UNCERTAINTY AND THE DYNAMICS OF AGGREGATE INVESTMENT IN MOROCCO

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Abstract

Investment is at the core of the process of economic growth. Most theoretical and empirical studies prove that it is a *sine qua non* factor of growth. The rates of aggregate investment in Morocco exhibited a declining or at best a stagnant trend since the end of the 1970s. External shocks, policy shifts, and domestic problems explain this situation. The uncertainty faced by economic agents may be a factor behind the poor performance of aggregate investment in Morocco. The results provide ambiguous conclusions. It is not evident if uncertainty measured by the conditional variance of two underlying variables affects investment or not. More research must be undertaken to improve the techniques of measuring the extent of uncertainty in the Moroccan economy and to identify its links with investment.

Keywords: Aggregate investment, uncertainty, GARCH model, Morocco

Introduction

Investment is at the core of economic activities. First, it is the direct source of the accumulation of physical capital. Second, the acquisition of new machines and equipments introduce more technical progress in the economic process via the new technologies that are embedded in those machines and equipments. Third, investment in education, health, training, and in the acquisition of know-how is necessary to increase the human capital which is a necessary complement to physical capital.

The decision to invest is complex and depends upon a great number of factors and especially on their interactions. One special feature of the decision to invest is that it is a forward-looking one. The investor starts his project if the immediately incurred costs are superior to the actualized expected rewards. Uncertainty, whatever its sources, affects the decision to invest; that is the volume, the structure, and the timing of investment. Unfortunately, from an analytical point of view the relationship between investment and uncertainty[7] is ambiguous (Dixit and Pindyck, 1994) even if empirical studies provide generally strong evidence suggesting a negative impact of uncertainty on investment.

In Morocco, economic growth is weak, instable and insufficient (Abouch and Ezzahid, 2004). The annual rate of growth depends heavily on the performance of agriculture. The financing of the balance of payments depends greatly on the transfers of Moroccans living abroad and on the revenues from tourism. Concerning national investment, it is neither of the desired rate, as a percentage of GDP, nor of the desired quality (Abouch and Ezzahid, 2004). A probable explanation is that local and foreign investors are discouraged by the uncertainty generated by the instable rate of economic growth and by the evolution of other macroeconomic variables and policies. This explanation is probable because we assist to an intriguing situation. Indeed, even if interest rates, as a proxy of the cost of capital, had dramatically decreased since the end of the 1990s; and national saving rate is above the investment rate, investment is still below the required levels for a strong take-off of the Moroccan economy. The paradox is reinforced by the fact that Morocco is reputed to be a macro-economically and politically stable country (World Bank, 2006).

In this paper, we will attempt to explore how uncertainty shapes the investment climate and impact the rate of investment in Morocco. Our purpose in this paper is twofold. First, we attempt to identify the sources of uncertainty faced by investors and construct measures to quantify its extent. Second, we examine econometrically the relationship between the different measures of uncertainty and the volume of investment in the Moroccan economy.

Our paper is structured as follows. In the second section, we discuss the major determinants of investment and the role of irreversibility and uncertainty of investment' projects in its dynamics. The third section reviews some empirical papers dealing with the links between investment and uncertainty. The fourth section presents the evolution of the investment rate in Morocco during the forty last years. The fifth section presents the methodology for measuring uncertainty and determining its links with investment. The last section concludes.

[7] In their first footnote Aizenman and Marion (1999, p. 175) noted that: "in principle, volatility and uncertainty are different phenomena. 'Volatility' refers to the tendency of a variable to fluctuate, while 'uncertainty' is present only when those fluctuations are unpredictable. In practice, volatile variables are frequently unpredictable. We use the two concepts interchangeably". We adopt completely this convention all over this paper.

Determinants of investment and the role of irreversibility and uncertainty

“Economics defines investment as the act of incurring an immediate cost in the expectation of future rewards. Firms that construct plants and install equipment, merchants who lay in a stock of goods for sale, and persons who spend time on vocational education are all investors in this sense” (Dixit and Pindyck, 1994, p. 3). Broadly speaking investment includes “the purchase of any asset or service that generates future production returns” (Stiroh, 2000, p. 3).

Investment in material and in immaterial assets is the unique source of the increase of the stock of capital. Consequently, it is a fundamental variable in the process of economic growth. It affects growth directly and indirectly via the technology embodied in new equipments and new production processes. Furthermore there are sound empirical findings proving that investment and institutions are the unique two factors that are robustly and significantly linked with growth (Levine and Renelt, 1992).

The importance of investment had been recognized by earlier economists who had produced numerous theories and models in order to explain firm’s decisions to invest. But these theories of investment had produced few successes when tested against data. In our opinion, this is due to the complexity of the phenomenon of investment.

The major theories explaining investment are the accelerator principle theory, the Jorgensen model and the q-theory of J. Tobin. In the accelerator model it’s the increase in the level of demand estimated by the increase in the gross domestic product Y_t that determines the level of the net investment. That is, investment is proportional to ΔY_t: $I_{nt}=\Delta K_t=v\Delta Y_t$. Thus investment is linked with the increases of demand by a constant v. One of the major shortcomings of the accelerator principle is the fact that the cost of investing, which is the cost of using capital, is omitted.

In his famous paper, D. Jorgensen (1963) laid out a model where investment is directly linked with the desired stock of capital and the real cost of acquiring capital items. The user’s capital cost ucc_t is:

$$ucc_t=P_k(r_t+\delta-\Delta P_k/P_k).$$

Where P_k, ΔP_k, r, and δ are the price of the capital acquired at time t, the reduction or the increase of the price of capital goods, the interest rate during the t^{th} period, and δ the speed of depreciation of capital goods. According to this formula a capital acquired at a price P_k will induce a cost during one period equal to the sum of three elements: $P_k r$ measuring the opportunity cost of immobilizing P_k during one period, δP_k is the loss of value due to amortization, and $-\Delta P_k$ which is a gain if the price of capital goes up and a loss if P_k goes down.

The widely known Tobins' q-theory of investment was first proposed by Keynes in his general theory. According to Keynes the decision to invest is commanded by the result of comparing the value of the capital at the market and the cost of acquiring this capital (Keynes, 1936). "if an additional unit of installed capital would raise the market value of the firm by more than the cost of acquiring the capital and putting it in place, then a value maximizing firm should acquire it and put it in place…To capture this notion in a observable quantitative measure, Tobin defined the variable q to be the ratio of the market value of a firm to the replacement cost of its capital stock" (Abel, 1990, p. 764);

Economists had always recognized the links between investment decisions and uncertainty but it was just since the end of the 1960s that they began to produce formal models of investment that take account of uncertainty (Arrow, 1968). The links between uncertainty and investment had been treated in different setups[8]. If it is assumed that firms are risk averse and markets are incomplete, then it is found that uncertainty decreases investment (Craine, 1989; Zeira, 1989). In other analytical structures (Abel, 1983; Hartman, 1972) where adjustments costs are symmetric and profits functions are price convex, "mean-preserving increases in price uncertainty raise investment of a competitive firm" (Caballero, 1991, p. 279).

A recent literature about the factors explaining investment introduces the irreversibility of investment as a fundamental element to account for the limited success of standard theories to fully explain the behavior of investment. According to this burgeoning literature, the failure of these theories is explained by the fact that they omit the impact of three inner characteristics of any investment decision (Dixit and Pindyck, 1994). The first characteristic is the almost irreversible nature of investment decisions. That is the impossibility for the initiator of the project to reverse her decision without incurring significant costs. One reason explaining this situation is the project, the firm, or the industry specific nature of acquired assets. Another reason is the impossibility to find a market that value assets at their right value by the fact of the lemons market explained by Akerlof (1970).

The second characteristic of investment decisions is the possibility to delay them. In standard theory, it was implicitly supposed that a project may be realized or not. In reality, "investors can control the *timing* of investment, and postpone it in order to acquire more information about the future" (Servén, 1996, p. 3)

[8] The investment-uncertainty relationship is affected by many factors such as: 1. the firm's attitude toward risk, 2. the degree of irreversibility of the project, 3. the value of the option to wait, 4. the form of the production technology, 5. the structure of products' market, and 6. the form of technological shocks, and so on…

The third characteristic of investment decisions is the impossibility to know the future environment and thus the uncertain nature of future outcomes. The interaction, of these three above characteristics of the decision to invest, influences the problem of realizing a project. Waiting for more information to decide to undertake or not a project may be a good strategy (value of waiting). So this option to wait against the obligation to undertake a project at present may be valued high and so impacts negatively the decision to invest.

The general conclusion of theoretical studies is that the impact of uncertainty on investment is neither systematic, neither linear, neither symmetric. This relationship between investment and uncertainty is likely to be influenced by the variables that dictate the behaviors of firms such as risk aversion and strategic considerations. There are also the very characteristics of firms' environment such as the structure of a sector, the existence or not of the possibilities of diversification, the completeness of markets, and other factors.

Empirical findings

It is obvious that we will survey here just some papers of the literature introducing uncertainty as determinant of investment. It is worth noting that authors use different measures to gauge the extent of uncertainty in an economy. There are differences also in the used methods, covered countries and analyzed periods. In this section we will review a sample of empirical literature studying the behavior of investment in developed and in developing countries. We must signal the fact that the analysis of the determinants of investment particularly private investment points out “issues specific to developing countries” (Rama, 1993, p.129). We have also to keep present in mind the classic *constat* that “formal models have been less successful in empirical implementation, and hence in providing insights into the determinants of investment spending” (Chirinko, 1993, p. 1876).

L. Servén (2003) focused on the impact of the volatility of real exchange rate on privately initiated investment in a sample of 61 developing countries. The author constructed a GARCH-based measure of real-exchange-rate volatility. Operationally he used “a GARCH (1,1) specification in a simple equation in which the (log) real exchange rate follows an AR(1) process with trend, which can have different parameters for each country" (Servén, 2003, p. 213). The author took "the conditional variance from the GARCH procedure as the relevant measure of real exchange rate uncertainty” (Servén, 2003, p. 213). Data in the unbalanced panel cover the period 1970-1995. The author control for the other variables habitually introduced to explain the behavior of investment. The author documented a systematic, negative, and highly significant effect of real exchange rate uncertainty on private investment.

Another paper focusing on the impact of uncertainty on investment is written by Darby et al. (1999). The authors adapt the framework proposed by Dixit and Pindyck (1994). Data are about the business sector in five economies namely: France, Italy, the United States, Germany and the United Kingdom. The authors documented important negative effects of exchange volatility on investment in the five countries.

The non-linearity aspect of the relation between investment and uncertainty is explored in the paper of H. Bo and R. Lensink (2000). The two authors used data related to a panel of Dutch manufacturing firms. Uncertainty is proxied/extracted/measured using a GARCH model. There are 57 firms and the data cover the period 1984-1996. The authors estimated different models in order to test for the robustness of investment-uncertainty relationship. When introduced in an equation of the behavior of investment, the two used measures of uncertainty "are significant with a negative sign, which is consistent with most of empirical literature" (Bo and Lensink, 2000, p. 10).

Another microeconomic look to the investment-uncertainty relationship is provided in the paper of C. Pattillo (1998). The importance of this paper stems from the fact that the author focused on an African country which is Ghana. The author attempted to know if really the increases of the perceived uncertainty push firms to delay investing until that "the marginal revenue product of capital (MRPK) reaches a firm-specific hurdle level" (Pattillo, 1998, p. 522). Three important results are documented by the author. The first result is the evidence in favor of the last proposition. That is the waiting attitude of firms in presence of irreversibility. The second result is the increasing negative effect of uncertainty for firms with significantly more irreversible investment. Furthermore, the author's "empirical results provide support for the prediction that firms wait to invest until the MRPK reaches a firm-specific hurdle level" (Pattillo, 1998, p. 549)

In their paper, P. Acosta and A. Loza (2005) attempted to identify the macro-economic determinants of private investment in Argentina over the period 1970-2000. The authors found that "the rhythm of capital accumulation from the private sector seems to have been determined mainly, in the short term, by transitory factors, both by yield (exchange rate, inflation, trade liberalization), as well as by shocks in the aggregate demand level. Controlling for other variables, the analysis shows evidence of a displacement effect (crowding out) coming from government investment decision" (Acosta and Loza, 2005, p. 404).

C. Sâman (2010) used a monthly data-set to explore the impact of uncertainty on investment behavior in Romania. The author used a GARCH model to construct a measure of uncertainty. The conditional variance of three variables is considered as the measures of uncertainty faced by economic agents. The first variable is the log of the consumer price index. The two other variables are the exchange rates of the Romanian money with respect to the USD (USD/Ron) and with respect to the Euro (Euro/Ron). The study spanned over the period 2000-2008. The author does not find a systematic result. If uncertainty is extracted from the CPI or the exchange rate of RON with respect to Euro a negative and significant relationship is found between uncertainty and investment. A positive and no significant link is found if the USD/Ron rate is considered.

Long-run patterns of investment in Morocco

Moroccan authorities had adopted since the end of the direct French colonialism different schemes to stimulate investment. The major tool was the sectorial and specific investment codes devised to promote investment especially in targeted industries, in export sector, and in less developed areas (Idali, 2005; N'souli and al., 1995). Since the mid-1990s, the government becomes less focused on specific sectors with an aim to create a favorable investment climate for all economic activities.

The evolution of the rate of aggregate investment had displayed an instable pattern over the period 1970-2010. The annual rate of investment oscillated between a minimum of 13.5% and a maximum of 33.1%. Theses two extreme rates were recorded in the 1970s. Over the entire sample the standard deviation of the annual rate of aggregate investment was 3.95%.

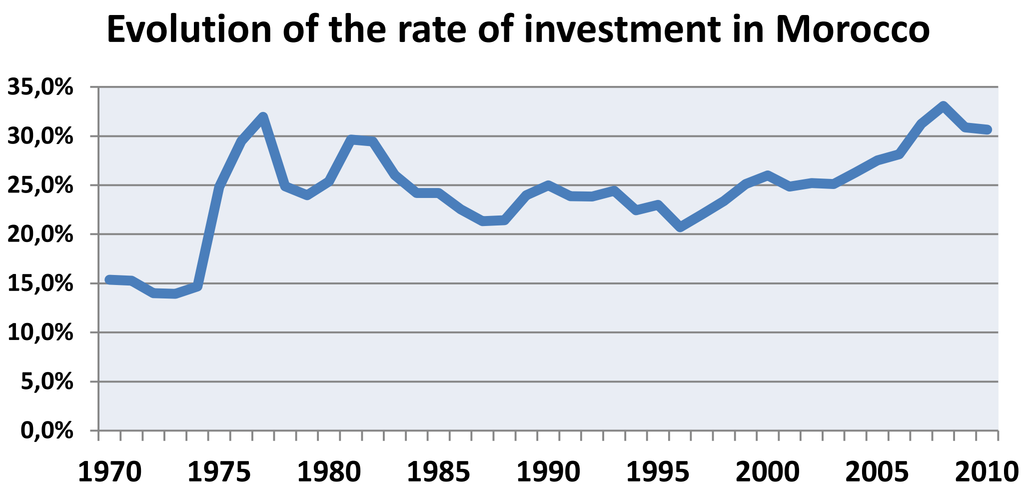
In examining the behavior of the rate of gross investment in Morocco, it is possible to distinguish over the period 1970-2010 four periods. The first period spanned from 1970 to 1974. During this period investment rate was low and gravitated around 14.6%. Over this period, Moroccan authorities applied especially conservative fiscal and monetary policies.

The second period began in 1975, just after the first oil crisis and the important increase of the prices of phosphate, and finished by the end of 1977. The revenues of phosphate' exports produced an increase in government expenditures especially capital items (N'souli and al., 1995, p. 1). During this period the rate of aggregate investment was mainly pushed up by government capital expenditures "which rose from 5.5 percent of GDP in the early 1970s to 11.6 percent of GDP in 1980" (N'souli and al., 1995, p. 1). By the end of this period, the rate of gross fixed investment attained its highest rate over our period of study.

The third period is long and exhibits especially a declining trend of the rate of aggregate investment. This period spanned from 1978 to 1996. During this period, important shocks, events, and policy transformations had been experienced or introduced with great impact on the rate of investment. It is important to notice the abrupt decline of the rate of investment and its pause[9] and its weak and an even recovery during the sub-period 1985-1993 (Goldsbrough and al., 1996).

The fourth period extended from 1997 to 2010. We remark especially a somewhat hesitating growing trend of the investment rate[10]. During this period investment rate is pushed up by foreign direct investment and by the recovery of private domestic investment in a context of a public strategy of building more infrastructures.

In 2008, the investment attained a high rate of over 33%. This performance is mainly due to the implementation of major public programs aiming to accelerate infrastructure construction and to develop tourism areas to achieve the objective of the Moroccan government. As expected the world crisis had its adverse effects on the rate of investment in 2009 and 2010.



Methodology, results, and discussion

The specification of the investment function

In the above discussion, four types of investment' determinants[11] are distinguished. The first class includes determinants that affect directly the rate of return of investment. The second group includes factors that affect the cost of capital mobilization. The third group includes factors impacting the availability of sources of financing investment. The fourth group comprises

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[9] We observe approximately the same behavior of the rate of investment in the MENA region (see Aysan et al., 2005 and 2006)

[10] For a similar discussion see Achy and Sekkat (2007); especially chapter 6.

[11] Chirinko (1993) identified three types of variables that determine the behavior of investment. The price variables (taxes, interest rate...), quantity variables (output, liquidity …), and autonomous shocks (animal spirit, technology shocks …).

factors that affect the investment climate such as macroeconomic stability, economic volatility, political risks, and so on. It is clear that uncertainty whatever its sources -that may be the variables of type 1, type 2, or type 3- is included in this last class of factors. There is another distinction that may be introduced it is about the structural or long-run and transitory or short-run determinants of investment.

Theory suggest that investment is determined by such factors as demand variations, availability of cash-flow, the user cost of capital, expected profits and so on; but provide few indications about the functional form of the relationship between these variables and the rate of investment. Furthermore, there are few indications about the exact proxies of the variables proposed as explanatory factors of the behavior of investment.

In this paper, we focus especially on the impact of uncertainty on the behavior of aggregate investment in Morocco. In doing this we take care to control by the classic set of variables considered as explanatory of the behavior of investment. For this, the first variable introduced is the real GDP as suggested by the accelerator model.

The second variable is the availability of funds in the economy. The modern literature on the finance-growth nexus [12] suggest that financial development, proxied by the ratio of credits to the economy to the GDP, the ratio M3/GDP, or the ratio M2/GDP, is a conducive factor for more investment in the economy. In this paper, we will use the ratio M3/GDP to measure the degree of financial development of the economy.

Investors accept to commit their funds in a project when they can borrow at relatively low interest rates. Furthermore, interest rate is an opportunity cost that any entrepreneurs take account of before investing. Interest rate r is also a prominent part of the user cost of capital. In this paper, interest rate on the 6 month treasury bills (I6MIB) is used as a proxy variable for the cost of funds in the economy.

Measuring uncertainty

The economic theory is not categorical about the investment-uncertainty relationship. There is neither an accord about the existence of a positive or a negative impact of uncertainty on investment nor an accord about its magnitude. In this paper, we attempt to uncover the nature and the magnitude of the investment-uncertainty relationship in Morocco during the period 1980-2010. We are somewhat more in favor of a negative impact of uncertainty on investment because most empirical studies have documented negative effects of uncertainty on investment. To test this hypothesis we

[12] For a survey of the literature see Levine (1997), Ezzahid (2003), and Abouch and Ezzahid (2011).

must first develop a measure to evaluate the extent of uncertainty faced by investing agents.

We will use the methodology applied by Bo and Lensink (2000) to measure the extent of uncertainty in Morocco. This methodology had been used by Servén (2003). Before exposing this methodology it is important to acknowledge the expost nature of this measure of uncertainty. The ex ante one may be the result of a survey to know the probability distribution of a variable for economic agents. Another method for measuring uncertainty uses the variance of a Wiener process.

The methodology of Bo and Lensink (2000) consists to use an economic variable that is strongly affected by uncertainty and extract its unpredictable component and use the variance of this part as a proxy of uncertainty in the economy. The application of this method proceeds in three steps. In the first step, we run a p-order auto-regressive model of the variable that is expected to embed uncertainty[13]. The order of the AR is chosen so as the residuals become white noise. Generally we use a 2-order autoregressive model. In the second step, the residuals from the AR simulation are computed. In the third step, we use an ARCH model to estimate the conditional variance or standard deviation of these residuals[14]. The new obtained series of conditional variance or conditional standard deviation becomes our uncertainty measures extracted from the underlying variable.

Practically, we run jointly two models. The first is an AR(p) for the underlying variable X_t. The second model is estimated in order to calculate the conditional variance σ^2 of X_t (Güris and Yavuz, 2004)

$$X_t = a_0 + \sum_{i=1}^{p} a_i X_{t-i} + \varepsilon_t \qquad (1)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \lambda_i \varepsilon_{t-i}^2 \qquad (2)$$

This formulation is equivalent to this one:

$$A(L) X_t = \varepsilon_t \qquad (3)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \lambda_i \varepsilon_{t-i}^2$$

In this last formulation *A(L)* is a p order polynomial of the lagged value of the variable X_t. In our case, we use a GARCH (p, q) model to

[13] In this situation it is implicitly supposed that some variables are likely to capture economic uncertainty faced by economic agents.

[14] Conditional variance measures the part of the variability of a variable that we can't predict given the information that we have until now.

estimate the conditional variance. That is we regress σ_t^2 on its past and on the squares of ε_{t-i}. For this, we will have:

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \lambda_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \delta_j \sigma_{t-j}^2 \qquad (4)$$

$\omega > 0$, $\lambda_i \geq 0$ for all i, $\delta_j \geq 0$ for all j, $p \geq 0$ and $q \geq 0$.

Restrictions on the values of λ_i and δ_j (with $\lambda_i + \delta_j < 1$ for ensuring stability) are introduced to ensure positive values of σ^2_t (Engle, 2001, p.160). In our case, we apply a GARCH (1, 1) model; that means that we will run the following equation:

$$\sigma_t^2 = \omega + \lambda \varepsilon_{t-1}^2 + \delta \sigma_{t-1}^2 \qquad (5)$$

Two variables are used as underlying ones to extract the unpredictable uncertainty faced by economic agents: the log of current gross domestic product (LCGDP) and the degree of financial development of the economy measured by the ratio M3/CGDP and noted M3CGDP. The data used in the GARCH model are the quarterly LCGDP and the quarterly M3CGDP. The sample period is from the first quarter of 1980 through the fourth quarter of 2010. Since the data used in evaluating the uncertainty-investment links has an annual frequency, we construct the volatility measures with the same periodicity by calculating the arithmetic mean of the conditional standard deviations of quarterly LCGDP and M3CGDP.

Before estimating the GARCH model, it is necessary to explore the stochastic proprieties of the real gross domestic product and the degree of financial development of the economy for valid inference and reliable parameters estimates from the GARCH model. The Augmented Dickey Fuller (ADF) test is used to state if these variables are stationary or not. Table 1 displays the results of the Augmented Dickey Fuller (ADF) test for the presence of unit roots in the series over the 1980:Q1-2010:Q4 sample period.

Table 1. Stochastic properties of the variables, quarterly data

Variables	**Variables in level**		**Variables in first difference**		**Conclusion**
	ADF statistic	**Critical values of the ADF statistic**	**ADF statistic**	**Critical values of the ADF statistic**	
LCGDP					
Case 1	-1.816	-3.448	-8.289	-3.448	
Case 2	-0.022	-2.886	-8.326	-2.886	I(1)+C
Case3	4.806	-1.944	-6.230	-1.944	
M3CGDP					
Case 1	-0.888	-3.447	-14.638	-3.447	
Case 2	2.525	-2.885	-13.950	-2.885	I(1)+C
Case 3	6.162	-1.943	-1.322	-1.944	

Notes: Case1 shows that the auxiliary regression is run with a constant and time trend; Case2 shows that auxiliary regression is run with a constant. Case 3 shows that auxiliary regression is run without any deterministic term or constant. The critical value is at 5% level. C and T indicate that the ADF test is conducted with a constant and a trend.

Before estimating the conditional variance of the LCGDP and the M3CGDP, we must check whether there is autocorrelation in the residuals of the conditional mean equation. The following two equations estimated by ordinary least squares provide the following results:

$$DLCGDP_t = \underset{(0.000)^*}{0.0086} - \underset{(0.000)}{0.407}\, DLCGDP_{t-1} - \underset{(0.0005)}{0.3141}\, \varepsilon_{t-4}$$

$$\begin{aligned} DM3CGDP_t = {} & \underset{(0.0000)}{0.0411} - \underset{(0.0000)}{0.2696} DM3CGDP_{t-1} - \underset{(0.0030)}{0.3205} DM3CGDP_{t-3} \\ & - \underset{(0.0004)}{0.7591}\, DM3CGDP_{t-4} + \underset{(0.0418)}{0.4191}\, \varepsilon_{t-3} + \underset{(0.0000)}{0.6433}\, \varepsilon_{t-4} \end{aligned}$$

(0.0000)(0.0000)

* In parentheses are the p-values. D is the first difference operator

These results show that all estimated coefficients in chosen models are significant at 5%. For the two dependant variables, the Ljung-Box statistics of the residuals show that there is no autocorrelation in residuals. The ARCH-LM test for the presence of ARCH disturbances shows that for the LCGDP and the M3CGDP the null hypothesis of no ARCH errors (i.e. homoscedastic process) is not rejected at the 5 % level. The diagnostic tests indicate that the residuals are serially uncorrelated. Thus the models appear adequate and we pass know to estimate the conditional mean and conditional variance of LCGDP and M3CGDP. The results for the first variable are:

$$\text{(eq1)}\ DLCGDP_t = \underset{(7.6223)^*}{0.0110} - \underset{(-3.5528)}{0.3285}\, DLCGDP_{t-1} - \underset{(-1.8868)}{0.1808}\, \varepsilon_{t-4}$$

$$\text{(eq5)}\ \sigma_t^2 = \underset{(1.0826)}{2.78E\text{-}05} + \underset{(1.7945)}{0.2148}^* \varepsilon^2_{t-1} + \underset{(7.0988)}{0.7603}^* \sigma^2_{t-1}$$

* Numbers in parentheses are the absolute values of the z-statistics. D is the first difference operator

The GARCH (1, 1) parameters in the conditional variance are stable because they sum to less than one (0.9751). The coefficient on the lagged squared residuals (ε^2_{t-1}) is significant at 10%. The coefficient on the lagged error variance (σ^2_{t-1}) is significant at 5%. Moreover, the normality test (Jarque-Bera) is significant at 5% which is consistent with the hypothesis that the residual from GARCH model is normally distributed, the diagnostic tests on the residuals and its square test statistics indicate that there is no serial correlation in the conditional variance, and the Lagrange multiplier test also indicates that the residuals are serially uncorrelated. The conditional mean and conditional variance of M3CGDP are reported in the following:

$$\text{(eq1)}\quad DM3CGDP_t = \underset{(8.0725)}{0.0326} - \underset{(4.5911)}{0.1905}\, DM3CGDP_{t-1} - \underset{(5.2619)}{0.3343}\, DM3CGDP_{t-3} - \underset{(15.6622)}{0.8051}\, DM3CGDP_{t-4} + \underset{(7.6813)}{0.3904}\, \varepsilon_{t-3} + \underset{(16.4153)}{0.6433}\, \varepsilon_{t-4}$$

$$\text{(eq 5)}\quad \sigma_t^2 = \underset{(2.9355)}{0.0030} + \underset{(1.7895)}{0.8742}{*}\,\varepsilon^2_{t-1}$$

* Numbers in parentheses are the absolute values of the z-statistics. D is the first difference operator

The coefficient on the lagged squared residuals (ε^2_{t-1}) is significant at 10%. The coefficient on the lagged error variance (σ^2_{t-1}) isn't significant, therefore the model is GARCH (1,0). Moreover, the normality test (Jarque-Bera) is significant at 5% which is consistent with the hypothesis that the residual from GARCH model is normally distributed, the diagnostic tests on the residuals indicate that there is no serial correlation in the conditional variance, and the Lagrange multiplier test indicates that the residuals are serially uncorrelated.

Data, results and discussion

It is important to precise that a variable may be used for two purposes. First to proxy a particular determinant affecting the decision to invest such as the 6 month real interest rate on treasury bills, that capture the cost of capital. The same variable may be used as an underlying variable to extract its conditional variance in order to construct a measure to gauge uncertainty. Another precision is about the distinction between economic instability that may be measured by the ratio of government deficit to GDP or the rate of inflation, and uncertainty that will be measured by the conditional variance of some underlying variables.

An important step in this work is to explore the stochastic properties of variables. We want to know if the variables are stationary or not and in this later case determine their order of integration. We use the ADF test to know if the series contain unit roots or not. Table 2 summarizes the main results.

Table 2. Stochastic properties of the variables, annual data

Variables	Variables in level		Variables in first difference		Conclusion
	ADF statistic	Critical values of the ADF statistic	ADF statistic	Critical values of the ADF statistic	
LRGDP	-2.775	-3.588	-11.395	-2.968	I(1)+C
LRGFCF	-2.801	-3.574	-4.495	-2.972	I(1)+C
M3CGDP	-1.482	-3.568	-5.019	-2.968	I(1)+C
RI6MTB	-2.021	-3.581	-10.249	-1.953	I(1)

The critical value is at 5% level. The ADF test is conducted with a constant (C) and a trend (T). Results are obtained using E-views 5

The variables that are supposed to affect the behavior of investment (the log of real gross fixed capital formation (LRGFCF)) are: the log of Real Gross Domestic Product (LRGDP), the degree of financial development of the economy (M3CGDP), the real interest rate to measure the cost of capital goods (RI6MIB = (1+I6MIB)/(1+INF), where I6MIB is the nominal interest rate for 6-months treasury bills and INF is the inflation rate), and a variable accounting for uncertainty faced by investing agents. Three systems are obtained depending on the used measure of uncertainty. Remark that each of the three systems contains LRGFCFt, LRGDPt, M3CGDPt, and RI6MIBt. The difference is that the first system and the second system contain the uncertainty extracted from M3CGDP and CGDP respectively. The third system contains both measures of uncertainty. Annex A provide the time evolution of the 6 variables.

System 1: $X_t = [LRGFCF_t, LRGDP_t, M3CGDP_t, RI6MIB_t, Unc\_LCGDP_t]$

System 2: $X_t = [LRGFCF_t, LRGDP_t, M3CGDP_t, RI6MIB_t, Unc\_M3CGDP_t]$

System 3: $X_t = [LRGFCF_t, LRGDP_t, M3CGDP_t, RI6MIB_t, Unc\_LCGDP_t, Unc\_M3CGDP_t]$

The max-eigenvalue test and the trace test are used to determine the number of cointegrating vectors among the variables of each of our three systems. Annex B summarizes the results. To complete the investigation for each system, we will run a VECM to capture in the same framework the short run dynamical relationships between variables and the long run dynamics resumed by the residual of the cointegrating equation lagged by one period. It is said that the VECM is validated if the coefficient attached to this residual is negative and significant. The following table provides the main long run relationship or the cointegrating vector found between the elements of each system.

Table 4. Cointegrating vectors between the elements of the three systems

	$LRGFCF_t$	**$LRGFCF_t$**	**$LRGFCF_t$**
Constant	7.042	7.221	4.056
$LRGDP_t$	0.280 (3.130)	0.264(3.056)	0.545 (4.455)
$M3CGDP_t$,	0.011 (9.784)	0.012 (10.566)	0.005 (2.271)
$RI6MIB_t$	-0.004(-0.393)	-0.008(-0.801)	0.014(1.092)
Unc_LCGDP_t	-9.010 (-1.044)	----	-107.562 (-5.031)
Unc_M3CGDP_t	----	-0.821 (-0.765)	15.954 (5.872)

In parentheses are the t-statistics. The results are obtained using E-views 5

For the first simulated system, the Johansen's unrestricted rank test indicates that the hypothesis of the existence of no cointegrating relationship is rejected at the 5% level, and the null hypothesis that there is at most one cointegrating equation is accepted because the trace test indicates one cointegrating relationships (45.41<47.86) and the Max Eigen-value test indicates, also, one cointegrating relationship at 5% (25.87<27.58) (see annex B).

The VECM is a framework capturing simultaneously the short run dynamical relationships and the long run links between the variables of a system. In the annex C we present the simulated VECM. For system 1 the VECM representation is validated because the coefficient attached to the error correction term (the lagged residual of the cointegrating vector) ζ_{t-1} is negative and significant. In the long run, the log of RGDP and the ratio of M3 to GDP affect positively investment. In contrary, the real cost of capital goods (RI6MIB) affects negatively investment, which is consistent with theoretical assumptions. Unc_LCGDP, as measure of uncertainty, affects negatively and insignificantly investment.

For the second simulated system, the Johansen's unrestricted rank test indicates that the hypothesis of the existence of no cointegrating relationship is rejected at the 5% level, and the null hypothesis that there is at most one cointegrating equation is accepted because the trace test indicates one cointegrating relationship (43.62<47.86) and Max Eigen test indicates, also, one cointegrating relationship at 5% level (18.25<27.58).

For system 2, the VECM representation is validated because the coefficient attached to the error correction term ζ_{t-1} is negative and significant. In the long run, the log of RGDP and the ratio of M3 to CGDP affect positively investment. The cost of capital goods proxied by RI6MIB affects negatively investment. This is consistent with theoretical analysis. The measure of uncertainty (Unc_M3CGDP) affects negatively but insignificantly investment.

In the last simulated system, the Johansen's unrestricted rank test indicates that the hypothesis of the existence of no cointegrating relationship is rejected at the 5% level, and the null hypothesis that there is at most one cointegration equation is accepted because the trace test indicates two cointegrating relationships (47.69<47.86) and the Max Eigen-value test indicates, also, two cointegrating relationships (26.92<27.58). The VECM is in column 3 in annex C.

The VECM representation is also validated for system 3. The coefficient attached to the error correction term ζ_{t-1} is negative and significant. In the long run, the log of RGDP and the ratio of M3 to CGDP affect positively investment. The cost of capital goods approximated by RI6MIB, also, affects positively investment. Paradoxically, in the third system the influence of uncertainty extracted from the current gross domestic product Unc_LCGDP) on investment is negative and significant; whereas uncertainty, extracted from the uncertainty extracted from the degree of financial development of the economy (Unc_M3CGDP), affects it positively and significantly.

For all models, the results presented above indicate the existence of long run links between the variables. The effect of the degree of financial development of the economy (M3CGDP) and the effect of the log of real gross domestic product (LRGDP) are positive. The influence of the cost of capital goods, proxied by RI6MIB, is negative in system1 and in system2 and positive in system 3. This is a rather striking result. In three systems real interest rate is insignificantly linked to investment.

The results reveal, also, a negative impact of uncertainty, extracted from the current gross domestic product (Unc_LCGDP) on the aggregate investment. Moreover, the simulation of systems two and three provides strong support of a non systematic impact of the uncertainty extracted from the degree of financial development of the economy (Unc_M3CGDP) on aggregate investment. These mitigated findings may be explained by the inadequate measures of uncertainty, the nature of the method used to capture its effect on investment or by the extent of our sample.

Concluding remarks

In her 2004 annual report, the World Bank reported that in 51 countries firms consider uncertainty about State policies and macroeconomic instability as their major problems (World Bank, 2004). Furthermore, there are sound theoretical and empirical findings that uncertainty of the investment climate coupled with the irreversibility of investment' decisions are important determinants of the process of capital accumulation especially in developing countries (Dixit and Pindyck, 1994; Pattillo, 1998; Servén, 1996)

The behavior of investment rate in Morocco is a striking phenomenon. Even if conditions related to interest rates, national savings, and other traditional determinants of investment decisions in Morocco are improved; investment rate is still insufficient. In this paper, we have attempted to know if uncertainty linked with fundamental variables in the economy explains the hesitating behavior of investment in Morocco.

Three major results are to be highlighted. First, there are many long-run links between investment and a set of its classic determinants. Second, In system 1 and in system 2, uncertainty impacts investment negatively and insignificantly investment. Third, when the two measures are introduced simultaneously to capture the extent of uncertainty in the economy, uncertainty related to current GDP affects negatively and strongly investment and uncertainty extracted from economy's degree of financial development affects investment positively and strongly.

One possible direction to improve this contribution is to explore how uncertainty affects private investment and public investment. It is necessary to do this because the two components of aggregate investment are obviously not lead by the same factors. Furthermore, Aizenman and Marion (1999) demonstrated that while private investment is adversely affected by volatility; there is no evidence of a negative impact of uncertainty on public investment. This thorough exploration of the dynamic of investment may also shed light on the dynamics of microeconomic decisions of firms concerning their capital stock. This is especially important if we know that micro-economically capital is lumpy and indivisible. Another fact is that firms taken individually may experiment long periods of zero investment and short periods of important investment spending. If firms don't invest that may indicate that they do not need more capital or that they wait for more advantageous conditions. For the State or the similar investing entities the behavior of investment may be more stable over time. Another way of improving the exploration of the links between investment and uncertainty is to devise more accurate measures of uncertainty and to use more subtle techniques to capture its probable impact on investment. Another possibility is to examine if uncertainty affect indirectly investment via its links with other variables that are linked with this strategic variable.

A major conclusion of studies exploring the links between irreversibility, uncertainty and the dynamics of investment is that "to encourage investment, the stability and predictability of the incentive framework -relative prices, demand, interest rates, taxes- may be much more important than the level of the incentives themselves" (Servén, 1996, p. 31).

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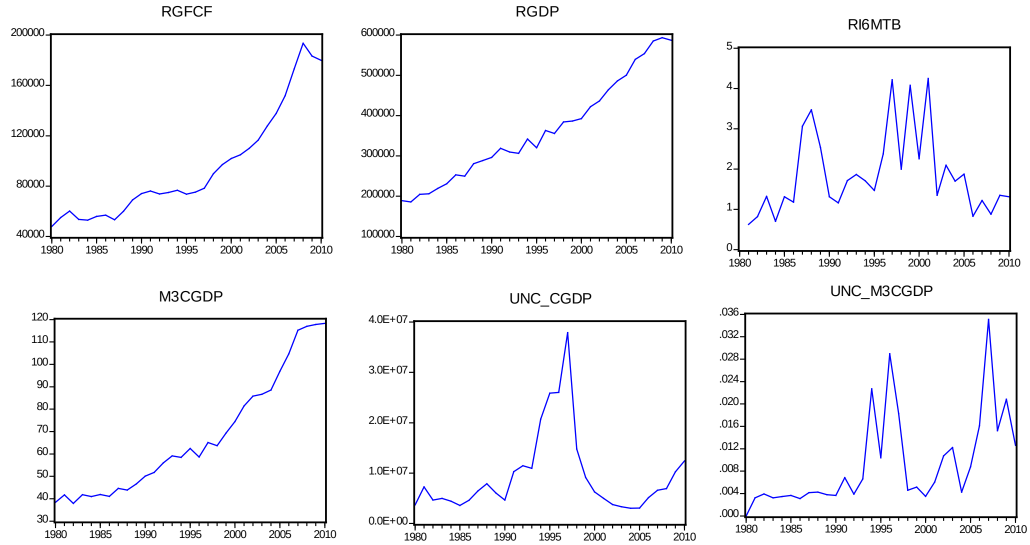
Annex A.
Evolution of the variables 1980-2010



Annex B.

Table 3. Results of the Johansen's unrestricted rank test
(Likelihood ratios trace and maximum Eigenvalue test)

H0	Eigen-value	Max-Eigen Statistic	Trace Statistic	Crtical value of the λ_{max} at 5% level	Crtical value of the trace at 5% level
			System 1		
r=0	0.769	40.988	86.399	33.877	69.819
r=1	0.603	25.872	45.411	27.584	47.856
r=2	0.342	11.718	19.539	21.132	29.797
r=3	0.228	7.250	7.820	14.265	15.495
r=4	0.020	0.571	0.571	3.841	3.841
			System 2		
r=0	0.751	38.924	82.546	33.877	69.819
r=1	0.479	18.252	43.622	27.584	47.856
r=2	0.445	16.492	25.370	21.132	29.797
r=3	0.271	8.857	8.878	14.265	15.495
r=4	0.001	0.021	0.021	3.841	3.841
			System 3		
r=0	0.847	52.537	140.811	40.078	95.754
r=1	0.765	40.585	88.275	33.877	69.819
r=2	0.618	26.923	47.690	27.584	47.856
r=3	0.348	11.962	20.767	21.132	29.797
r=4	0.269	8.756	8.804	14.265	15.495
r=5	0.002	0.049	0.049	3.841	3.841

- r is the number of the hypothesized cointegrating relationships. Results are obtained by using E-views 5

Annex C

Table 5. Results of the simulated VECM

	System 1	System 2	System 3
	D(LRGFCF)	***D(LRGFCF)***	***D(LRGFCF)***
ζ_{t-1}	-0.889 (-4.933)	-0.854(-4.404)	-0.482(-3.524)
D(LRGFCF$_{-1}$)	0.708(3.710)	0.810 (3.852)	0.316 (1.536)
D(LRGDP$_{-1}$)	-0.162 (-0.632)	-0.264 (-0.810)	-0.208(-0.573)
D(M3CGDP$_{-1}$)	0.006(1.866)	0.005 (1.294)	0.008 (1.920)
D(RI6MTB$_{-1}$)	0.006 (0.795)	0.006 (0.7.07)	0.001 (0.129)
D(Unc_RGDP$_{-1}$)	-23.046 (-1.287)	----------	-26.312 (-1.223)
D(Unc_M3CGDP$_{-1}$)	----------	0.629 (0.511)	-3.069 (-1.738)
C*	-0.001 (0.086)	0.002 (0.101)	0.014 (0.660)

We note that the residual series for each system appear to be the white-noise.

* indicates the intercept.

- D(..) indicates the first difference of the variable: D(Y)=Y-Y-1.
- The t-statistics are in ( ).
- Results are obtained by using E-views 5.