vmatrix}$ respectively (containing the between countries substitution parameters), the own substitution parameters and costs of the two overseas rival goods, and the cross substitution parameters of the domestic rival in the demand functions of the overseas country.

While an increase in *S* in the 1x1 model decreases (increases) the equilibrium price of the appreciating (depreciating) country, the introduction of the *within* competition may have the reverse sign which and may dominate the *between* competition, depending on the signs and values of the parameters. In other words, the *within* effect allows the equilibrium price elasticities with respect to S of all firms to be either positive or negative and hence exposure can be either positive or negative depending on the relative sizes of these two which in turn depends on the values of the parameters.

We now turn to the impact of *S* on the equilibrium profits of the two home and two foreign countries, i.e.: $\frac{\partial \Pi^*_{1,h}}{\partial S}, \frac{\partial \Pi^*_{2,h}}{\partial S}, \frac{\partial \Pi^*_{1,f}}{\partial S}, \frac{\partial \Pi^*_{2,f}}{\partial S}$. These are easy to calculate using the F.O.Cs and replace the outputs using the demand functions (5).

Proposition 5.

The impact of *S* on the profit of each home firm depends on the elasticities of its competitors, domestic and foreign. More specifically, it depends on the sign (and if negative on the size too) of the partial elasticity of the two foreign firms with respect to *S*. It also, depends on the sign and size of the elasticity of the price of the rival home firm with respect to *S*. This is easy to check by looking at the derivatives of the profit functions of each of the two home firms:

$$\frac{\partial \Pi^*_{i,h}}{\partial S} = P^*_{i,h}\, m^*_{i,h}\left[\theta_{ij,h} P^*_{j,h}\frac{\varepsilon_{P^*_{j,h},S}}{S} + \theta_{ii,f} P^*_{i,f}\left(1+\varepsilon_{P^*_{i,f},S}\right) + \theta_{ij,f} P^*_{j,f}\left(1+\varepsilon_{P^*_{j,f},S}\right)\right]$$

for *i=1,2, j=1,2, j≠ i* ,where, $\varepsilon_{P^*_{i,h},S} = \frac{\partial P^*_{i,h}}{\partial S}\frac{S}{P^*_{i,h}}, \varepsilon_{P^*_{j,h},S} = \frac{\partial P^*_{j,h}}{\partial S}\frac{S}{P^*_{j,h}}$ are the partial elasticities of the foreign prices at their equilibrium point with respect to the exchange rate *S*, i.e. the exchange rate pass-through of foreign competitors. The term $\varepsilon_{P^*_{j,h},S} = \frac{\partial P^*_{j,h}}{\partial S}\frac{S}{P^*_{j,h}}$ is the partial elasticity of the home rival price, a *within market* exchange rate pass-through. Finally, the term

$m_{i,h}^{*} = \frac{\left(P_{i,h}^{*} - c_{i,h}\right)}{P_{i,h}^{*}}$ is the equilibrium price-cost-margin of the *i* home firm. Here the price elasticities, in contrast to the 1x1 case, can be either negative or positive, because of the existence of both *within* and *between* countries competition.

Similarly, the impact of *S* on the profit of each foreign firm depends on the sign (and if positive on the size too) of the partial elasticity of the two home firms with respect to *S*, and also on the sign and size of the elasticity of the price of the rival foreign firm with respect to *S*. This is derived by calculating the derivatives of profit functions for each of the two foreign firms: $\frac{\partial \Pi_{if}^{*}}{\partial S} = P_{i,f}^{*}\, m_{i,f}^{*} \left[\lambda_{ij,f} P_{j,f}^{*} \frac{\varepsilon_{P_{j,f}^{*},S}}{S} + \lambda_{ii,h} P_{i,h}^{*} \left(\varepsilon_{P_{i,h}^{*},S} - 1\right) + \lambda_{ij,h} P_{j,f}^{*} \left(\varepsilon_{P_{j,h}^{*},S} - 1\right)\right]$ for *i=1,2, j=1,2, j≠ i,* where, $\varepsilon_{P_{i,h}^{*},S} = \frac{\partial P_{i,h}^{*}}{\partial S} \frac{S}{P_{i,h}^{*}}, \varepsilon_{P_{j,h}^{*},S} = \frac{\partial P_{j,h}^{*}}{\partial S} \frac{S}{P_{j,h}^{*}}$ are the partial elasticities of the home prices at their equilibrium point with respect to the exchange rate *S.* Again the price elasticities, in contrast to the 1x1 case, can be either negative or positive, because of the existence of both *within* and *between* countries competition. The term $\varepsilon_{P_{j,f}^{*},S} = \frac{\partial P_{j,f}^{*}}{\partial S} \frac{S}{P_{j,f}^{*}}$ is the partial elasticity of the foreign rival price or the *within market* exchange rate pass-through. Finally, the term $m_{i,f}^{*} = \frac{\left(P_{i,f}^{*} - c_{i,h}\right)}{P_{i,f}^{*}}$ is the equilibrium price-cost-margin of the *i* foreign firm.

Hence profits are dependent on the exchange rate price elasticity of the overseas rivals and also on the impact of a change in *S* on the price of the domestic rival. The analogy with the 1x1 case is obvious; if there is no *within* countries competition and there is only one foreign rival the above relations collapse to the relations from proposition (1) in paragraph (3.1.1.1).

To summarize, in the 2x2 case the link between the pass through of each firm on the exposure of the other firm remains, but it is more complicated as compared to the 1x1 case. In the 1x1 case if the pass on of the foreign firm is inelastic, then $\frac{\partial \Pi_{h}^{*B}}{\partial S} > 0$ and hence exposure is positive. In the 2x2 case it depends on the sign (and if negative on the size too) of the pass on of both foreign firms and it also, depends on the sign and size of the elasticity of the price of the rival home firm with respect to *S*. For example, in the Sports market if Adidas competes in an international duopoly with Nike, then its exposure to EUR/USD is positive when the pass on of Nike is inelastic. However, if there is another domestic competitor to Adidas, say Puma, then the exposure of the former firm will also be affected by the *within* competitor and its exposure can be either positive or negative depending on the sign and size of the price elasticities with respect to S of the domestic (Puma) and foreign (Adidas) competitor.

3.2.2. Between and Within Countries Cournot Competition

In this paragraph we study the impact of S on equilibrium profits and prices when firms set quantities both *within* country and *between* countries, e.g. the Cournot framework, so we invert the demand functions (Eq. (5)) to give the prices that will "clear" the markets for given outputs:

$$\begin{bmatrix} P_{1,h} \\ P_{2,h} \\ P_{1,f} \\ P_{2,f} \end{bmatrix} = \begin{bmatrix} \theta_{11,h} & \theta_{12,h} & \theta_{11,f}S & \theta_{12,f}S \\ \theta_{21,h} & \theta_{22,h} & \theta_{21,f}S & \theta_{22,f}S \\ \lambda_{11,h}\frac{1}{S} & \lambda_{12,h}\frac{1}{S} & \lambda_{11,f} & \lambda_{12,f} \\ \lambda_{21,h}\frac{1}{S} & \lambda_{22,h}\frac{1}{S} & \lambda_{21,f} & \lambda_{22,f} \end{bmatrix}^{-1} \begin{bmatrix} q_{1,h} - \theta_{1,o} \\ q_{2,h} - \theta_{2,o} \\ q_{1,f} - \lambda_{1,o} \\ q_{2,f} - \lambda_{2,o} \end{bmatrix}$$

Or by partitioning the system, $\begin{bmatrix} q_h \\ q_f \end{bmatrix} = \begin{bmatrix} \theta_o \\ \lambda_o \end{bmatrix} + \begin{bmatrix} \Theta_h & S\Theta_f \\ \frac{1}{S}\Lambda_h & \Lambda_f \end{bmatrix} \begin{bmatrix} P_h \\ P_f \end{bmatrix}$, where $P_h = \begin{bmatrix} P_{1,h} \\ P_{2,h} \end{bmatrix}$ and $P_f = \begin{bmatrix} P_{1,f} \\ P_{2,f} \end{bmatrix}$ are the vectors of home and foreign prices, $q_h = \begin{bmatrix} q_{1,h} \\ q_{2,h} \end{bmatrix}$ and $q_f = \begin{bmatrix} q_{1,f} \\ q_{2,f} \end{bmatrix}$ are the vectors of home and foreign quantities, Θ_h, Θ_f are the home matrices of own and cross substitution parameters between home prices and foreign prices respectively, and Λ_h, Λ_f are the foreign matrices of own and cross substitution parameters for home prices and foreign prices respectively. To solve for the prices, we need:

$$\begin{bmatrix} \Theta_h & S\Theta_f \\ \frac{1}{S}\Lambda_h & \Lambda_f \end{bmatrix}^{-1}$$

$$= \begin{bmatrix} \left(\Theta_h - S\Theta_f{\Lambda_f}^{-1}\frac{1}{S}\Lambda_h\right)^{-1} & -{\Theta_h}^{-1}S\Theta_f(\Lambda_f - \frac{1}{S}\Lambda_h{\Theta_h}^{-1}S\Theta_f)^{-1} \\ -\left(\Theta_h - S\Theta_f{\Lambda_f}^{-1}\frac{1}{S}\Lambda_h\right)^{-1}{\Lambda_f}^{-1}\frac{1}{S}\Lambda_h & (\Lambda_f - \frac{1}{S}\Lambda_h{\Theta_h}^{-1}S\Theta_f)^{-1} \end{bmatrix}$$

$$\Theta^{-1} = \begin{bmatrix} (A_{11})^{-1} & -S{\Theta_h}^{-1}\Theta_f(A_{22})^{-1} \\ -\frac{1}{S}{\Lambda_f}^{-1}\Lambda_h(A_{11})^{-1} & (A_{22})^{-1} \end{bmatrix},$$

where, $A_{11} = \Theta_h - \Theta_f {\Lambda_f}^{-1} \Lambda_h$, $A_{22} = \Lambda_f - \Lambda_h {\Theta_h}^{-1} \Theta_f$, $det(\Theta_h) = \Delta_1 = \theta_{11,h}\theta_{22,h} - \theta_{12,h}\theta_{21,h} > 0$ and $\det(\Lambda_f) = \Delta_2 = \lambda_{11,f}\lambda_{22,f} - \lambda_{12,f}\lambda_{21,f} > 0$. As the firms produce substitutes, the cross price effects (the off-diagonal terms of Θ) are positive. The matrix Θ_h is negative definite, since its diagonal elements are negative; its off-diagonal terms (i.e. the cross price effects) are positive. Also the "*between countries*" substitution matrix Θ_f is positive definite, since its diagonal elements are positive. We need to calculate the following matrices and we can prove that their off diagonal elements of:

$$(A_{11})^{-1} = \left(\Theta_h - \Theta_f {\Lambda_f}^{-1} \Lambda_h\right)^{-1},\ (A_{22})^{-1} = \left(\Lambda_f - \Lambda_h {\Theta_h}^{-1} \Theta_f\right)^{-1}$$

are negative (please refer to the MA).We also calculate ${\Theta_h}^{-1}\Theta_f$ and ${\Lambda_f}^{-1}\Lambda_h$. We show that these matrices are negative definite and that their off diagonal terms are also negative (please refer to the MA). Hence:

$$P_h = (A_{11})^{-1}(q_h - \theta_o) - S{\Theta_h}^{-1}\Theta_f (A_{22})^{-1}(q_f - \lambda_o)$$

$$P_f = -\frac{1}{S}{\Lambda_f}^{-1}\Lambda_h (A_{11})^{-1}(q_h - \theta_o) + (A_{22})^{-1}(q_f - \lambda_o)$$

There is a clear correspondence between these values and those derived in the Cournot 1x1 model, e.g.

$$P_h = \frac{\theta_f S\lambda_o - \lambda_f\theta_o}{a} + \frac{\lambda_f}{a} q_h - \frac{\theta_f}{a} S q_f = \frac{\lambda_f}{a}(q_h - \theta_o) - S\frac{\theta_f}{a}(q_f - \lambda_o)$$

$$P_f = \frac{\lambda_h\theta_o - \theta_h\lambda_o S}{aS} - \lambda_h \frac{1}{Sa} q_h + \frac{\theta_h}{a} q_f = -\frac{\lambda_h}{aS}(q_h - \theta_o) + \frac{\theta_h}{a}(q_f - \lambda_o)$$

where, $a = \theta_h\lambda_f - \theta_f\lambda_h > 0$. The difference is of course that in the first set of equations $q_h, \theta_o, q_f, \lambda_o, P_h, P_f$ are all vectors, while in the second set they are scalars. The replacement of $\frac{\theta_h}{a}$ $(\frac{\lambda_f}{a})$ in the 1x1 model with $(A_{22})^{-1}$ $((A_{11})^{-1})$ in the 2x2 model and the replacement of $\frac{\theta_f}{a}$ $(\frac{\lambda_h}{a})$ by ${\Theta_h}^{-1}\Theta_f(A_{22})^{-1}({\Lambda_f}^{-1}\Lambda_h(A_{11})^{-1})$ indicates the addition of within competition in the model.

We next turn our attention to the optimisation of the payoff functions of the home and foreign firms:

Home Country:

$$[\frac{\partial \Pi_{1,h}}{\partial q_{1,h}}, \quad \frac{\partial \Pi_{2,h}}{\partial q_{2,h}}]' = [0, \quad 0]' \Leftrightarrow [\frac{\partial (\mathrm{P}_{1,h} \cdot q_{1,h})}{\partial q_{1,h}}, \quad \frac{\partial (\mathrm{P}_{2,h} \cdot q_{2,h})}{\partial q_{2,h}}]' - [c_{1,h}, \quad c_{2,h}]' = [0, \quad 0]'$$

Hence F.O.C.:

$$2(A_{11})^{-1}(q_h) - S\Theta_h{}^{-1}\Theta_f(A_{22})^{-1}q_f = (A_{11})^{-1}\theta_o - \Theta_h{}^{-1}S\Theta_f(A_{22})^{-1}\lambda_o + c_h$$

Foreign Country:

$$[\frac{\partial \Pi_{1,f}}{\partial q_{1,f}}, \quad \frac{\partial \Pi_{2,f}}{\partial q_{2,f}}]' = [0, \quad 0]' \Leftrightarrow [\frac{\partial (\mathrm{P}_{1,f} \cdot q_{1,f})}{\partial q_{1,f}}, \quad \frac{\partial (\mathrm{P}_{2,f} \cdot q_{2,f})}{\partial q_{2,f}}]' - [c_{1,f}, \quad c_{2,f}]' = [0, \quad 0]'$$

Hence F.O.C:

$$-\frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1}(q_h) + 2(A_{22})^{-1}(q_f) = (A_{22})^{-1}\lambda_o - \frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1}\theta_o + c_f$$

Solving for the two F.O.Cs derived above, we obtain the vectors q_h^* *and* q_f^* (omitting the C superscripts for simplicity):

$$q_h^* = \frac{\begin{vmatrix} (A_{11})^{-1}\theta_o - S\Theta_h{}^{-1}\Theta_f(A_{22})^{-1}\lambda_o + c_h & -S\Theta_h{}^{-1}\Theta_f(A_{22})^{-1} \\ (A_{22})^{-1}\lambda_o - \frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1}\theta_o + c_f & 2(A_{22})^{-1} \end{vmatrix}}{\begin{vmatrix} 2(A_{11})^{-1} & -\Theta_h{}^{-1}S\Theta_f(A_{22})^{-1} \\ -\frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1} & 2(A_{22})^{-1} \end{vmatrix}} \text{ and}$$

$$q_f^* = \frac{\begin{vmatrix} 2(A_{11})^{-1} & (A_{11})^{-1}\theta_o - S\Theta_h{}^{-1}\Theta_f(A_{22})^{-1}\lambda_o + c_h \\ -\frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1} & (A_{22})^{-1}\lambda_o - \frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1}\theta_o + c_f \end{vmatrix}}{\begin{vmatrix} 2(A_{11})^{-1} & -S\Theta_h{}^{-1}\Theta_f(A_{22})^{-1} \\ -\frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1} & 2(A_{22})^{-1} \end{vmatrix}}.$$

We now study how *S*, in a 2-country-2-firm-Cournot-setting - affects the home and foreign prices and profits. To do this we first evaluate the impact of *S* on equilibrium outputs. While in the 1x1 Cournot model a foreign-currency appreciation increases (decreases) the equilibrium quantity of the firm in the appreciating (depreciating) country, the following proposition shows that this is not necessary in the 2x2 Cournot model. The addition of *within* competition leads an ambiguous sign for the partial derivatives of the equilibrium quantities with respect to S as these depend on whether the *between* competition impact more than exceeds the *within* competition impact or not, in a similar way to the one discussed in the Bertrand model.

Proposition 6.

In the 2x2 Cournot model a foreign-exchange rate appreciation increases the equilibrium quantity of the home goods when:

$$\begin{vmatrix} 2(A_{11})^{-1} & -{\Theta_h}^{-1}S\Theta_f(A_{22})^{-1} \\ -\frac{1}{S}{\Lambda_f}^{-1}\Lambda_h(A_{11})^{-1} & 2(A_{22})^{-1} \end{vmatrix} \begin{bmatrix} q_{1,h}^* \\ q_{2,h}^* \end{bmatrix} =$$
$$-{\Theta_h}^{-1}\Theta_f(A_{22})^{-2}\lambda_o + {\Theta_h}^{-1}\Theta_f(A_{22})^{-1}c_f > \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

It also decreases the equilibrium quantity of the foreign goods when:

$$\begin{vmatrix} 2(A_{11})^{-1} & -{\Theta_h}^{-1}S\Theta_f(A_{22})^{-1} \\ -\frac{1}{S}{\Lambda_f}^{-1}\Lambda_h(A_{11})^{-1} & 2(A_{22})^{-1} \end{vmatrix} \begin{bmatrix} q_{1,f}^* \\ q_{2,f}^* \end{bmatrix} =$$
$$= -\frac{1}{S^2}{\Lambda_f}^{-1}\Lambda_h(A_{11})^{-1}c_h + \frac{1}{S^2}{\Lambda_f}^{-1}\Lambda_h(A_{11})^{-2}\theta_o < \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Proof.

Please refer to the MA.

In plain English a foreign-currency appreciation increases (decreases) the equilibrium quantity of the home (foreign) goods when the *between* competition impact either dominates the *within* competition impact, or is re-enforced by it when the latter has the same sign. In other words, if by adding a *within* competition dimension in the 2x2 model we find that equilibrium quantity of the home (foreign) goods decreases (increases) as a result of a foreign currency appreciation, then this reversal of signs in the impact of the exchange rate on the equilibrium quantities implies that the *within* competition effect is an opposing force to the *between* competition effect and that the former dominates the latter. The impact of the exchange rates on the prices is given by the derivatives of the optimal price vectors with respect to S are:

$$\frac{\partial P_h^*}{\partial S}(A_{11})^{-1}\left(\frac{\partial q_h^*}{\partial S}\right) - S{\Theta_h}^{-1}\Theta_f(A_{22})^{-1}\left(\frac{\partial q_f^*}{\partial S}\right) - {\Theta_h}^{-1}\Theta_f(A_{22})^{-1}(q_f^* - \lambda_o)$$

$$\frac{\partial P_f^*}{\partial S}=\frac{1}{S^2}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1}(q_h^*-\theta_o)-\frac{1}{S}\Lambda_f{}^{-1}\Lambda_h(A_{11})^{-1}\left(\frac{\partial q_h^*}{\partial S}\right)+(A_{22})^{-1}\left(\frac{\partial q_f^*}{\partial S}\right)$$

Finally, the derivatives of the profit vectors with respect to *S* as set out below measure the impact of the exchange rate on the equilibrium profits of the two home firms and two foreign firms respectively:

$$\frac{\partial \Pi_h^*}{\partial S}=\frac{\partial q_h^*[P_h^*-c_h]}{\partial S}=\frac{\partial q_h^*}{\partial S}[P_h^*-c_h]+\frac{\partial P_h^*}{\partial S}q_h^*$$
$$\frac{\partial \Pi_f^*}{\partial S}=\frac{\partial q_f^*[P_f^*-c_f]}{\partial S}=\frac{\partial q_f^*}{\partial S}[P_f^*-c_f]+\frac{\partial P_f^*}{\partial S}q_f^*$$

The signs of both the prices and the profits are indeterminate given on the earlier results regarding the signs of the optimal quantity vectors after the introduction of the *within* competition, which was absent in the 1x1 case.

4. Profit and value maximization

Value and profit maximization are not equivalent objectives as they differ in a number of different aspects. The one of importance here is that profit maximization ignores the time dependence of profits. In other words, profit maximization is a short-sighted goal, and firm value maximization a long-sighted one. To reconcile these two goals we need to assume that the value of the firm is a time additive function of future profits as we explain below.

However, since the value of the firm is the present value of its future dividends, it is highly correlated with profits. The value V_t of a stock at time *t* is the present value of its future stream of dividends D_{t+i}. If we further assume that the dividends are a constant fraction of profits *b*, the dividend policy of the firm is very simple and stable as the value, of the firm at time *t* is the present value of its future stream of profits, at the risk free discount rate r_f:

$$V_t=\sum_{i=1}^{\infty}\frac{(D_{t+i})}{(1+r_f)^i}=\sum_{i=1}^{\infty}\frac{b(\Pi_{t+i})}{(1+r_f)^i}$$

4.1 Durability and firm value

There is another implicit assumption in the above model, that the value of the firm is a time additive function of future profits namely (time separable over time):

$$V_t = V_t\left(\frac{(\Pi_{t+1})}{\left(1+r_f\right)^1}, \frac{(\Pi_{t+2})}{\left(1+r_f\right)^2}, \cdots, \frac{(\Pi_{t+n})}{\left(1+r_f\right)^n}, \cdots\right) = \sum_{i=1}^{\infty} \frac{(\Pi_{t+i})}{(1+r_f)^i}$$

The last assumption means that the profits of period *t* do not spillover in future periods t+i, for $i = 1, 2, \ldots$. For this to hold we need to assume that there are no adjustment costs, so that the cost structure of the firm is one where costs in the current period do not spill over in future periods. Finally, we need to assume that the demand is not dynamic; consumers neither form expectations about their future purchases, nor do they postpone their purchases to exploit price fluctuations and the product cannot be stored in inventories and thus cannot be consumed in the next period (Levine, 1985). Hence, we need to restrict our study to non-durable goods.

Gross and Schmitt dynamic model recognises that current profits spillover in future periods when the good is durable. They also show that price interdependence matters and the exchange rate changes have significant feedback effects on prices resulting to lower pass-through in the long-run than in the short-run. However, as we have mentioned before, they study only exchange-rate pass through and not foreign exposure in a Bertrand model in which only two foreign firms serve a market with no home production. In our empirical application we proxy long run and short run exposure with stock price and profit exposure respectively.

5. Empirical Application

We examine nine markets and in all of them except the Detergent market there is both *between* and *within* countries competition as in our 2x2 theoretical model. The Detergent market is a 1x1 international oligopoly model, dominated by the British-Dutch Unilever and the US Procter & Gamble (Economist, 2012b).

5.1 Sample

We build an international sample of semiannual data from Bloomberg spanning from 1984 to 2015 presented in Table 1 in the Empirical Appendix (henceforth EA). We look at semiannual profits, converting the profits of those firms that release their profits on a quarterly basis to semiannual. We also consider a number of sub periods based on market data availability to allow for inter firm comparisons. According to Bodnar *et al.*, the 10-year period fulfils the need of a long sample size while at the same time the form of competition in an industry is stable enough to yield meaningful estimates of pricing behavior and profit outcomes. We also, check for any effects stemming from the financial crisis of 2007-2009.

We examine the robustness of the exposure by estimating exposure for the first 10-year period, computing a Huber M-estimator which is more resilient to outliers and by removing distant observations. The standard approach to examine the sensitivity of our results to outliers is to examine the standardized residuals from the regression by dropping each observation in isolation, as well as all of the observations simultaneously from the sample; we remove observations with standardized errors above 2 or below -2 (results are available upon request).

Chow *et al.* (1997) and Bodnar and Wong (2003) argue that stock price exposures are identified better at higher frequencies. Bartram uses three data frequencies: 1, 5 and 9 months; the 5 months are close to our scenario of 6 months. Estimating exposures using longer horizons is more precise given the noise in high-frequency exchange rates in relation to the persistence of movements with low frequency (Bartram; Bodnar and Wong, 2003; Chow *et al.*, 1997).

We study exchange rate exposures using specific markets where firms compete in an international oligopoly, within a price or quantity setting. Our data includes stock prices and profits from twenty-two MNCs from nine developed markets. We use two forms of profits, fiscal and calendar profits after taxes (henceforth PAT) as reported in Bloomberg. The firms in our sample are as follows: eight US firms (Nike, PepsiCo, Coca-Cola, Procter & Gamble [henceforth P&G], Colgate-Palmolive [henceforth Colgate], Estée Lauder [henceforth EL], Mattel and Hasbro) whose PAT are in US dollars (USD). Five French firms (LVMH Moët Hennessy Louis Vuitton SE [henceforth LVMH], Pernod-Ricard [henceforth RI FP], L'Oréal, Danone, Rémy Martin). Two German firms (Adidas, Puma), two Dutch firms (Heineken, Unilever [henceforth UN]) and one Belgian (Anheuser-Busch [henceforth AB-InBev]). These ten firms have their PAT in Euros (EUR). Finally, there is one Japanese firm (Shiseido) whose PAT is in Japanese yen (JPY), one Swiss (Nestlé) whose PAT is in Swiss francs (CHF), one British (SABMiller) whose PAT is in British pounds (GBP) and one Danish (Carlsberg) whose PAT is in Danish Krone (DKK).

We chose these markets, and these countries for several reasons apart from data availability. First, we wished to study international oligopolies to enable us to test the findings of our theoretical models in terms of the impact of changes in exchange rates. Second, we chose markets of differentiated consumable goods since we study a simple static framework and for this we need to assume that profits of period *t* do not spill in subsequent periods. Third, as mentioned above, we also study the effect of the financial crisis on stock prices and profits. Finally, it is reasonable to assume that these nine markets are internationally integrated and the world indices are good proxies for the global market portfolio. The next section gives a brief description of each market.

5.2 Markets and Market structure

We study nine markets within which these twenty-two MNCs compete. Four of them, act in more than one international market: Nestlé (Food processing, Pet food and Bottled water), PepsiCo (Food processing and Bottled water), P&G (Detergent, Pet food and Cosmetics) and UN (Detergent and Cosmetics). In this way Nestlé faces competition from USD in all its markets and from EUR from its Bottled water segment. PepsiCo from CHF and from EUR from its Bottled water segment. P&G faces competition in each market from a different currency: from EUR in Detergent, from CHF in Pet food and from EUR and JPY in cosmetics. Finally, UN faces pressures from USD in Detergent and from USD and JPY in Cosmetics. Below, we briefly describe each market (for full details please refer to the EA).

1) *Apparel, Sports clothing, and Accessories*. It forms an oligopoly, followed by a fringe of firms: Nike is the global leader, followed by Adidas and Puma (Economist, 2013).

2) Food processing. There are three leading food processing companies; Two US firms, PepsiCo and Kraft Foods, and one Swiss firm, Nestlé. Together they produce a large fraction of global processed food sales and control the world market for food (Market Watch, 2014). Nestlé is the largest food firm in the world (Economist, 2012a; Market Watch, 2014). PepsiCo is the second largest food and beverage business in the world (foodprocessing.com, 2014) and controls famous soda brands like Pepsi, and food brands like Doritos.[2]

3) Beer market. There are four brewers, who control about half of the global market (Economist, 2011). In order of size these are AB-InBev, SABMiller, Heineken and Carlsberg. (Economist, 2014; 2015).

4) Detergent market. This market is dominated by two companies, UN and P&G. The revenues of UN come from three general categories: Home & Personal Care, Foods & Refreshment, and other operations. The revenues of P&G come from three general categories: Household Care, Beauty and Grooming, and Health and Well-Being.

5) Pet food market. 80% of the global Pet-food is controlled by P&G, Nestlé, Mars (a privately held firm that does not disclose its financial information), and Colgate (The Guardian, November 2009). The direct competition for P&G in this market is the segment Snacks and Pet and for Nestlé is the segment Pet Care. The revenue of Colgate comes from Oral, Personal and Home Care and Pet Nutrition.

6) Cognac market. The big four producers of Cognac are LVMH, Courvoisier, Martell, and Rémy Martin-Rémy Cointreau (Slate, 2008). LVMH is the global leader selling more than 40 percent of the global production of Cognac, and its biggest percentage of profit is through its international exports (Cognac-expert, 2015). It belongs to Moët Hennessy, which is co-owned by LVMH (66%) and Diageo (34%). Courvoisier is a brand of cognac of Beam Suntory, a subsidiary of Japanese Suntory. The production is based on France. The direct competition for Suntory Holdings Limited in this market is the account Alcoholic Beverages. The third firm Martell is part of the Martell Mumm Perrier-Jouët subsidiary of the wines and spirits group, Pernod-Ricard that produces distilled beverages. Finally, Rémy Martin primarily produces cognac. As of 2011, it was owned by Rémy Cointreau, a French alcoholic beverage company.

7) Cosmetics market. The production of cosmetics is dominated by a few MNCs: L'Oréal, P&G, UN, Shiseido and EL. L'Oréal is larger than P&G and UN (Click Press, 2008). Shiseido is the largest cosmetics firm in Japan, and the fourth in the world (Wall Street Journal, 2010). EL is a US firm and the direct competition in this market contains all its revenues.

[2] In 2012, Kraft was divided into Kraft Foods Group and Mondelez (Market Watch, 2014), reducing significantly the number of observations for Kraft Foods in our sample. Hence, we study only PepsiCo and Nestlé.

8) Bottled water market. This comprises of the Non-sparkling Segment and the Sparkling segments. It has been studied before by Friberg and Ganslandt (2007). Nestlé, Danone, Coca-Cola and PepsiCo, lead the global market. (Research and Markets, 2015) The direct competition for Nestlé, Danone, Coca-Cola and PepsiCo in this market are the accounts Water, Bottled Waters, Non-Alcoholic Beverages and Beverages respectively.

9) Toy market. It is dominated by Mattel Inc., Hasbro Inc., Bandai Co., Ltd., MGA Ent., and LEGO (Economist, 2013; Time, 2008).[3] Mattel, is the largest toymaker in the world (Fortune, 2013). Hasbro comes second (Fortune, 2013) and Bandai holds the third place (Time, 2008).

5.3 Empirical Specification

We follow the seminal work of Jorion (1990) but instead of only using as a dependent variable the changes in the stock price of a firm, we also use the changes in total PAT as we proxy long run exposure with stock price exposure and short run exposure with profit exposure.

We examine the foreign exchange rate exposure with regard to the currencies of the major competitors, by running for each firm univariate as well as multivariate regressions using the bilateral exchange rates [henceforth BERs]. The exposure of the individual firm can be identified with BERs as set out by our theoretical model in terms of the firm competing in an international oligopoly with specified foreign and domestic competitors. We use three of the four major currency pairs, namely EUR/USD, USD/JPY, and USD/CHF, but not GBP/USD. We also, use the following five pairs: GBP/EUR, EUR/DKK, GBP/DKK, EUR/JPY, EUR/CHF. The data are from DataStream and Bloomberg. This specification measures how the dependent variable of the firm is affected by the changes in foreign exchange rate. So, our estimating equations are as follows:

$$\left(\frac{\Delta \mathrm{P}_S}{\mathrm{P}_S}\right)_{i,t} = \beta_{0,i,t} + \sum_{j=1}^{k} \beta_{1,j,t} \left(\frac{\Delta \mathrm{S}}{\mathrm{S}}\right)_{j,t} + \beta_{2,i,t} R_{m,t} + \varepsilon_{1i,t} \text{ (Changes in stock prices; Jorion 1990)} \quad (6)$$

[3] MGA Ent is privately held and does not disclose its financial information (PRNewswire, 2015). It is the fourth-largest producer of toys in the world (Time, 2008).Finally, the fifth producer in terms of sales is the Lego Group a private firm based in Denmark that also does not disclose its financial information (The LEGO Group, 2013).

$$\left(\frac{\Delta\Pi}{\Pi}\right)_{i,t} = \gamma_{0,i,t} + \sum_{j=1}^{k} \gamma_{1,j,t} \left(\frac{\Delta S}{S}\right)_{j,t} + u_{1i,t} \qquad \text{(Changes in PAT)} \qquad (6)'$$

The term $R_{m,t}$ is the return on a value-weighted market index, which controls for market movements. If each of the nine developed markets is integrated with the rest of the world then R_t is the same for all markets and a broad-based global index can be used, the return of which is calculated from the Morgan Stanley Capital International (MSCI) world index. This is a free-float weighted equity index and contains developed world markets but not emerging markets. The returns were calculated as first differences of each price index and expressed as percentages. We assume that the home country is integrated in the world capital markets, since, it is unrealistic to assume that the markets are closed to foreign agents as all of them are now easily accessible. The market portfolio of the home country is not the one of that country; it is comprising of all markets that are accessible to agents in the home country; thus this global approach uses a global market portfolio that includes all the relevant securities in the form of this broad-based global index. (see Stulz, 1995).

$\left(\frac{\Delta P_S}{P_S}\right)_{i,t}$ is the rate of change on the common stock of the *ith* firm, $\left(\frac{\Delta\Pi}{\Pi}\right)_{i,t}$ is the rate of change in PAT for firm *i*, and $\left(\frac{\Delta S}{S}\right)_{j,t}$ the of the end-of-period BER rate of change of its j*th* major competitor as measured by the domestic price of the foreign currency.[4] So, a positive value for $\left(\frac{\Delta S}{S}\right)_{j,t}$ denotes a domestic currency depreciation; *k* is the number of major foreign competitors. For example, in beer AB-InBev is a Belgian exporter and has SABMiller (UK), Heineken (Netherlands) and Carlsberg (Denmark) as major competitors. This means that we run a bivariate regression with two regressors, the BERs EUR/GBP and EUR/DKK. We obtain the exposure coefficients $\beta_{1,j,t}$ using the above time series regressions, which are adjusted for market movements; each measures the sensitivity of changes in the dependent variable of the firm to changes in foreign exchange rates.

4 The bilateral exchange rate, *S*, is the price of the foreign currency in units of the home currency of the exporting firm (If Germany is the exporter and the dollar is the currency of the foreign market, then the exchange rate is measured in EUR/USD).

We follow Bartram, who argues that when using the stock returns as a dependent variable we need to include the market return to control for correlated economic effects affecting stock markets which are uncorrelated with exchange rates. In this way they estimate exposure separate from that captured by the market (Bodnar and Wong). In contrast, regressions with cash flow as dependent variables do not include a market index as an explanatory variable to evaluate the impact of the financial risks on cash flows; hence as our dependent variable is PAT in (6)' we do not include the market return. This is another difference in the treatment of stock price and PAT exposures.

We also test (6) and (6)' for the impact of the financial crisis by using a dummy variable for the years 2007-2009 (detailed results are available upon request).

5.3.1 Real Exchange Rates

While the bilateral exchange rates are of direct relevance to our theory, we also use the real exchange rate as an index that captures the economy-wide implications of exchange rates for comparison purposes and to comply with the majority of the literature as explained below. The real exchange rate s [henceforth RER], is calculated as usual; the nominal exchange rate N is adjusted for the consumer price index of the specific country. The real effective exchange rate is expressed in constant prices of 2010 and it is calculated as a weighted geometric average of the exchange rates of selected countries.

Mainstream studies of exchange rate exposure, use end-of-month exchange rates (Bodnar *et al.,* 2002). Jorion uses a RER, while Bodnar *et al.,* use RERs calculated using monthly average prices from DataStream.[5] Bartram estimates the exchange rate exposure of 6,917 U.S. nonfinancial firms from DataStream and his results show that several firms are significantly exposed to at least one of the foreign exchange rates Canadian Dollar, JPY and EUR.

Our empirical application uses four major currencies; USD, EUR, JPY, GBP and it also includes CHF and DKK; the data are from DataStream.[6] As an index for the entire economy, the RER is a parsimonious representation and thus convenient in use (Jorion). It also deals with the problem of multicollinearity arising since many cross-exchange rates are fixed relative to

[5] DataStream provides a synthetic Euro exchange rate for dates before its introduction.
[6] Danish krone is pegged to EUR in ERM II, the EU exchange rate mechanism.

each other, or nearly so (Jorion). However, the RER may dilute the market exposure of the individual firm that can be identified with BERs as it is an economy wide instrument while the BERs are "firm in relation to its market competitors" instruments:

$$\left(\frac{\Delta P_s}{P_s}\right)_{i,t} = \beta_{0,i,t} + \beta_{1,j,t}\left(\frac{\Delta s}{s}\right)_{j,t} + \beta_{2,i,t}R_{m,t} + \varepsilon_{i,t} \qquad (7)$$

$$\left(\frac{\Delta \Pi}{\Pi}\right)_{i,t} = \gamma_{0,i,t} + \gamma_{1,j,t}\left(\frac{\Delta s}{s}\right)_{j,t} + u_{i,t} \qquad (7)'$$

$\left(\frac{\Delta s}{s}\right)_{j,t}$ is the rate of change of the j*th* end-of-period RER. A positive value for $\left(\frac{\Delta s}{s}\right)_{j,t}$ denotes a domestic currency appreciation. A positive (negative) exposure coefficient means that a depreciation of the domestic currency leads to an increase (decrease) in the dependent variable of the firm overall. In other words, a domestic currency depreciation (appreciation) is favorable (unfavorable).

5.3.2 Overall Significance of the Exchange Rates Model

When exchange rates are highly correlated, hoping to find individually significant exposures might be asking too much due to multicollinearity. A Wald-test can be used to determine whether, as a group, the exchange rates affect profits or stock prices. Hence in (6) we use a Wald-statistic to test whether in all the explanatory variables except the market return are jointly insignificant, and in (6)' whether all explanatory variables are jointly insignificant.

For ordinary least squares with conventionally estimated standard errors, the F and the Wald-statistic are identical. If, however, robust standard errors are used, the equivalence between the two breaks down. Since, we have corrected our results for autocorrelation and heteroscedasticity with the Newey-West procedure, the F-statistic is not robust to heterogeneity or serial correlation and we need a robust Wald-statistic to test that all the exposure coefficients, or a subgroup of them, are zero. A similar argument applies for the Huber M-estimator. In this case the F-test is not a robust statistic as well, and we calculate the Rn-squared statistic which is a robust version of a Wald-test. It tests the hypothesis that either all or a subgroup of the non-intercept coefficients are zero. The statistic is asymptotically distributed as a chi-squared with degrees of freedom the number of the non-intercept robust coefficient estimates in question.

6. Empirical Results

6.1. Exposure to Bilateral Exchange Rates

We conduct stock returns and PAT regressions for each firm with respect to the BERs to measure foreign exchange exposure in Eqs. (6) - (6)' using semiannual data setting *k=1*. The exposure coefficient $\beta_{1,j,t}$ is estimated in Eq. (6) and it is adjusted for market movements; we correct our results for autocorrelation and heteroscedasticity with the Newey–West procedure. The results of the univariate (one BER at a time) bilateral exchange rate regressions indicate that 22.73% (five out of twenty-two) of the sample firms having a significant foreign exchange exposure as indicated in Table 2, column 2. To enhance comparability among the firms in each market we also match the estimation periods. For example in the Sports market the available data for Nike is for the period 1990-2015 but for Adidas and Puma for 2000-2015. Hence we also run a regression for Nike for the period 2000-2015. The percentage of significant results in Table 2 increases when we match the estimation periods to 31.82% (seven out of twenty-two), as the stock price exposure of both Heineken (in terms of EUR/GBP) and RI FP become significantly positive. All firms are positively exposed to their corresponding BERs.

In the majority of firms the stock price exposures are resilient to the different robustness checks; however they are not robust for Adidas and EUR/USD, Nestlé and CHF/USD, AB-InBev and EUR/GBP and UN and EUR/USD. Also, the financial crisis affects the results of Heineken and EUR/DKK and P&G and USD/JPY (results are available upon request).

The calendar PAT for most firms are the same to the fiscal PAT. The calendar PAT are in one period before the fiscal PAT for: Nike, P&G, SABMiller and EL; therefore we do not conduct firm-by-firm regressions of calendar PAT changes on changes in the exchange rates as the results will be identical to the results from the regressions on fiscal PAT for these four firms. There are different reported figures for the calendar and fiscal PAT for: AB-InBev, RI FP and Shiseido and we run both calendar PAT and fiscal PAT regressions for these firms.

Notably, only Heineken has significant fiscal PAT exposure to EUR/DKK (-190.084, p-value 4.05%, and adjusted R-square [henceforth $\bar{R}^2$], equal to 12.32%), in the univariate BER regressions during 2000-2015. Moreover, we note that some firms are significantly exposed to the BERs when we match the estimation periods. For example, PepsiCo has a significant exposure to USD/CHF (1.1626, p-value 2.88% and $\bar{R}^2$ equal to 8.59%), since the three outliers in PAT were all during the 90s. Also, Heineken is significantly exposed to EUR/DKK (-239.0256, p-value 2.69% and $\bar{R}^2$equal to 14.99%) during 2002-2015. The PAT results are resilient to the different robustness checks for all firms (the results are available upon request).

[Insert Table 2]

The stock returns on changes in the bivariate (both BERs at the same time) BER regressions in Eq. (6) for k=2 result in 18.18% (four out of twenty-two) of the sample firms having a significant exchange exposure (Table 3), which is lower than the univariate BER regressions. When we match the estimation periods the results do not change. The bivariate stock returns regressions can serve as an indication of how firms are affected by different competitors within their international market. So in Table 3, we see that Heineken is affected by EUR/GBP but not EUR/DKK implying that competition from SABMiller maybe strong, while competition from Carlsberg is less so. Similarly, Carlsberg faces strong competition from SABMiller but not from AB-InBev and Heineken.

[Insert Table 3]

As mentioned in section 5.3.2 we use the Wald-test to determine whether, as a group, the exchange rates affect stock prices or PAT changes and evaluate the overall significance of the exchange rate model in those two regressions. The results of the test for the stock returns are presented in Table 3, column 4 for both entire and matching estimation periods, confirm what we have revealed for the partial effect of each exchange rate on those firms. When we match the estimation periods the results do not change.

The corresponding results for the overall significance on the fiscal and calendar PAT changes are not reported (results are available upon request). No firm has a significant calendar PAT exposure to the bivariate BER regressions irrespective of whether we match the estimation periods or not, although the results are not resilient to the different robustness checks for Heineken, Nestle and PepsiCo. The Wald-statistic for the overall significance of the fiscal PAT of PepsiCo indicates that profits are jointly significantly affected by USD/CHF and USD/EUR for the common market period 2000-2015.

We note that Hasbro is the only company that has combination of a significant fiscal PAT exposure (13.9980, p-value 2.90% and $\bar{R}^2$equal to 1.75%) in the bivariate BER regression, while its stock price is not significantly exposed to either or both BERs, USD/JPY and USD/DKK. In the majority of firms the PAT results are resilient to the different robustness checks; the results are not robust for AB-InBev, UN and Hasbro. The PAT of Hasbro are also insignificant during 1990-2015, to both USD/JPY and USD/DKK in the univariate BER regressions. When we drop all the outliers simultaneously the coefficient of USD/DKK becomes significantly positive. The joint significance tests confirm the results (available upon request). The Wald-test of joint significance confirms the results (Table 3). When we drop all the outliers simultaneously the coefficient of USD/JPY becomes significantly negative. When we drop the first half of 2008 observation, the coefficient of USD/DKK becomes significantly negative. After the other robustness checks it remains insignificant. We note that the economic crisis affects the results of Heineken and Carlsberg (results are available upon request).

Some firms have significant fiscal PAT exposures to the bivariate BER regressions when we match the estimation periods; Heineken has a significant exposure to EUR/DKK (-191.5474, p-value 4.99% and $\bar{R}^2$ equal to 9.56%) during 2000-2015 and (-239.2175, p-value 3.53% and $\bar{R}^2$ equal to 11.78%) during 2002-2015, and PepsiCo a significant exposure to USD/CHF (1.1444, p-value 4.03% and $\bar{R}^2$ equal to 5.79%).

6.2. Discussion of univariate and bivariate regression results

As we noted above, when we regress the stock price of Heineken (Table 3) jointly on EUR/GBP and EUR/DKK, EUR/GBP is significant but both coefficients are insignificant in the univariate BER regressions (Table 2, column 2). However, after the robustness tests, the stock price of Heineken is again significantly positive to EUR/GBP (results are available upon request).

In the Sports market the stock price of Nike (Table 2, column 2) is insignificant to USD/EUR when we include the entire sample period, 1990-2015, as the estimation period. When we estimate exposure for 1990-2000 we find a significantly positive exposure coefficient. The stock price exposure of Puma to EUR/USD is insignificant.

The stock price of Nestle is significantly exposed to CHF/USD and not to CHF/EUR in Table 2, column 2. This implies that the link between the exposure of Nestlé and pass through of its US competitors, PepsiCo, Coca-Cola, Colgate, and P&G is either stronger or in the same direction to the link of its exposure and pass through of its European competitor, Danone. The robustness of this result is confirmed below when we study the impact of the RERs on the stock price of Nestlé, which is significantly negative to CHF in its full sample period 2000-2015.

In the Beer market AB-InBev faces both *within* (EUR) competition from Heineken and *between* competition from the other brewers and pressures from EUR/GBP and EUR/DKK. The same applies for Heineken. SABMiller faces only *between* competition from the other brewers and pressures from GBP/EUR and GBP/DKK. Finally, Carlsberg faces only *between* competition from the other brewers and pressures from DKK/EUR and DKK/GBP. The stock price of AB-InBev is not significantly exposed to neither EUR/GBP nor to EUR/DKK, neither in the joint Wald-test nor in the individual t-tests. However, when we remove the outlier, or we calculate Huber M-estimator we conclude that our model provides a better fit than the market return model only, during 2000-2015. This result is not confirmed during the common period 2002-2015. The results are not robust for AB-InBev and EUR/DKK. The stock price of AB-InBev remains insignificant to EUR/DKK, during 2002-2015 (Table 2, column 2) and after we calculate the Huber M-estimator. However, after the other robustness checks it becomes significantly positive.

The bivariate stock price exposure of Heineken to EUR/GBP and EUR/DKK is significant during 2000-2015 (as well as for the period 2002-2015), with the coefficient of EUR/DKK not significant while the coefficient of EUR/GBP is significantly positive; the joint significance tests confirm the results (Table 3). The joint Wald-test also, confirms the impact of the BERs on the stock returns of Heineken during 1997-2015 or 2000-2015. During 2000-2015, the same period as AB-InBev and SABMiller, there is no change in the qualitative results for the stock price or the PAT of Heineken. When we account for the effect of the crisis both coefficients become significant; the coefficient of EUR/GBP is positive and the coefficient of EUR/DKK is negative.

The PAT of Heineken are insignificant to EUR/GBP, but become significantly positive when we drop the outlier in the first half of 2009. They are also insignificant to EUR/DKK during 1997-2015 and become significantly negative to EUR/DKK during 2000-2015. The PAT of Heineken to EUR or EUR/GBP is insignificant during 2002-2015 and significantly negative for EUR/DKK. For the PAT of Heineken to both EUR/GBP and EUR/DKK during 2002-2015, the coefficient of EUR/DKK is significantly negative while the coefficient of

EUR/GBP is insignificant. The R_N^2 statistic confirms the joint significance of the coefficients (results available upon request). After calculating the Huber M-estimator, the pattern remains the same. When we drop the outlier, both coefficients become significant, negative for the EUR/DKK and positive for the EUR/GBP. The fiscal PAT of SABMiller to GBP/DKK during 2002-2015 is insignificant.

In the Detergent market, there is only *between* competition, between UN and P&G. Neither the stock price nor the PAT of UN are exposed to EUR/USD during 2000-2015. The same is true for P&G and USD/EUR during 1990-2015 or 2000-2015 (Table 2, column 2). During 1990-2000 the exposure becomes positive.

In the Pet food market Colgate faces *within* competition from P&G and Mars and *between* competition from Nestlé. We study the stock price exposure of P&G to USD/CHF, since the *between* competition stems from Nestle and not UN in this market. The exposure is insignificant (Table 2, column 2). We also study the reaction of PAT of P&G to USD/CHF (results available upon request). During 2000-2015, the fiscal PAT are still insignificant, while there are significantly negative for 2000-2010. The Pet stock price and PAT exposure of Nestlé to USD and to CHF/USD is the same with to its exposure in the food market so we do not study it again.

In the Cognac market LVMH faces both *between* competition from Suntory and *within* competition from the other firms and pressures from EUR/JPY. The same applies for the other firms in the market except Suntory. The Cognac market is very interesting as all the three French firms have significant stock price exposures to EUR and, except RI FP, to EUR/JPY during 2000-2015. The latter is the result of competition by Japanese Suntory, the second largest firm behind LVMH. The exposure of French cognac firms to exchange rates and especially to JPY mainly comes from the fact that over 96% of produced cognac is exported (Cognac-expert.2010a). Cognac is a product difficult to produce to a country other than France as its quality is heavily depended on environmental conditions; hence Japanese Suntory has its plants in France. As the Japanese Yen is strong, Japanese can buy Cognac for a price lower than in France (Cognac-expert.2010b), while the French firms cannot easily react to attempts by Suntory to pass through the exchange rate appreciation. We cannot study Suntory because our sample size for this company is small.

The stock price exposure of LVMH to EUR/JPY is significantly positive during all three periods, 1999-2015, 2000-2015 and 2002-2015 (Table 2, column 2). Unlike the stock price, the PAT of LVMH are insignificant to EUR/JPY for all three periods. The stock price of RI FP becomes significantly positive to EUR/JPY during 2002-2015.

In the Cosmetics market L'Oréal faces both *within* competition from UN and *between* competition from P&G, Shiseido and EL and the same for UN. L'Oréal faces pressures from both EUR/USD and EUR/JPY. UN faces *within* competition from L'Oréal Group and *between* competition from P&G, Shiseido and EL and pressures from EUR/USD and EUR/JPY. The cosmetics stock price exposure of UN to EUR and EUR/USD is the same with its exposure in the Detergent market. We study the exposure of UN stock price to EUR/JPY (Table 2, column 2) since the *between* competition comes from Shiseido at this market. Similarly, we study the reaction of PAT of UN to EUR/JPY and jointly on EUR/USD and EUR/JPY; in both cases the coefficients are insignificant and the Wald-test in Table 3 confirms this result.

P&G faces both *within* competition from EL and *between* competition from the other three firms. The cosmetics stock price exposure of P&G to USD or to USD/EUR is the same with to its exposure in the Detergent so we do not study it again. We need to study the stock price exposure of P&G to USD/JPY (Table 2, column 2) since Shiseido is one of the *between* competitors in this market.

The stock price of P&G is not significantly exposed to USD/EUR during 1996-2015 (Table 2, column 2); it is also insignificant to USD/JPY. The stock price of P&G during 1996-2015, is insignificant to both USD/EUR and USD/JPY and the Wald-test confirms the results (Table 3). We also study the stock price and fiscal PAT exposure of P&G to all three USD/EUR, USD/JPY and USD/CHF and to the pairs USD/EUR, USD/CHF and USD/JPY and USD/CHF (results are available upon request).While the stock price and fiscal PAT exposure of P&G are all insignificant during the period 1990-2015, variations in the periods produce some significant results in common estimation periods. EL faces *within* competition from P&G and *between* competition from the other three firms.

Shiseido faces only *between* competition. The stock price exposure of Shiseido to JPY/USD (JPY/EUR) is positive (insignificant) during both 1999-2015 and 2000-2015 (Table 2, column 2). The bivariate regression stock price exposure of Shiseido to both JPY/USD and

JPY/EUR confirms this finding with only the former significant in both periods (Table 3). Hence, Shiseido is significantly affected by JPY/USD only, implying that the link between the pass through of P&G and EL and the exposure of Shiseido is stronger than the link between the pass through of L'Oréal and UN and the exposure of Shiseido. The Wald-test confirms the joint significance of JPY/USD and JPY/EUR (Table 3).

In the Bottled water market Danone faces only *between* competition and pressures from both EUR/CHF and EUR/USD (both coefficients are insignificant both unilaterally and jointly). Coca-Cola faces both *within* competition from PepsiCo and *between* competition from the other three firms. The stock price of Coca-Cola is insignificant to both USD/CHF and USD/EUR for the univariate BER regressions (Table 2, column 2) and for the bivariate BER regressions (Table 3). This may be because Coca-Cola is a strong firm and also because PepsiCo is a strong domestic competitor resulting to a *within* effect in the opposite direction to the *between* effect.

The PAT of Coca-Cola are also insignificant to both BERs USD/CHF and USD/EUR, in both the univariate and the bivariate BER regressions in all three periods and the Wald-test of joint significance confirms the results (results available upon request).

The bottled water stock price exposure of PepsiCo to USD/CHF is the same with its exposure to Food processing so we do not study it again. We only need to study stock price exposure of PepsiCo to USD/EUR and in both USD/CHF and USD/EUR, since Danone is one of the *between* competitors in this market. We also study the common market period, 2000-2015. PepsiCo faces both *within* competition from Coca-Cola and *between* competition from the other two MNCs. The insignificance of the results in both univariate and bivariate regressions may be the result of one or both of the two reasons mentioned for Coca-Cola.

Nestle faces only *between* competition and pressures from both CHF/EUR and CHF/USD. The bottled water stock price exposure of Nestlé to CHF/USD is the same to its exposure to Food processing or Pet so we do not study it again. We study the stock price exposure of Nestlé to CHF/EUR and in both CHF/EUR and CHF/USD, since Danone is one of the *between* competitors in this market segment. The stock price of Nestlé is significantly positively exposed to CHF/USD but not to CHF/EUR, in both the univariate and the bivariate BER regressions, and the Wald-test of joint significance confirms the results (Table 3). Hence, the link between the exposure of Nestlé and the pass through of its US competitors, PepsiCo, Coca-Cola, Colgate, and P&G is stronger than the link between its exposure and the pass through of its European competitor, Danone. The financial crisis does not change the pattern.

In the Toy market Mattel faces *within* competition from both Hasbro and MGA and *between* competition from Bandai and Lego and pressures from USD/JPY and USD/DKK. Hasbro faces *within* competition from Mattel and MGA and *between* competition from Bandai and Lego and pressures from USD/JPY and USD/DKK. Mattel and Hasbro are of equal strength and they are not significantly exposed to USD. Unfortunately we cannot study Bandai because our sample size for this company is small. It would be interesting to have data for Bandai Toy firm, since in this train of thought Bandai should be significantly exposed to JPY. The PAT of Hasbro are negatively exposed to USD. When we regress the PAT of Hasbro jointly on USD/JPY and USD/DKK, USD/JPY is insignificant while USD/DKK is significant. This implies that the link between the exposure of Hasbro and the pass through of Lego is stronger than the link between the exposure of Hasbro and the pass through of Bandai. This is intuitive since the revenues of Hasbro mainly come from Toys, while the revenue of Bandai from Video Game Contents, and other electronic toys, so the competition of Hasbro is stronger with Lego than Bandai. The pattern remains the same when we drop the outliers or account for the effect of the crisis. When we calculate the Huber M-estimator we estimate exposure for the first 10-year period both coefficients become insignificant. Bandai faces only *between* competition and pressures from JPY/USD and JPY/DKK.

Finally, P&G along with Nestlé are the only firms in our sample that act in three international markets: Nestlé (Food processing, Pet food and Bottled water), and P&G (Detergent, Pet food and Cosmetics). P&G has two strong domestic competitors Colgate and EL and four competitors from different countries; UN, L’Oréal, Nestlé, and Shiseido. Moreover, it is the only firm in our sample that faces pressures from three BERs: USD/CHF from Pet, USD/EUR from the Detergent market and USD/EUR and USD/JPY from Cosmetics. However, unlike Nestlé that is significantly exposed to CHF and CHF/USD, P&G is exposed to neither USD nor any BER.

6.3. Exposure to Real Exchange Rates

It is the BERs that are of relevance to our theory but we also use the RERs which as an index captures the economy-wide implications of exchange rates and it is useful for comparisons. We conduct firm-by-firm regressions of stock returns and PAT changes on changes in the RERs and we measure currency exposure on stock market returns and PAT changes in Eqs. (7) - (7)'.

Table 2, column 4, reports the stock price exposure to the RERs. We find that 40.91% (nine out of twenty-two) of the sample firms have significant foreign exchange exposure. The percentage of the sample firms with significant foreign exchange exposure increases when we match the estimation periods to 45.45% (ten out of twenty-two) as the stock price exposure of Heineken becomes significantly negative. In the majority of firms the results are resilient to the different robustness checks; the results are not robust for Adidas, Puma and Carlsberg (results are available upon request).

The 40.91% and 45.45% are much higher than the 22.73% and 31.82% respectively that come from regressions using the RERs. This is expected as RERs capture other factors as well apart from competition. The existence of the *within* competition may also mask some of the strength of the *between* competition when the former runs in the opposite direction to the latter resulting in smaller and less significant BERs. Indeed a few firms from our sample are exposed to RERs but not to the BERs: Puma, AB-InBev, RI FP and Danone. The fact that each of these four firms come from different markets (Sports, Beer, Cognac, Bottled water respectively) further confirms our modelling results that for some firms the existence of *within* competition may mask the *between* competition effect on exposure when the former runs in the opposite direction to the latter in the market where it operates. On the other hand, the stock price of Carlsberg is significantly positively exposed to DKK/GBP and in the bivariate regression the coefficient of DKK/EUR is insignificant while the coefficient of DKK/GBP is significantly positive while the Wald-test confirms the joint significance of both DKK/EUR and DKK/GBP (Table 3). However, the stock price of Carlsberg is not exposed to DKK (Table 2, column 4). Here we are dealing with a case where there is only the *between* effect affecting the stock price exposure of Carlsberg given the values of the cross price effects of the parameters.

All firms are negatively exposed to RERs except for Puma which is positively exposed to EUR; after the alternative robustness checks Adidas becomes also significantly exposed to EUR but with a negative coefficient.[7] Remarkably, at least one firm in each market has a significant stock price exposure to RER except in the Toy market that neither Mattel nor Hasbro are significantly exposed.

On the other hand, the percentage of firms with significant PAT exposure to RER turns to be much smaller (results are available upon request). Notably, only Hasbro has significant fiscal PAT exposure to USD (-29.9671, p-value 1.82% and $\bar{R}^2$ equal to 4.25%), while its stock return exposure in Table 2, column 4 is insignificant. What may distinguish the Toys market is that toys may be considered as semi-durables or even durables, indicating that long run exposure (proxied by the stock price exposure) is lower than short run exposure (proxied by the profits exposure) for such goods as opposed to consumables (see section 4). The difference in the nature of Toys in terms of their durability may be one of the factors explaining why this market alone seems to have a significant profit exposure and an insignificant stock price exposure. This hypothesis is beyond the scope of this article but it can be the focus of a future article that compares these two types of exposures for durable and consumable goods.

No firm has a significant calendar PAT exposure on RER irrespective of whether we match the estimation periods or not (results are available upon request). The results are not resilient to the robustness checks for Adidas and Hasbro; for Hasbro when we calculate the Huber M-estimator or account for the effect of the crisis its PAT become insignificant (results are available upon request).

In the Sports market, while the stock price of Nike is not exposed to USD, the stock price of Adidas and Puma is significantly exposed to EUR (albeit only for one firm at a time depending on whether we look at the pre-robustness results (Puma) or the post-robustness results (Adidas)). Although Adidas has Puma and Puma has Adidas as a strong domestic rival, Nike does not face *within* countries competition. Also exposure depends on the power that your competitors have to pass on the changes of the exchange rate to the price of the product; if Nike has more power to pass on the exchange rate changes as compared to Adidas and Puma this

[7] However, when we run the different robustness checks the exposure of Puma to EUR becomes insignificant.

results to Adidas and Puma being exposed to EUR.[8] It is important to remember that the *within* countries cross price effects are not symmetric, i.e. $\theta_{12,h} \neq \theta_{21,h}$ so the fact that for Puma the *within* competition with Adidas may mask the *between* competition the reverse is not necessarily true, as our empirical results confirm. The stock price exposure of Nike (as reported in Table 2, column 4) and PAT to USD remains insignificant during 2000-2015. Puma is the only firm in our sample with a positive exposure to EUR (Table 2, column 4) while Adidas has an insignificant one. These results can be loosely (as these are RER rather than BER regressions) referenced back to our *within* and *between* competition model. In the *between* and *within* competition case exposure depends on the sign (and if negative on the size too) of the pass on of the foreign firm (Nike) and it also, depends on the sign and size of the elasticity of the price of the rival (Adidas and Puma) firms with respect to *S*. If the existence of the domestic competitor Puma affects the exposure of Adidas through the *within* competition effect, its exposure is insignificant (Table 2, column 4) implying that the *within* and *between* effects work in opposite directions and offset each other. On the other hand, for Puma the existence of Adidas affects the exposure of Puma through the *within* competition effect and its exposure is positive given the sign and size of the price elasticities with respect to *S* of Adidas and Nike, the domestic and foreign competitor correspondingly.

In the Food processing market results remain unchanged for PepsiCo and USD during 2000-2015 with respect to the 1990-2015 period.

In the Beer market, the exposure of the stock price of AB-InBev to EUR remains significantly negative during 2002-2015, and its PAT remain insignificant. The stock price of Heineken, from insignificant during 1997-2015, becomes significantly negative to EUR during 2000-2015 and 2002-2015 (Table 2, column 4). The PAT of Heineken to EUR is insignificant during 2002-2015.

In the Detergent market, the only 1x1 international oligopoly of our sample, neither the stock price nor the PAT of UN are significantly exposed to EUR, during 2000-2015 (Table 2,

[8] The stock price exposure of Adidas is insignificant as reported in Table 2. However, following robustness checks the exposure of Adidas to the EUR becomes significantly negative.

column 4).The same is true for P&G. It is not significantly exposed to USD during 1990-2015 or 2000-2015.

In the Pet food market the Pet stock price exposure of P&G to USD is the same to its exposure in the Detergent market so we do not study it again.

In the Cognac market the stock price of LVMH is significantly negative to EUR during all three periods, 1999-2015, 2000-2015, the same period as RI FP, and 2002-2015, and after the robustness checks (Table 2, column 4). However, it becomes insignificant (though marginally) when we account for outliers during 1999-2015 and 2002-2015. The PAT of LVMH are insignificant to EUR, in all three periods. The stock price of RI FP is significantly negative to EUR during 2000-2015 (Table 2, column 4).

In the Cosmetics market, the stock price of P&G is not significant to USD during 1996-2015, the same period as EL (Table 2, column 4). The stock price of EL is not significantly exposed to USD during its full sample period, 1996-2015, or during 2000-2015 (Table 2, column 4). When we estimate exposure during 2000-2010, it becomes significantly negative.

In the Bottled water market the stock price of Coca-Cola is insignificant to USD, during 1984-2015, or during 1990-2015 and 2000-2015 (Table 2, column 4). Also the PAT of Coca-Cola are insignificant to USD, in all three periods. Both the exposure of the bottled water stock price of Nestlé to CHF is the same to its exposure to Food processing or Pet Food and the exposure of the bottled water stock price of PepsiCo to USD is the same with to its exposure in Food processing so we do not study it again.

7. Conclusions

We describe a novel theoretical framework encompassing both *within* and *between* countries competition and we study the impact of exchange rates on the returns and profit changes of firms competing in an international oligopoly. We look at firms offering differentiated consumable goods competing under price and quantity competition. Interestingly, a foreign currency appreciation has a greater impact on the equilibrium prices of the home and foreign firms in the case of quantity competition as compared to price competition.

To avoid dynamic interaction effects, we focus on consumable goods producers to estimate exchange rate exposure arising from the strategic interactions *between* and *within* firms.

Our theoretical results support the mainstream view that as the foreign currency appreciates, the home firm gains at the expense of her overseas rival, since it allows the former to optimally charge higher prices and forces the foreign rival to reduce her equilibrium prices in a quantity setting *between* countries only competition model. However, this result does not always hold in other specifications. So in the case of price competition it depends on the price exchange rate elasticity of the rival firm in a market where there is only *between* countries competition like, for example, the Detergent market, dominated by UN and P&G.

The coexistence of *between* and *within* competition, enhances our understanding of competition interactions among firms within an international oligopoly. The *between* and the *within* countries competition may act as two opposing forces when it comes to the impact of the exchange rate on the optimal prices (quantities) and profits in both the Bertrand and the Cournot models. One example is the Sports market (see 3.2.1 and discussion in section 6.1).

We test exposure to real and bilateral exchange rates using stock price and profit data, from twenty-two multinational firms from nine markets during 1984-2015. We examine the robustness of exposure using alternative robustness tests. While it is the bilateral exchange rates that are of direct relevance to our theory, we also use the real exchange rate which as an index captures the entire economy. The empirical results, featuring distinctive examples of multinational firms like Nestlé and Procter & Gamble, confirm our argument as derived from our theoretical analysis, that there is a link between the size of the pass through of each firm on the exposure of the other firm; hence the ability of each firm to pass on the exchange rate changes to its customers affects the magnitude of the impact of exchange rate on the profits (or stock prices) of the other firm. The percentage of firms with significant stock price exposure to the bilateral exchange rates is 31.82%, much lower than the 45.45% that comes from the real exchange rates regressions, as the latter capture other factors as well apart competition.

References.

Aggarwal, Raj., Harper, Joel., T., 2010. Foreign exchange exposure of “domestic” corporations, *Journal of International Money and Finance* 29, 1619-1636.

Bartram, Sohnke., M., 2007. Corporate cash flow and stock price exposures to foreign exchange rate risk. *Journal of Corporate Finance* 13, 981-994.

Bartov, Eli., Bodnar, Gordon., M., 1994. Firm valuation, earnings expectations, and the exchange rate exposure effect. *Journal of Finance* 44, 1755-1785.

Berman, Nicolas., Martin, Philippe., and Mayer, Thierry., 2012. How do Different Exporters React to Exchange Rate Changes? *Quarterly Journal of Economics* 127, 437-492.

Bodnar, Gordon., M., Dumas, Bernard., and Marston, Richard., C., 2002. Pass-through and Exposure, *Journal of Finance* 57, 199-231.

Bodnar, Gordon., M., and Gentry, William M., 1993. Exchange rate exposure and industry characteristics: evidence from Canada, Japan, and the USA. *Journal of International Money and Finance* 12, 29-45.

Bodnar, Gordon., M., and Wong, M.H. Franco. 2003. Estimating exchange rate exposures: some 'weighty' issues. *Financial Management* 32, 35-68.

Brissimis, Sophocles., N., Kosma, Theodora S., 2006. Market conduct, price interdependence and exchange rate pass-through, *Bank of Greece Working Paper* 51.

Chow, Edward H., Lee, Wayne Y., and Solt, Michael E., 1997. The exchange-rate risk exposure of asset returns. *Journal of Business* 70, 105-123.

Click Press, 2008, Available online:
[http://www.clickpress.com/releases/Detailed/82987005cp.shtml[Accessed 31/05/2016.]

Cognac-expert.2010a., Available online: https://blog.cognac-expert.com/china-is-now-the-2nd-biggest-consumer-of-cognac-in-the-world/ [Accessed 03/06/2016.]

Cognac-expert.2010b., Available online: https://blog.cognac-expert.com/japan-bar-yen-rich-business-men/ [Accessed 03/06/2016.]

Cognac-expert.2015.,Available online: https://www.cognac-expert.com/cognac-brands/hennessy-cognachttps://www.whiskyandmore.co.nz/other-spirits-for-sale/buy-hennessy-xo-cognac-france-online/ [Accessed 17/07/2015.]

Dekle, Robert., 2005. Exchange Rate Exposure and Foreign Market Competition: Evidence from Japanese Firms, *Journal of Business* 78, 281-300.

Dornbusch, Rudiger., 1987. Exchange rates and prices, *American Economic Review* 77, 93-106.

Emmerentze, Ellen, November 6th, 2014. Adidas profit dented by foreign-exchange effects, *Marketwatch*, Retrieved July 17, 2015.

Feenstra, Robert., C., Gagnon, Joseph., E., and Knetter, Michael., M.,1996. Market share and exchange rate pass-through in world automobile trade, *Journal of International Economics* 40, 187-207.

Friberg, Richard., Ganslandt, Mattias.2007 Exchange rates and cash-flows in differentiated product industries – a simulation approach, *Journal of Finance* 62, 2475-2502.

Food Processing's Top 100. 2015. Available online: http://www.foodprocessing.com/top100/top-100-2014/[Accessed 31/05/2016.]

Fortune 2013, Hasbro-Best Companies to Work For 2013. Available online: http://archive.fortune.com/magazines/fortune/best-companies/2013/list/.Retrieved May 31,2016.

Froot, Kenneth.,A., and Klemperer, Paul.,1989. Exchange rate pass-through when market share matters, *American Economic Review* 79, 637-654.

Gross, Dominique., M., Schmitt, Nicolas.,2000. Exchange rate pass-through and dynamic oligopoly: An empirical investigation, *Journal of International Economics* 52, 89-112.

He, Jia., and Ng, Lilian K., 1998. The foreign exchange exposure of Japanese multinational firms. *Journal of Finance* 53, 733-754.

Hickman, Leo. Britain's problem with pets, *The Guardian*, November 13, 2009. Available online: http://www.theguardian.com/environment/2009/nov/13/ethical-living-carbon-emissions

[Accessed 31/05/2016.]

Hutson, Elaine., and Laing, Elaine., 2014. Foreign exchange exposure and multinationality, *Journal of Banking and Finance* 43, 97-113.

Jorion, Philippe., 1990. The exchange rate exposure of U.S. multinationals, *Journal of Business* 63, 331-345.

Klemperer, Paul D., and Margaret A. Meyer., 1986. Price competition vs. quantity competition: the role of uncertainty, *Rand Journal of Economics* 17, 618-638.

Krugman, Paul., 1987. Pricing to market when the exchange rate changes, in Swen W. Arndt and John D. Richardson, eds.: Real-Financial Linkages among Open Economies *MIT Press*, Cambridge, MA.

Levine, David., 1985. A Simple Durable Goods Model, *Quarterly Journal of Economics* 100, 775- 788.

Marston, Richard., C., 2001. The effects of industry structure on economic exposure, *Journal of International Money and Finance* 20,149-164.

Oxelheim, Lars., and., Wihlborg, C Clas., G., 1995. Measuring macroeconomic exposure: the case of Volvo cars. *European Financial Management* 1, 241-263.

PR Newswire, 2015. MGA Entertainment Goes Where The Kids Are. Available online. http://www.prnewswire.com/news-releases/mga-entertainment-goes-where-the-kids-are-300096157.html. [Accessed 31/05/2016.]

Research and Markets, 2015. Available online. http://globenewswire.com/news-release/2015/10/09/774979/0/en/Global-Bottled-Water-Market-2015-2019-with-Coca-Cola-Danone-Nestl%C3%A9-PepsiCo-Dominating.html. [Accessed 31/05/2016.]

R.L.G. and L.P., August 26th 2013, The runner-up: A vigorous competition among sportswear-makers. *Economist*, Retrieved July 17, 2015.

Singh, Nirvikar., and Xavier., Vives, 1984, Price and Quantity Competition in a Differentiated Duopoly, *Rand Journal of Economics* 15, 546-554.

Steinberger Mike., April 2008. Cognac Attack! The king of brandies is back. Which ones are worth drinking? Slate.

Stulz, Rene.1995. The Cost of Capital in Internationally Integrated Markets: The Case of Nestle, *European Financial Management* 1, 11-22.

Stulz, Rene.M., Williamson, Rohan., 1997. Identifying and quantifying exposures. In: Jameson, R. (Ed.), Financial risk and the corporate treasury. *Risk Publications*, 33-51.

Time. 28 January 2008. Lego Celebrates 50 Years of Building. Available online: http://content.time.com/time/world/article/0,8599,1707379,00.html.Retrieved May 31, 2016.

(The) Economist.2011. The global beer industry: Sell foam like soap. The Economist. Available online: http://www.economist.com/node/18651308. Retrieved May 31, 2016.

(The) Economist. 2012a, Fighting for the next billion shoppers: The eternal battle between Procter & Gamble and Unilever is intensifying in the developing world, The Economist 403, 69-71. Retrieved July 17, 2015.

(The) Economist. 2012b, Available online: http://www.economist.com/news/special-report/21568064-food-companies-play-ambivalent-part-fight-against-flab-food-thought. Retrieved May 31, 2016.

(The) Economist. 2013, The toy industry; Child's play. Available online: http://www.economist.com/blogs/schumpeter/2013/09/toy-industry. Retrieved May 31, 2016

(The) Economist. 2014, Brewery mergers Foamy war SABMiller may be swallowed up by its main rival, AB InBev, The Economist. Available online: http://www.economist.com/news/business/21618862-sabmiller-may-be-swallowed-up-its-main-rival-ab-inbev-foamy-war. Retrieved May 31, 2016.

(The) Economist. 2015, A giant drinks merger, Beer monster, The Economist. Available online: http://www.economist.com/news/business/21665074-ab-inbev-may-combine-sabmiller-flat-market-big-beer-brands-beer-monster.Retrieved May 31, 2016.

(The) LEGO Group. 2013. About Us. The LEGO Group. Available online: http://www.lego.com/en-gb/aboutus/lego-group. Retrieved May 31, 2016.

(The) Wall Street Journal 2010. Japan's Shiseido Agrees to Acquire Bare Essentials http://www.wsj.com/articles/SB10001424052748704363504575003844097292162. Retrieved May 31, 2016.

Williamson, Rohan, 2001. Exchange rate exposure and competition: evidence from the automotive industry. *Journal of Financial Economics* 59, 441-475.

Yang, Jiawen., 1997. Exchange rate pass-through in U.S. manufacturing industries, *Review of Economics and Statistics* 79, 95-103.

Fig. 1. The Bertrand-Nash Equilibrium in the 1x1 differentiated goods duopoly model.

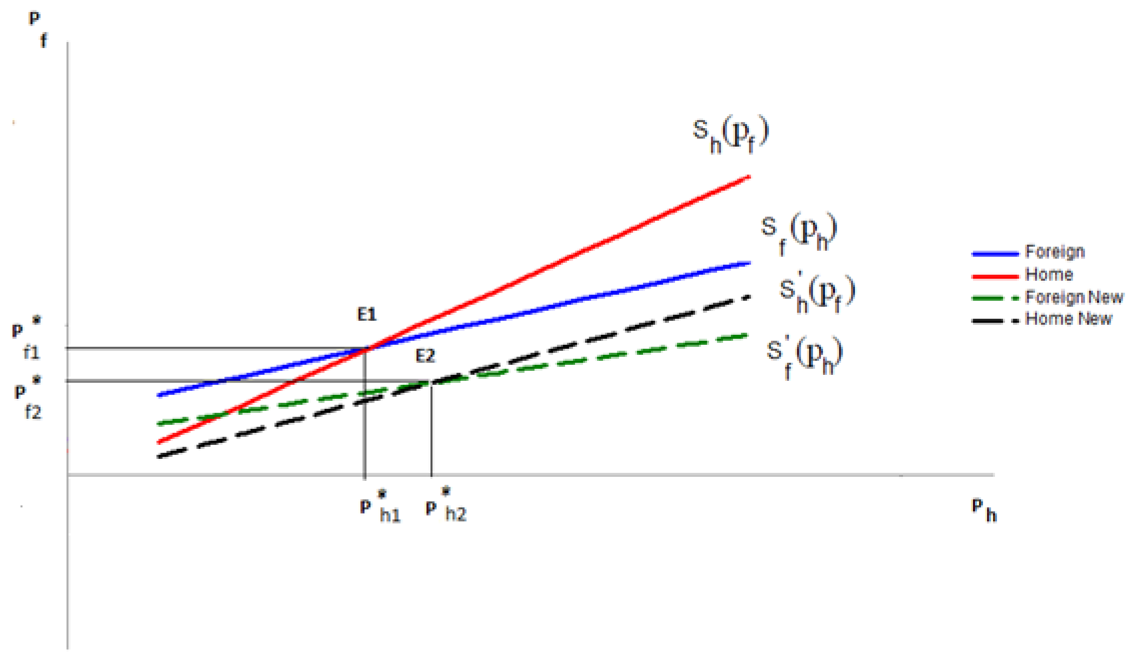

Fig. 2. The Cournot - Nash Equilibrium in the 1x1 differentiated goods duopoly model.

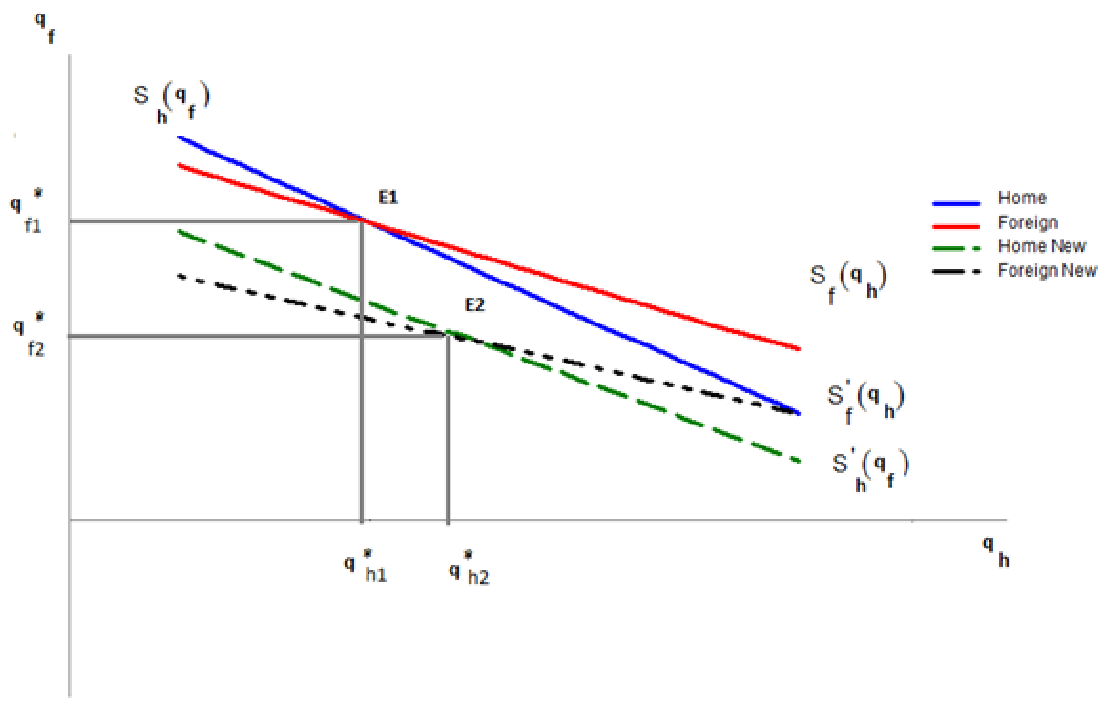

Table 2

Univariate bilateral exchange rate (BER) and **Real exchange rate (RER)** exposure estimations of stock prices. *C* denotes **common market estimation periods** and *NA* Not Applicable.

Firm	**Bilateral Stock price Exposure**	**Adj-R-square**	**Real Stock price Exposure**	**Adj-R-square**	**BER**	**RER**	**Time period**
			Apparel, Sports clothing, and Accessories Market				
Nike	Insignificant		Insignificant		USD/EUR	USD	1990-2015
Nike	Insignificant		Insignificant		USD/EUR	USD	2000-2015[C]
Adidas	Insignificant		Insignificant		EUR/USD	EUR	2000-2015[C]
Puma	Insignificant		4.0191 (0.0397)	10.86%	EUR/USD	EUR	2000-2015[C]
			Food processing Market				
PepsiCo	Insignificant		Insignificant		USD/CHF	USD	1990-2015
PepsiCo	Insignificant		Insignificant		USD/CHF	USD	2000-2015[C]
Nestlé	0.6588 (0.0001)	37.11%	-1.4289 (0.0003)	50.38%	CHF/USD	CHF	2000-2015[C]
			Beer Market				
AB-InBev	Insignificant		-4.3280 (0.0345)	45.51%	EUR/GBP	EUR	2000-2015
AB-InBev	Insignificant		NA		EUR/DKK	EUR	2000-2015
AB-InBev	Insignificant		-4.2657 (0.0029)	40.96%	EUR/GBP	EUR	2002-2015[C]
AB-InBev	Insignificant		NA		EUR/DKK	EUR	2002-2015[C]

SABMiller	Insignificant		Insignificant		GBP/EUR	GBP	2000-2015
SABMiller	Insignificant		NA		GBP/DKK	GBP	2000-2015
SABMiller	Insignificant		Insignificant		GBP/EUR	GBP	2002-2015[C]
SABMiller	Insignificant		NA		GBP/DKK	GBP	2002-2015[C]
Heineken	Insignificant		Insignificant		EUR/GBP	EUR	1997-2015
Heineken	Insignificant		NA		EUR/DKK	EUR	1997-2015
Heineken	Insignificant		-2.5000 (0.0345)	34.15%	EUR/GBP	EUR	2000-2015
Heineken	Insignificant		NA		EUR/DKK	EUR	2000-2015
Heineken	1.3623 (0.0252)	41.21%	-2.7447 (0.0400)	33.22%	EUR/GBP	EUR	2002-2015[C]
Heineken	Insignificant		NA		EUR/DKK	EUR	2002-2015[C]
Carlsberg	Insignificant		Insignificant		DKK/EUR	DKK	2002-2015[C]
Carlsberg	2.6023 (0.0063)	54.68%	NA		DKK/GBP	DKK	2002-2015[C]
			Detergent Market				
UN	Insignificant		Insignificant		EUR/USD	EUR	2000-2015[C]
P&G	Insignificant		Insignificant		USD/EUR	USD	1990-2015
P&G	Insignificant		Insignificant		USD/EUR	USD	1996-2015
P&G	Insignificant		Insignificant		USD/EUR	USD	2000-2015[C]
			Pet food Market				
P&G	Insignificant		Insignificant		USD/CHF	USD	1990-2015

P&G	Insignificant		Insignificant		USD/CHF	USD	1996-2015
P&G	Insignificant		Insignificant		USD/CHF	USD	2000-2015[C]
Colgate	Insignificant		Insignificant		USD/CHF	USD	1990-2015
Colgate	Insignificant		Insignificant		USD/CHF	USD	2000-2015[C]
Nestlé	0.6588	37.11%	-1.4289	50.38%	CHF/USD	CHF	2000-2015[C]
	(0.0001)		(0.0003)				
			Cognac Market				
LVMH	1.0000	76.74%	-3.9498	65.38%	EUR/JPY	EUR	1999-2015
	(0.0000)		(0.0003)				
LVMH	0.8562	71.38%	NA		EUR/JPY	EUR	2000-2015
	(0.0000)						
LVMH	0.9420	74.50%	-3.9826	71.19%	EUR/JPY	EUR	2002-2015[C]
	(0.000)		(0.0003)				
RI FP	Insignificant		-2.3914	20.96%	EUR/JPY	EUR	2000-2015
			(0.0049)				
RI FP	0.6137	47.56%	-2.1517	39.95%	EUR/JPY	EUR	2002-2015[C]
	(0.0006)		(0.0053)				
Rémy	1.0979	27.17%	-4.9110	25.45%	EUR/JPY	EUR	2002-2015[C]
Martin	(0.0020)		(0.0021)				
			Cosmetics Market				
L'Oréal	Insignificant		-3.3474	29.98%	EUR/USD	EUR	2000-2015[C]
			(0.0004)				
L'Oréal	Insignificant		NA		EUR/JPY	EUR	2000-2015[C]
UN	Insignificant		Insignificant		EUR/USD	EUR	2000-2015[C]
UN	Insignificant		Insignificant		EUR/JPY	EUR	2000-2015[C]

P&G	Insignificant		Insignificant		USD/EUR	USD	1990-2015
P&G	Insignificant		Insignificant		USD/EUR	USD	1996-2015
P&G	Insignificant		Insignificant		USD/EUR	USD	2000-2015[C]
P&G	Insignificant		Insignificant		USD/JPY	USD	1990-2015
P&G	Insignificant		Insignificant		USD/JPY	USD	1996-2015
P&G	Insignificant		Insignificant		USD/JPY	USD	2000-2015[C]
EL	Insignificant		Insignificant		USD/EUR	USD	1996-2015
EL	Insignificant		Insignificant		USD/EUR	USD	2000-2015[C]
EL	Insignificant		NA		USD/JPY	USD	1996-2015
EL	NA		Insignificant		USD/JPY	USD	2000-2015[C]
Shiseido	1.2222 (0.0050)	21.20%	-1.7417 (0.0005)	22.71%	JPY/USD	JPY	1999-2015
Shiseido	1.2642 (0.0036)	25.59%	-1.6893 (0.0013)	21.24%	JPY/USD	JPY	2000-2015[C]
Shiseido	Insignificant		NA		JPY/EUR	JPY	1999-2015
Shiseido	Insignificant		Insignificant		JPY/EUR	JPY	2000-2015[C]
			Market for Bottled water				
Danone	Insignificant		-2.3675 (0.0183)	20.58%	EUR/CHF	EUR	2000-2015[C]
Danone	Insignificant		NA		EUR/USD	EUR	2000-2015[C]
Coca-Cola	Insignificant		Insignificant		USD/CHF	USD	1984-2015
Coca-Cola	Insignificant		Insignificant		USD/CHF	USD	1990-2015

Coca-Cola	Insignificant		Insignificant		USD/CHF	USD	2000-2015[C]
Coca-Cola	Insignificant		NA		USD/EUR	USD	1984-2015
Coca-Cola	Insignificant		NA		USD/EUR	USD	1990-2015
Coca-Cola	Insignificant		NA		USD/EUR	USD	2000-2015[C]
PepsiCo	Insignificant		Insignificant		USD/CHF	USD	1990-2015
PepsiCo	Insignificant		Insignificant		USD/CHF	USD	2000-2015[C]
PepsiCo	Insignificant		NA		USD/EUR	USD	1990-2015
PepsiCo	Insignificant		NA		USD/EUR	USD	2000-2015[C]
Nestlé	0.6588 (0.0001)	37.11%	-1.4289 (0.0003)	50.38%	CHF/USD	CHF	2000-2015[C]
Nestlé	Insignificant		Insignificant		CHF/EUR	CHF	2000-2015[C]
Toys Market							
Mattel	Insignificant		Insignificant		USD/JPY	USD	1990-2015[C]
Mattel	Insignificant		NA		USD/DKK	USD	1990-2015[C]
Hasbro	Insignificant		Insignificant		USD/JPY	USD	1990-2015[C]
Hasbro	Insignificant		NA		USD/DKK	USD	1990-2015[C]

Table 3

Bivariate bilateral exchange rate (BER) exposure estimations of stock prices. A star and a double star denote that the coefficient is significant at the 1% and 5% level, respectively. *C* denotes **common market estimation periods** and *NA* Not Applicable.

Firm	Stock price Exposure	Adj-R-square	Wald-test Linear Restrictions stock returns	BER1	BER2	Time period
			Beer Market			
AB-InBev	Insignificant		Insignificant	EUR/GBP	EUR/DKK	2000-2015
AB-InBev	Insignificant		Insignificant	EUR/GBP	EUR/DKK	2002-2015[C]
SABMiller	Insignificant		Insignificant	GBP/EUR	GBP/DKK	2000-2015
SABMiller	Insignificant		Insignificant	GBP/EUR	GBP/DKK	2002-2015[C]
Heineken	1.4566 (0.0050)	39.60%	10.2751 (0.0004)	EUR/GBP*	EUR/DKK	1997-2015
Heineken	1.3010 (0.0167)	40.64%	6.8224 (0.0040)	EUR/GBP*	EUR/DKK	2000-2015
Heineken	1.3872 (0.218)	39.20%	4.0977 (0.0300)	EUR/GBP**	EUR/DKK	2002-2015[C]
Carlsberg	2.6932 (0.0019)	55.55%	15.19563 (0.0000)	DKK/ EUR	DKK/GBP*	2002-2015[C]
			Cosmetics Market			
L'Oréal	Insignificant		Insignificant	EUR/USD	EUR/JPY	2000-2015[C]

UN	Insignificant		Insignificant	EUR/USD	EUR/JPY	2000-2015[C]
P&G	Insignificant		Insignificant	USD/EUR	USD/JPY	1990-2015
P&G	Insignificant		Insignificant	USD/EUR	USD/JPY	1996-2015
P&G	Insignificant		Insignificant	USD/EUR	USD/JPY	2000-2015[C]
EL	Insignificant		Insignificant	USD/EUR	USD/JPY	1996-2015
EL	Insignificant		Insignificant	USD/EUR	USD/JPY	2000-2015[C]
Shiseido	1.2399 (0.0074)	18.85%	5.1745 (0.0120)	JPY/EUR	JPY/USD*	1999-2015
Shiseido	1.3231 (0.0042)	26.99%	5.4002 (0.0106)	JPY/EUR	JPY/USD*	2000-2015[C]
			Market for Bottled water			
Danone	Insignificant		Insignificant	EUR/CHF	EUR/USD	2000-2015[C]
Coca-Cola	Insignificant		Insignificant	USD/CHF	USD/EUR	1984-2015
Coca-Cola	Insignificant		Insignificant	USD/CHF	USD/EUR	1990-2015
Coca-Cola	Insignificant		Insignificant	USD/CHF	USD/EUR	2000-2015[C]
Nestlé	0.8633 (0.0007)	48.85%	9.6125 (0.0009)	CHF/EUR	CHF/USD*	2000-2015[C]
PepsiCo	Insignificant		Insignificant	USD/CHF	USD/EUR	1990-2015
PepsiCo	Insignificant		Insignificant	USD/CHF	USD/EUR	2000-2015[C]
			Toy Market			
Mattel	Insignificant		Insignificant	USD/JPY	USD/DKK	1990-2015[C]
Hasbro	Insignificant		Insignificant	USD/JPY	USD/DKK	1990-2015[C]