Exchange rate Volatility and Growth

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First draft

The idea that adopting a single currency (*i.e.* suppressing nominal exchange rate variations) should boost growth in Europe was first developed in the early 1990, in the European Commission report, *One market, one money*. The theoretical foundations of this Report relied on transaction costs economies that would arise from the use of a single currency, as well as on reduced uncertainty (European Commission, 1990). It concluded that a single currency, by cancelling exchange rate uncertainty, would foster growth in the European area.

In the mean time, the theory of investment under uncertainty made new progresses, and allowed for an explicit formalisation of the negative impact of uncertainty on investment (Dixit and Pindyck, 1994) : when coupled with irreversibility in investment, uncertainty increases the value of the implicit option to wait until the next period before investing.

This approach has stimulated an important research. In particular, special attention was paid to the relationship between uncertainty in exchange rates and investment, or other connected macro-economic variables such as employment or growth (see Carruth and al., 2000, for a review of literature), showing that increased uncertainty has in most case have a negative impact on investment, and more generally on growth.

The influence of exchange rate volatility on growth or investment should depend on the fact that some part of the cost – or the price – of the goods produced are denominated in a foreign currency. Hence, it should depend on the external exposure of firms, and in a more macro-economic setting, on the openness of the country. Moreover, the recent literature (Fontagné & Freudenberg, 1999, or Ricci, 1997) suggests that the impact of exchange rate volatility should depend on the nature of specialisation. The more inter-industry (or vertically differentiated) the specialisation, the less the sensitivity of industries to exchange rate shocks or volatility. Hence, in assessing the impact of exchange rate volatility on investment – or the gains stemming from fixed exchange rates – one should take into account both the rate of openness of countries, and the nature of trade between partners.

In this paper, we offer a theoretical analysis of the link between exchange rate uncertainty and investment, building on the fact that uncertainty in exchange rates affects demand. After a brief review of the literature (section I), a model is elaborated. We show that the link between investment and exchange rate volatility is highly dependent on the market structure under which the firm is operating (section 2). This theoretical analysis is then applied to the EU

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area, through an econometric analysis of the impact of exchange rate volatility on investment, where the nature of trade is accounted for (section 3).

1. The literature on investment under (exchange rate) uncertainty

1.1 Theoretical models of investment under uncertainty

The impact of uncertainty on investment is not a recent source of concern. It was for instance developed by Lucas (1967), who noted that uncertainty reduces investment in the presence of adjustment costs[1]. But uncertainty has also a negative impact on investment in Tobin's q-model (1969), or when the investment process includes irreversibilities (Nickell, 1974, 1978). The recent strand of literature however develops another kind of analysis, relying on the option to wait approach (Dixit & Pindyck, 1994).

1.1.1 The option to wait approach (Dixit & Pindyck, 1993)

Considers the decision by a firm to undertake an investment of present value *V* that would imply a given sunk cost *I*. In the traditional net present value approach, the firm will only decide to invest if the net present value of the project is positive, i.e. $V - I \geq 0$. However, when the value of the investment is moving through time and is uncertain, the optimal behaviour of the firm changes.

The value of the investment is usually assumed to follow a geometric Brownian motion with drift (Darby & al., 1999, Dixit & Pindyck, 1993 for instance):

$$dX = \alpha X\, dt + \sigma X\, dz \qquad (1.)$$

where *X* is the present value of the investment, α is the mean of *dX* and σ is the standard deviation of *dX*. *dz* is the random increment of a Wiener process such that :

$$dz = \varepsilon_t \sqrt{dt}\text{, where } \varepsilon_t \sim N(0,1),\ E(\varepsilon_i \varepsilon_j) = 0 \quad \forall i, j \quad i \neq j \qquad (2.)$$

The firm will delay it investment decision so as to maximise the expected present value of the option to invest *F*(*X*), given by :

$$F(X) = \max E[(X_T - I)\exp(-\rho T)] \qquad (3.)$$

where X_T is the value of the investment at the unknown future point in time, *T*, at which the investment decision is made ; ρ is the discount rate and I is the present value of the cost of the investment. The optimality is reached when there is a strict equivalence for the firm between the expected return from delaying the investment and the opportunity cost of this delay. Hence, the firm can find some interest in the strategy of waiting, because it is equivalent for her to the case of holding an option to postpone investment. Indeed, in this case, "*Delaying the investment decision and holding the option is equivalent to holding an asset which pays no dividends but may appreciate as time passes*" (Carruth and *al*., 2000, p. 122).

Resolving this condition leads to define the optimal investment timing payoff, which is given by[2]:

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[1] This is the most widely adopted view. However, it is possible to find a positive relationship between uncertainty and investment, like in Hartman (1972) or Abel (1983). This positive effect appears when the marginal product of capital is convex in price, so that an increase in the variance of return increases the value of a marginal unit of capital. Such conclusions also appear in Sung & Lapan (2000).

[2] See Carruth & al., 2000, for a complete demonstration.

$$X^* = \frac{b}{b-1} I \qquad (4.)$$

where $b = \frac{1}{2} - \alpha/\sigma^2 + \sqrt{\left(\alpha/\sigma^2 - \frac{1}{2}\right)^2 + 2\rho/\sigma^2}$ (5.)

Equation (4) defines the wedge $b/(b-1)$ between the payoff needed to induce the investor to exercise the option to invest, X^*, and the present value of the cost of the investment, *I*. Given that $b > 1$, the wedge is always above 1, and hence $X^* > I$.

Hence, in the presence of irreversibility and uncertainty, the net present value principle, which equate X^* to *I*, is no longer applicable. The firm will only invest if the expected value of the investment is above some threshold level. The level of this threshold increases with the uncertainty about future returns (in line with the theory of options, which values are shown to increase with the volatility of the underlying asset) ; it also increases with the discount rate ρ and with the drift term in the evolution of the expected rate of return α.

1.1.2 Exchange rate volatility, irreversibility in investment and market structures

Using a model inspired by Dixit (1989), Belke and Gros (1998) show that exchange rate volatility reduces investment even in the absence of risk aversion. Investigating this simple model allows to highlight the importance of market structures on the magnitude of option-to-wait strategies.

Suppose a firm willing to engage in an irreversible investment (which cost is, for the sake of simplicity, set to unity). The return of this investment is uncertain and depends on the behaviour of the exchange rate.[3] For each period *t*, this return includes a certain component, r_t, and a stochastic element. The latter depends on the exchange rate behaviour and is uniformly distributed between $-s_t$ and $+s_t$. The exchange rate follows a random walk, hence its expected value in period *t* is equal to its observed value in (*t*-1). The model ignores discount and depreciation factors, and uses a three period analysis.

The expected investment return, when investment is implemented in period 0, is

$$E_0(I_0) = -1 + r_1 + r_2 \qquad (6.)$$

In period 1, the firm will only implement its investment if the observed exchange rate in period 1, e_1, allows for a future profit. Hence, the following condition must be met:

Condition (1) $e_1 + r_2 \geq 1$ (7.)

This is met if

Condition (2) $s_1 + r_2 \geq 1$ (8.)

which we will suppose is the case. Conditions (1) and (2) then allow to compute the expected return in period 0 of the waiting strategy, where investment is only implemented in period 1.

The probability for the observed period 1 exchange rate not to meet condition (1) (*i.e.* the probability for $e_1 \notin [1-r_2, s_1]$) is $1-(s_1+r_2-1)/2s_1$. If it is realised, there is no investment.

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[3] One justification for this assumption can be found in the fact that the investment is implemented to extend the export capacities of the firm; if the firm prices to market, its profit margins must therefore absorb changes in exchange rates.

The probability for the observed period 1 exchange rate to induce a positive expected return for the investment (i.e. the probability for $e_1 \in [1-r_2, s_1]$) is $(s_1 + r_2 - 1)/2s_1$. In this case, the expected return is $(e_1 + r_2 - 1)$.

Since the distribution in uniform, the computation of the expected return in period 0 of a waiting strategy yields

$$E_0(I_1) = \frac{(s_1 + r_2 - 1)^2}{4s_1} \qquad (9.)$$

Here, it appears that an increased exchange rate volatility in period 1 raises the value of the wait-and-see strategy, while it does not influence the value of the strategy of investing in period 0.

Indeed, $\frac{\partial E_0(I_0)}{\partial s_1} = 0$ and $\frac{\partial E_0(I_1)}{\partial s_1} = \frac{(s_1 + r_2 - 1)}{4s_1^2}(s_1 + 1 - r_2) > 0$, because condition (2) is met.

However, the relative value of both strategies (investing *vs.* waiting) is not affected only by exchange rate volatility. The investment return also influences the choice of a strategy.

If $Av_0 = E_0(I_0) - E_1(I_0)$ is the relative value of investing today, $\frac{\partial Av_0}{\partial r_1} > 0$ and $\frac{\partial Av_0}{\partial r_2} > 0$.

Hence, the relative value of investing today rises with returns, and the probability that the investment will never be undertaken rises with the fall in the return of this investment.[4] *Hence, the influence of exchange rate volatility depends on the market structure under which the firm operates. Here, the highest the mark-up, the less the sensitiveness of the firm to exchange rate volatility when it considers investing.*

1.2. Investment and exchange rate uncertainty

Theoretical models of investment under exchange rate uncertainty are deeply rooted in micro-economic analysis. But their theoretical impact on the macro-economic behaviour of investment can be ambiguous, as pointed by Carruth and al. (2000). Indeed, exchange rate volatility tends to increase the threshold point that expected returns must reach before investment be implemented, but does not necessarily affect the observed rate of return, once the investment is made. In fact, the theoretical models based on irreversibilities bear as a main conclusion that exchange rate volatility should affect the *timing* of investment decisions: firms will tend to postpone the implementation of investment, leading to a non-linear process of investment. However, such empirical implications are highly difficult to test, at the macro-economic as well as at the micro-economic level. This is why empirical investigations at the macro level restrict themselves to examining the correlation between some measure of uncertainty and macro-economic aggregates such as investment, growth or employment (Belke and Gros, 1998, for instance).

But even with such simplifications, empirical links can be difficult to observe. This is the case if many macro-economic factors intervene in the investment decision, among which it is difficult to discriminate for the role of exchange rate volatility. This is also the case if the wait-and-see behaviour of firms tends to convert transitory shocks (for instance on exchange rates) into more permanent – and hence less verifiable – fluctuations (Bernanke, 1983). A

[4] More precisely, the relative weight of the investment return determines the threshold level xxxx under(above ?) which the investment must be implemented immediately.

similar argument is developed by Dixit (1989, 1992), who argues that the presence of a threshold effect in the investment function, and the waiting strategy of firms, can produce investment hysteresis, and can therefore apparently disconnect the behaviour of investment from exchange rate fluctuations.

Despite such limitations, numerous empirical works have been undertaken to assess the impact of uncertainty on investment. Broadly speaking, two major sources of uncertainty were identified, namely demand and price uncertainty.

As far as demand uncertainty is concerned, Ogawa & Suzuki (2000) test for the impact of sales growth rate uncertainty on fixed investment in Japan, finding a negative relationship that heavily depends on the degree of irreversibility in capital: the more irreversible the investment, the more important the impact of demand uncertainty. These conclusions are in line with previous works by Guiso & Parigi (1996, 1999), carried on a sample of Italian firms. But broader measures of uncertainty were also proven to have a negative impact on investment: according to Price (1996), the volatility of GDP has a negative impact on investment; while the uncertainty on the market share is also shown to impact investment (Driver, Yip and Dahkil, 1996). As to Aizenman & Mario (1996), they show that macro-economic volatility, broadly defined by an index including volatility in monetary, fiscal and external variables, can be shown to have a negative impact only on private investment.

The impact of price uncertainty has been tested on different kinds of prices. It is usually shown to be negative on the volume of investment: this is the conclusion reached by Huizinga (1993), working on real wages uncertainty (measured by ARCH estimates of conditional variance). Consistently, Episcopos (1995) finds a negative relationship between the instability of interest rates or stock market indexes and the growth of investment.

In the stream of this empirical literature, numerous works relate exchange rate uncertainty to (both domestic and foreign) investment. The link between foreign direct investment (FDI) and exchange rate uncertainty is rather mixed, as exchange rate volatility can both discourage foreign investment (Cushman, 1988, relying on a risk averse firm setting; Kulatilaka & Kogut, 1996, who use an option model) and produce an incentive to hedge against exchange rate shocks through foreign location (Aizenman, 1991). However, empirical studies point to a negative influence of exchange rate volatility on FDI (Cushman, 1988 or Campa, 1993, on FDI in the US, or Bénassy-Quéré et al., 2001 on FDI to emerging countries).

As to the impact of exchange rate volatility on domestic investment, the evidence is also mixed: Goldberg (1993) finds a negative impact of exchange rate volatility on US investment (2-digit level), while Campa & Goldberg (1995) find almost no impact. However, the pooling of industries might be an explanation for such deceiving results: Ghosal & Lougani (1996) show that the negative impact of price uncertainty on investment crucially depends on the competitive structure of the market. In a similar fashion, Darby & *al.* (1999) find that exchange rate uncertainty has a significant and negative impact on investment in Europe, that depends on the industry under study.

2. A model of investment under exchange rate uncertainty

2.1. Exchange rate uncertainty and demand risk: the impact on investment

Here, we develop a theoretical model building on the impact of exchange-rate led demand uncertainty on investment decisions, in the line of Ogawa & Suzuki (2000). We show that the influence of exchange rate uncertainty depends on the external exposure of the firm, which sells or buys on foreign markets. Hence, the “openness ratio” of the firm is, in any case, the fundamental transmission channel of exchange rate uncertainty on investment (and production) behaviour. Moreover, this model also underlines the importance of market structures in negative impact of uncertainty on profits and investment.

The firm produces a good which can be sold both on the domestic and on the foreign market. We suppose that the firm has already built the productive capacity so as to meet the domestic demand, and focus on its strategy when investing for selling abroad is concerned.

The price in national currency, *p*, is exogenous[5]. If the foreign demand function takes a CES form with an elasticity of substitution s between domestic and foreign goods (Armington hypothesis), and if the market share of domestic producers in foreign markets is small, the foreign demand for domestic exports can then be written as follows:

$$D = A \cdot e^{\mathrm{s}} \tag{10.}$$

where *A* is a constant, *e* is the nominal exchange rate (an increase denotes an appreciation), which is i.i.d. on the interval $[1 - s_1; 1 + s_1]$, and $\mathrm{s} > 1$.

The firm has a two-period horizon. It sets its production capacity choice *Q* (therefore the desired investment level) in period 1, and faces a marginal investment and production cost expressed in national currency, *c*. In period 2, it sells the maximum quantity on the foreign market, all remaining produced goods being definitively lost.[6]

The expected profit of the firm is

$$V = -cQ + pE(S) \tag{11.}$$

where $S = \min(D, Q)$.

For a given level of production Q, there is e_Q so that

First case: for $e < e_Q$, $D < Q$. In this case, the profit of the firm is

$$\Pi_1 = pD - cQ \tag{12.}$$

Second case: for $e > e_Q$, $D > Q$. In this case, the profit of the firm is

$$\Pi_2 = (p - c)Q \tag{13.}$$

For a given level of production *Q*, the expected profit of the firm is

$$E(\Pi) = p_1[pE_1(D) - cQ] + p_2[(p - c)Q] \tag{14.}$$

with p_1 probability of case 1 and $p_2 = 1 - p_1$ the probability of case 2.

When there is no risk aversion, the firms sets *Q* to maximise the expected profit. With $D = Ae^{\mathrm{s}}$, the production level set by the firm is such that

$$Q \in \left[A(1 - s_1)^{\mathrm{s}} ; A(1 + s_1)^{\mathrm{s}}\right] \tag{15.}$$

If this condition is met, $e_Q = (Q / A)^{1/\mathrm{s}}$. Then,

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[5] This assumption can be explained by the fact domestic conditions do determine the pricing of the firm for all markets. Although there is evidence of export pricing to market strategies, the resolution in a general equilibrium framework of price determination would not change the intuition behind the model.

[6] Differentiating between the period when the capacity of production is determined and the period when the production takes place doesn't affect the intuition of the model. This is also true if we include inventory costs instead of supposing that the production in excess is lost.

$$p_1 = \left(e_Q - (1 - s_1)\right)/2s_1 \text{ and } p_2 = 1 - p_1 \tag{16.}$$

and

$$E_1(D) = \frac{A}{s + 1} \frac{1}{\left(\frac{Q}{A}\right)^{1/s} - (1 - s_1)} \left[\left(\frac{Q}{A}\right)^{(s+1)/s} - (1 - s_1)^{s+1} \right] \tag{17.}$$

Once $E(\Pi(Q))$ is known, the optimal production level of the firm can be determined:

$$Q^* = A\left((1 + s_1) - 2\frac{s_1 c}{p} \right)^{s} \tag{18.}$$

This optimum production level belongs to the definition domain $\left[A(1 - s_1)^{s} ; A(1 + s_1)^{s}\right]$ if $p > c$, which is also the condition for $E(\Pi) > 0$.

It must be noted that if the marginal investment and production cost c is paid in foreign currency (i.e. the investment considered is a FDI), the above formula given by (18) does not change. This result may seem strange as we do add a price effect to the already considered demand effect; however, this is due to the absence of risk-aversion and to the absence of any trend in the evolution of the exchange rate.

2.2. Market structures

As soon as $p < 2c/s_1$, the production level set by the firm is a decreasing function of s_1, *i.e.* of volatility. Hence, as long as we suppose a "normal" level of volatility (for instance between 0 and 20%) and a reasonable level of gross margins (less than 50%), exchange rate volatility has a negative impact on investment. Moreover, the sensitivity of production to volatility decreases with the ratio c/p: the more important the mark-up (i.e. p/c), the less important the negative influence of exchange rate volatility. In other words, when there is a strong cost advantage, the risk induced by volatility weights less than the potential benefits due to increased sales. This result comes from the convexity of the demand function towards the exchange rate and must be handled with care: when dynamic strategic interactions are taken into account, the reverse may be observed as firms with strong market power may feel able to afford to wait (and decrease the risk) before investing[7].

Mark-ups strongly vary across industries and countries: Oliveira-Martins et al. (2000) find they are substantially lower in fragmented industries (low sunk-costs oligopolistic sectors; numerous agents) than in segmented industries (high sunk-costs oligopolistic sectors; few competitors). So, even without taking into account the export pricing to markets strategies, the specialisation of a country is going to affect its reaction to exchange rate volatility.

3. Empirical results

According to the models presented above, the negative influence of exchange rate uncertainty on investment crucially depends on two fundamental variables. The first one is the exposure of the firm to international trade, since the impact of exchange rate fluctuations comes from the fact that prices are set in a foreign currency. The second one is the nature of competition that is faced by the firm. In the model developed above, firms are all the more sensitive to

[7] Guiso and Parigi (1996) obtain this result by studying, at a micro level, Italian firms.

exchange rate risk that they operate with low mark-ups; conversely, the higher their mark-ups, the less sensitive they are to exchange rate fluctuations. Transposing the model to a macro-economic setting suggests that exchange rate volatility should have a magnified negative impact when the economy is open (firms are operating a the world level), and when competition is far from monopolistic competition. This latter assumption will be approximated through the kind of international trade that is undertaken by the country.

We test the macro-economic implications of the theoretical model on the countries of the European Union. Since 1979, these countries have engaged in a process of exchange rate stabilisation which has ended in the launching of the euro, and which should in principle have been favourable to investment. The analysis is run on a panel of 14 European countries (EU15 less Luxembourg), from 1980 to 1996, which corresponds to a maximum sample of 238 observations.

In order to confirm the outcomes of the theoretical model, we run different estimations, in order to verify, step by step, the sensibility of the theoretical model. Hence, we run 5 sets of estimations, using two different measure of investment, using the within estimator for panel data. We use two definition of investment. The first one is the standardised volume of investment (base 100 in 1990), defined by IV_{it}, and the second one is the share of investment in GDP (IMF data).

$$\log(IV_{it}) = \alpha_1 GDPG_{i,t-1} + \alpha_2 \log(GDPV_{i,t-1}) + \alpha_3 ECUVOL_{it} + e_i + u_t + \varepsilon_{it} \quad (1)$$

$$\log(IV_{it}) = \beta_1 GDPG_{i,t-1} + \beta_2 \log(GDPV_{i,t-1}) + \beta_3 ECUVOL_{it} + \beta_4 OPEN_{it} + e_i + u_t + \varepsilon_{it} \quad (2)$$

$$\log(IV_{it}) = \chi_1 GDPG_{i,t-1} + \chi_2 \log(GDPV_{i,t-1}) + \chi_3 VOLOPEN_{it} + e_i + u_t + \varepsilon_{it} \quad (3)$$

$$\log(IV_{it}) = \phi_1 GDPG_{i,t-1} + \phi_2 \log(GDPV_{i,t-1}) + \phi_3 VOLOPENH_{it} + e_i + u_t + \varepsilon_{it} \quad (4)$$

$$\log(IV_{it}) = \varphi_1 GDPG_{i,t-1} + \varphi_2 \log(GDPV_{i,t-1}) + \varphi_3 VOLOPENV_{it} + e_i + u_t + \varepsilon_{it} \quad (5)$$

The aim of this set of estimates is to highlight the macro-economic impact of exchange rate volatility on investment. For this purpose, we had to use control variables. Here, we have control for the (lagged) growth of GDP, which induces an accelerator mechanism.[8] We also control for the lagged GDP volume (multiplier).

In a second step, the estimates are run on the investment as a share of GDP ($IGPD_{it}$). We control for the persistence in investment series by introducing the lagged share of investment in GDP, instead of the lagged GDP volume.

$$IGDP_{it} = \alpha_1 GDPG_{i,t-1} + \alpha_2 IGDP_{i,t-1} + \alpha_3 ECUVOL_{it} + e_i + u_t + \varepsilon_{it} \quad (1')$$

$$IGDP_{it} = \beta_1 GDPG_{i,t-1} + \beta_2 IGDP_{i,t-1} + \beta_3 ECUVOL_{it} + \beta_4 OPEN_{it} + e_i + u_t + \varepsilon_{it} \quad (2')$$

$$IGDP_{it} = \chi_1 GDPG_{i,t-1} + \chi_2 IGDP_{i,t-1} + \chi_3 VOLOPEN_{it} + e_i + u_t + \varepsilon_{it} \quad (3')$$

$$GDPI_{it} = \phi_1 GDPG_{i,t-1} + \phi_2 IGDP_{i,t-1} + \phi_3 VOLOPENH_{it} + e_i + u_t + \varepsilon_{it} \quad (4')$$

$$GDPI_{it} = \varphi_1 GDPG_{i,t-1} + \varphi_2 IGDP_{i,t-1} + \varphi_3 VOLOPENV_{it} + e_i + u_t + \varepsilon_{it} \quad (5')$$

[8] It was not possible to control for the contemporaneous growth of GDP, because of the endogeneity problem highlighted in the theoretical model, which argues implicitly that GDP growth should be influenced by exchange rate volatility.

The volume of investment should be the more appropriate variable for testing the conclusions of the model, since uncertainty should reduce de global amount that firms choose to invest. However, it is very well documented that macro-economic variables set in levels are usually not stationary. It would not be statistically significant however to perform panel stationarity tests on our data, given the small time dimension of the sample. However, in order to control this potential problem, we also use the investment in proportion of GPD, which should not exhibit a unit root. In either case, an alternative specification is tested where we restrict the definition of investment to private investment excluding construction.

The exogenous variables are the following.

(i) Exchange rate volatility (*$VOLECU_{it}$*). It is the standard deviation of the monthly percentage changes of nominal exchange rates of European countries against a basket of the 15 currencies of the European Union. It is expressed in %. The basket is weighted by the GDP converted by purchasing power parity exchange rates (source: CHELEM-CEPII database). Nominal exchange rate data come from the IMF, *International Financial Statistics*, line *rf*. Hence, this is a measure of the variability of exchange rates around their trend, not of their movements through time.

(ii) Openness (*$OPEN_{it}$*). It is measured as the share of exports and imports with the 15 European partners, compared to GDP, and expressed in percentages. Hence, it is an intra-European openness.

(iii) The cross impact of volatility and openness (*$VOLOPEN_{it}$*). It is captured by the following multiplicative variable : $VOLOPEN_{it} = VOLECU_{it} \cdot OPEN_{it}$.

(iv) The cross impact of volatility, openness and the nature of competition (*$VOLOPENH_{it}$*). In this first step of the analysis, the magnitude of mark-ups is proxied by the nature of trade, on the ground that two-way trade in similar products should be more competitive – and hence firms should impose less mark-ups – than two-way trade in quality-differentiated products[9]. This intuition is also present in Fontagné & Freudenberg (1999). A further development of this empirical work is planed to use estimated mark-ups in the line of Oliveira-Martins et al. (1996). Hence, exchange rate volatility should be all the more detrimental on investment that trade is a more “pure” two-way trade.

(v) GDP and Investment data come from the IFS of the IMF and OECD sources.

The results of the estimations are presented in tables 1 and 2.

[9] This intuition can also be defended on more theoretical grounds. Indeed, in theoretical models of international trade, two-way trade in vertically differentiated products is explained by models of monopolistic competition, while two-way trade in horizontally differentiated products is explained by models of oligopolistic (hence more competitive) competition.

Estimation results

Table 1. The impact of exchange rate volatility on the volume of investment (total and private – excluding stockbuilding – fixed capital formation)

Steps of the estimation	1/ ER volatility		2/ ER volatility + openness		3/ ER volatility × openness		4/ ER volatility × nature of trade		5/ ER volatility × horizontal		6/ ER volatility × vertical	
Investment	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private
Nb. obs	252	252	252	252	252	252	176	176	176	176	176	176
GDPG	1.251 [.001]	1.534 [.000]	1.315 [.001]	1.525 [.000]	1.211 [.002]	1.494 [.000]	1.632 [.001]	1.259 [.002]	1.620 [.001]	1.244 [.002]	1.732 [.001]	1.331 [.002]
Log($GDPV_{(-1)}$)	1.642 [.000]	1.306 [.000]	1.618 [.000]	1.356 [.000]	1.663 [.000]	1.292 [.000]	.925 [.002]	1.066 [.000]	.932 [.002]	1.074 [.000]	.884 [.002]	1.029 [.000]
ECUVOL	-.023 [.083]	-.009 [.601]	-.027 [.040]	-0.013 [.452]	-	-	-	-	-	-	-	-
OPEN	-	-	-.007 [.001]	-.006 [.021]	-	-	-	-	-	-	-	-
VOLOPEN	-	-	-	-	-.001 [.000]	-.001 [.014]	-	-	-	-	-	-
VOLOPENH	-	-	-	-	-	-	-.007 [.041]	-.009 [.005]	-.005 [.002]	-.007 [.000]	-	-
VOLOPENV	-	-	-	-	-	-	.001 [.621]	.002 [.458]	-		-.001 [.302]	-.001 [.309]
F test (A,B=A_i,B)	F(14,220) =11.184 [.000]	F(14,219)= 19.534 [.000]	F(14,219) =12.727 [.000]	F(14,218) =19.005 [.000]	F(14,220)= 11.665 [.000]	F(14,219)= 18.014 [.000]	F(11,146)= 13.881 [.000]	F(11,147)= 17.447 [.000]	F(11,147)= 14.127 [.000]	F(11,148)= 17.226 [.000]	F(11,147)= 13.023 [.000]	F(11,148)= 16.586 [.000]
Hausman test	$\chi^2(3)$= 4.045 [.256]	$\chi^2(3)$= 17.968 [.000]	$\chi^2(4)$= 13.552 [.009]	$\chi^2(4)$= 20.702 [.000]	$\chi^2(3)$= 3.060 [.382]	$\chi^2(3)$= 16.419 [.001]	$\chi^2(4)$= 3.533 [.973]	$\chi^2(4)$= 19.031 [.001]	$\chi^2(3)$= 2.674 [.445]	$\chi^2(3)$= 18.315 [.000]	$\chi^2(3)$= 2.555 [.465]	$\chi^2(3)$= 17.005 [.001]
Theta	.083	.047	.072	.048	.079	.051	.064	.051	.063	.052	.069	.054
R^2 adj	.853	.772	.862	.779	.859	.778	.851	.801	.851	.800	.846	.788

Source: authors calculations

Table 2. The impact of exchange rate volatility on the share of investment in GDP in percent (total and private – excluding stockbuilding – fixed capital formation)

Steps of the estimation	1/ ER volatility		2/ ER volatility + openness		3/ ER volatility × openness		4/ ER volatility × nature of trade		5/ ER volatility × horizontal		6/ ER volatility × vertical	
Investment	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private
Nb. Obs	252	252	252	252	252	252	176	176	176	176	176	176
GDPG	.257 [.005]	.213 [.000]	.257 [.009]	.206 [.000]	.248 [.006]	-215 [.000]	.237 [.015]	.162 [.000]	.0235 [.016]	.161 [.000]	.247 [.013]	.168 [.000]
I/Y(-1)	.283 [.122]	.866 [.000]	.316 [.081]	.885 [.000]	.302 [.097]	.861 [.000]	.218 [.284]	.739 [.000]	.0225 [.269]	.742 [.000]	.233 [.258]	.756 [.000]
ECUVOL	-.378 [.182]	-.140 [.202]	-.473 [.338]	-.097 [.338]	-	-	-	-	-	-	-	-
OPEN	-	-	-.175 [.030]	.044 [.030]	-		-	-	-	-	-	-
VOLOPEN	-	-	-	-	-.021 [.003]	-.004 [.166]	-	-	-	-	-	-
VOLOPENH	-	-	-	-	-	-	-.145 [.032]	-.070 [.025]	-.115 [.001]	-.048 [.006]	-	-
VOLOPENV	-	-	-	-	-	-	.023 [.646]	.017 [.025]	-	-	-.028 [.265]	-.008 [.345]
F test (A,B=A_i,B)	F(14,220) = 17.958 [.000]	F(14,219) = 1.686 [.060]	F(14,219) =19.710 [.000]	F(14,218)= 2.173 [.010]	F(14,220)= 17.773 [.000]	F(14,219)= 1,883 [.035]	F(11,146)= 17.453 [.000]	F(11,147)= 2.879 [.002]	F(11,147)= 18.311 [.000]	F(11,148)= 2.858 [.002]	F(11,147)= 16.509 [.000]	F(11.148)= 2.282 [.001]
Hausman test	$\chi^2(3)$= 1.046 [.740]	$\chi^2(3)$= 8.882 [.031]	$\chi^2(4)$= 12.177 [.016]	$\chi^2(4)$= 14.053 [.007]	$\chi^2(4)$= 1.407 [.843]	$\chi^2(3)$= 8.8683 [.031]	$\chi^2(6)$= 6.654 [.354]	$\chi^2(4)$= 17.313 [.002]	$\chi^2(4)$= .181 [.996]	$\chi^2(3)$= 15.955 [.001]	$\chi^2(5)$= 2.221 [.819]	$\chi^2(3)$= 13.4000 [.004]
Theta	.051	.549	.047	.424	.052	.504	.051	.312	.049	.315	.054	.0345
R^2 adj	.581	.921	.611	.923	.592	.921	.610	.906	.612	.906	.599	.903
p-values between brackets. We used Whites's heteroskedasticity correction												

Source: authors' calculations

The econometric results confirm the importance of the control variables (lagged GDP growth and GDP level), and the small, but significant, importance of exchange rate variables for investment[10].

The volatility of European countries currencies against the “euro” bears the expected negative sign in explaining investment. However, the level of significance is low when this variable is taken alone (less than 10% for investment in volume, and not significant for investment as a share of GDP).

However, as expected according to the theoretical analysis, the impact of exchange rate volatility is magnified when openness variables are taken into account. When a separate openness variable is introduced, the volatility variable becomes significant at more conventional – even if still low – levels (10% significance for both investment variables). More interestingly, combining openness and volatility through a multiplicative variable yields expected and significant results: the more open a country, the more negative the impact of volatility.

Distinguishing the impact of volatility according to the nature of trade also tends to confirm the theoretical intuition, that the impact of exchange rate volatility on investment differs according to the competitive structure of markets. Introducing both horizontal and vertical differentiation in the econometric estimation yields deceiving results, but this is probably linked to the co-linearity between trade in vertically and trade in horizontally differentiated products. Indeed, introducing only one of the variables into the econometric estimation confirms the theoretical conclusions of the above models: the more horizontally differentiated trade is (i.e. the sharpest price competition is) the more detrimental is exchange rate volatility, for a given openness ratio. This result is significant at the 5 % level. Conversely, a higher volatility, for a given level of openness, does not have a significant influence on investment when only vertically differentiated trade is taken into account.

4. Conclusion

The empirical results seem to confirm the theoretical analysis: for exchange rate volatility to have a significant impact on trade, the external exposure of countries has to be taken into account. This result is even more significant when openness is really combined to exchange rate volatility, and not only controlled for. And the econometric results allow to discriminate between a significant negative impact of volatility on investment when trade is horizontally differentiated, and a not significant (positive) impact of volatility on investment when trade is vertically differentiated.

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[10] Exchange rate variables, when they are significant, usually explain only a small part of variance. See for instance Bénassy-Quéré, Fontagné and Lahrèche-Révil (2000, 2001).

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