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A Small Scale Macroeconomic Model for Morocco

By Youssef OUKHALLOU ^{a†} & Abla MRABTI ^b

Abstract. In this research paper, we build a New Keynesian reduced-form macroeconomic model for Morocco. The model encompasses three main blocks: an aggregate demand equation (IS curve), a price-setting equation (Phillips curve) and a Taylor-type monetary policy rule. In our model, we consider a significant forward-looking component when explaining inflation dynamics, which enables us to include agent's expectations. The downstream aim of this work is to provide the research community with new possibilities in terms of economic workhorse modelling, particularly for monetary policy analysis purposes.

Keywords. Small scale model, Forward-looking expectations, Monetary policy, Fixed exchange regime.

JEL. C32, E12, E17, E43, E47.

1. Introduction

Monetary policy analysis instruments have been the focus of many research papers during the latest decades. The aim was to generate a common language, shared, to a certain extent, by economists as well as policymakers, and on which they could rely to assess the economy's features and to drive forecasts. To begin, the Keynesian theoretical framework laid emphasis on aggregate variables such as national income, consumption, investment, government expenditures, and unemployment rate. Workhorses such as IS-LM and Mundell-Fleming models explored the relationships between these variables, beyond any microeconomic behavioural foundations; these models, among others, were claimed to be empirically observed and verifiable.

However, during the 1970's "great inflation" period, those Macro-founded models, mainly Keynesian, had not been able to "see it coming", and consequently accumulated substantial critics from noteworthy economists. The main argument of the latter was that the models had failed to explore the full implications of *endogenously* formed expectations on the behaviour of economic agents (Snowdon & Vane, 2005). These economists, to whom we refer as the New Classical school, defended the modelling of the economy as an economic equilibrium and considered the rational expectations' hypothesis, as introduced by Muth (1961) and developed afterwards by Sargent (1975) and Lucas (1976).

To overcome those insufficiencies, and in order to re-establish strong specifications for the macroeconomic models, the stress in the research was shifted

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toward the microeconomic foundations as a plinth of aggregate economic phenomena analysis. The first to have explicitly introduced and modelled this framework, i.e. real business cycle, would be Kydland & Prescott (1982). Since, the effectiveness of RBC models' predictions has been enhanced as Goodfriend & King's (1997) "new neoclassical synthesis" opened onto the conciliation of the short run Keynesian analysis with the new classical long run perspectives, in what is known today as the Dynamic Stochastic General Equilibrium (DSGE). The works of other economists, e.g. Barro (1977) and Mishkin (1982) were of crucial added-value, providing empirical evidence to the issue. Calvo (1983), Fischer (1977) and Phelps & Taylor (1977) showed the real effect of nominal disturbances, thereby bringing more accuracy to the models by including rigidities.

The DSGE models proved indeed to be a strong and reliable workhorse for economic analysis and policy evaluation; as a matter of fact, many central banks included them in their toolboxes for monetary prevision and simulation purposes, since they are founded on the behaviour of optimising agents and based on the neoclassical theory of growth. Also, these models have provided an elaborate image of various features of the economy. Whereas, their main drawback is that they are often exceedingly robust and too sophisticated for policymakers, who would generally confine themselves to simple, plausible and coherent models that are sufficiently adequate to capture monetary policy transmission mechanisms. Besides, DSGE modelling is seen as a real challenge in central banks in developing countries.

As a result, more economists aim to build advanced but simplified macroeconomic models with the tractability and communicability features of the IS-LM. Therefore, there has been a convergence between the IS-LM framework and the DSGE approach which seriously considers rational expectations and the micro-foundations of macroeconomic phenomena. This "synthesis" has led to the emergence of core models; the simplest one consists on the combination of an aggregate demand (IS), an aggregate supply (Phillips Curve), and a monetary policy reaction function (e.g. Taylor Rule).

The model we motivate and describe in this paper is subscribed in this very line and is, at the image of the above-mentioned small scale models, embedded on the dynamic stochastic general equilibrium models. To a large extent, our research work fits in the line of the models developed by Batini & Haldane (1999), Svensson (2000a), and Arreaza *et al.* (2003), and Martínez *et al.* (2002). These macro models are: Structural, i.e. each equation reflects a justified economic relationship; in general equilibrium, i.e. all variables of interest are endogenous and interdependent. They take into account the Lucas critic, or even Friedman's, as they embody both forward-looking and backward-looking expectations. The stochastic elements are explicitly introduced and constitute an integral part of the models. This sets them apart from deterministic models that are made stochastic only by the addition of an error term.

In the present research paper, we first review the literature regarding the issue. Then, we shift emphasis toward describing the idiosyncrasies of the Moroccan macroeconomic framework and data. In the third section, a New Keynesian macroeconomic reduced-form model is introduced for the Moroccan economy; it encompasses three main blocks: an aggregate demand equation, a price setting equation and a Taylor rule. Afterwards, we discuss the calibration approach we followed out to parameterize the equations system. By the end, we get to discuss the monetary policy analysis by simulating three different shocks.

2. Small Scale Models: Reviewing the Literature

As a matter of fact, the category of models that we intend to develop in this paper is suitable for developing countries, since it does neither require long series nor too many components (e.g. microeconomic variables...). In addition, most developing countries have just recently started inflation targeting policy and their statistical material is still in the process of development'. For that matter, using a

small and communicable model that embodies few but pertinent macroeconomic variables seems to be the optimal choice for this category of countries. Moreover, an inflation targeting policy puts central banks under the obligation to communicate their monetary policy stance to economic agents. These models could be an efficient tool for this sort of communication. Consequently, a substantial number of central banks, notably in low and middle income economies, started recently to engage this sort of models as a tool for monetary policy analysis.

The main purpose of the model we build in this paper is to simulate various scenarios for analyzing monetary policy transmission mechanisms in the short run. Our model belongs to the line of New Keynesian reduced-form models, side to side with the work of Berg *et al.* (2006b) which introduces 4 blocks: an aggregate demand, an aggregate supply, an interest parity equation and a monetary policy rule. The authors chose parameterization techniques, based on economic principles and available econometric evidence, and announce the possibility of an iterative process to adjust, in an economically consistent way, coefficient values that were chosen, to examine the properties of the model, and to make changes in the structure of the model when this is required for the model to behave appropriately. Other papers used the same type of models to answer different questions. Giordani (2004) based his model on from a modified version of Svensson (2000a) in order to compare its impulse responses to the VAR's; the model does not refer to any exchange rate equation, and concludes that the Taylor rule provides a description that does not fit the Canadian monetary policy. Mahadeva & Smidkova (2001) shed the light on disinflation targeting in the Czech Republic, using a small scale model with forward looking expectations and three transmission channels: the real interest rate, the anticipations of inflation and the exchange rate. The paper uses approximately the same blocks as the ones mentioned above. Arreaza *et al.* (2003) use a small scale macroeconomic model (SSMM) that is made of four blocks (IS equation, Phillips Curve, IRR and an Uncovered Interest Parity (UIP)) and that encompasses rational expectations. Their objective was to conduct simulation experiments in order to analyze the effect of shocks on inflation and to investigate the effect of a temporary increase in public expenditure and an increase in interest rate. Tanuwidjaja & Choy (2006) use this sort of models to examine the role of central bank credibility in achieving inflation targeting. Their model offers new possibilities, as it introduced an oil equation as well as an LM curve.

The last-mentioned paper corroborates how the tractability of the new Keynesian reduced-form models allows the modeller to set adjustments in the model's structure out to match the characteristics of the economy they are describing. We can see how such models provide a systematic framework that can help policymakers have clear insights on the macroeconomic features and allow them to ask the right questions, in relevance with their own respective economy. And most importantly, such models are often derived explicitly from microeconomic foundations in the literature, and the aggregation of these micro-foundations usually leads to equations that are similar to the ones we introduce in the present paper.

Beyond the fact that it is a developing country, Morocco follows a fixed exchange rate regime; although it is an open economy, its capital account is closed. The fixity of the exchange regime and its potential impact on monetary policy has been discussed in several papers, e.g. Benigno *et al.* (2007). The main conclusion of the latter joins Obstfeld & Rogoff's (1996), emphasizing that a fixed exchange regime does not necessary imply that the "peppers" and the "leaders" should have the same policy rule. This is somehow consistent with reality: in the context of 2008 financial crisis's aftermath, we have witnessed a strong downward influence on interest rates in the U.S. and in the Euro Zone, while Bank Al-Maghrib chose not to act on the key interest rate taking into account the distortions and other structural features of the kingdom's economy.

3. The Moroccan data and macroeconomic framework

Before assessing any modelling experimentation for the Moroccan economy, we might have to draw a panoramic image of its specificities. It is worth noticing in this framework that since the early 1980s, the policy goal was to achieve a sustainable growth and reduce the debt burden by being more market oriented. Following the steps of the Structural Adjustment Program (SAP), the features of the modern economy and banking system did not start to really show up until 1996, which coincides with the liberalization of the loan rates, but most importantly with the advent of a new inflation regime. That explains the reason why we chose the time sample 1996-2010, since it provides enough data to drive a model that specifically represents the contemporary monetary policy framework, without biasing the analysis with context-related economic, fiscal and monetary perturbations that took place starting from the year 2011. This time sample could be decorticated into a certain number of time frames.

During the late 1990s, Morocco had known a mild activity growth, with an average of 2.8 percent. Inflation was kept then slightly under the 3 percent threshold. In 2001, GDP growth rate had scored 6.5 percent, and in 2002, it reached around 4.2 percent; this drastic increase was mainly driven by the agricultural output (propitious weather conditions). We should keep in mind the significant influence of the agricultural component on the Moroccan GDP as well as the price level since the country is viewed, to some extent, as agriculture-oriented. This fact constitutes one of the underlying reasons behind the volatility of the output, especially when seen the random aspect of the agricultural activity, tightly tributary of the rainfall level. As for the central bank's interest rate, it hasn't moved much from 3.25 percent from 2003 to 2010, except for a subtle 0.25 percent variation in 2009. It is worth mentioning, however, that in the period from 2011 up to the present, the interest rate was reduced several times in order to support economic growth that has been suffering from exceptionally low agricultural output and the economic repercussion of the international financial crisis on foreign demand. In this context, in 2014 alone, the interest rate was reduced twice. Its level is at 2.25 percent since 2016.

On the other hand, Morocco is an open economy. However, its behaviour does not affect world prices. Subsequently, we consider the "small open economy" hypothesis in the modelling process. Whereas, there are still some "barriers", e.g. a closed capital account, preventing free capital mobility. Besides, the exchange rate is kept under control, which limits its fluctuations, and eventually the strength of its channel of monetary transmission.

As explained above, we use quarterly data starting from 1996Q1 up to 2010Q4², including inflation, GDP, interest rate and exchange rate in the Moroccan economy. As a price level measure, we use the consumer price index inflation gap. The real activity is measured by the gap between real GDP and potential output, which is computed through the Christiano-Fitzgerald Frequency filter. All variables are de-trended using this filter that identifies the long term fluctuations as part of the growth trend and classifies the more jumpy ones as part of the cyclical component. We chose not to use the Hodrick-Prescott filter as the cycle series it yields would be characterised by an intense volatility, thereby most likely reducing the significance of the relations between the variables in the model.

In the period examined in this paper, Bank Al-Maghrib does consider the short interest rate as the first operational instrument of monetary policy, but makes use of other instruments as well (e.g. the reserve requirement). As a consequence, we substitute the key interest rate with the weighted average interest rate (*Taux moyen pondéré*) which is, in this case, subject to more fluctuations in response to different shocks.

As we can notice in Figure 1, the average interest rate is on a downward trend, which is consistent with the openness and liberalization policy that has characterised Morocco during our sample period. To a certain extent, this evolution

is in co-movement with the real exchange rate, which started decreasing since 1999. As for GDP, it follows, on the contrary, a globally increasing path since 1996 (and even since the mid 1980s); this observation should confirm the countercyclical relationship that exists between output growth and the interest rate, or even the exchange rate. As regards to inflation, it has been sustained at an average 2 percent rate for the period 1996-2011.

4. Building the reduced-form model

As mentioned above, the model encompasses three main blocks: the aggregate demand, represented by an IS curve that relates the output gap with expected and lagged explanatory variables; the aggregate supply, i.e. a Phillips curve which sets the price level according to expected inflation, the output gap and the exchange rate. The third block is the monetary policy rule; we assume that the Moroccan central bank follows a Taylor rule that relates the interest rate with expected inflation and the output gap.

Fundamentally, those equations are based on the log-linearization of the Euler equation of consumption resulting from the optimization program of a DSGE model. Thus, the model fits in the New Keynesian framework, providing empirical evidence down from agents' individual behaviour, through first order conditions. Hence, the equations below could be perceived as the aggregation of the latter. The model is set in a stochastic context, as it encompasses random shocks (aggregate uncertainty regarding the future), as agents only know the distribution of the said shocks³; they do not have insights on whether the future values of innovations are going to be zero or one. It is possible to assume that in the case of a linear model, there is no significant divergence between the stochastic and the deterministic results. Still, we prefer not to put aside this potential possibility, in case the model is basically non-linear and just approximated through our first order log-linearization process.

All variables are log-linearized. Furthermore, they are expressed in terms of gap (deviation from the trend level). The Augmented Dickey-Fuller unit root test indicates that all gap variables are stationary, which is supposed to enhance the estimates, by reducing residuals' serial autocorrelation.

4.1. The Aggregate Demand Equation

The IS curve we use here is comparable the type of equations derived from the household optimization program. We consider forward-looking as well as backward-looking expectations, in order to incorporate the persistence. We take into account the small open economy assumption, as mentioned above. Thus, beyond what had been proposed by Berg *et al.* (2006a; 2006b), i.e. an aggregate demand that depends on the real interest rate, the real exchange rate in addition to the past and expected output itself, we included foreign output as an exogenous variable as well, since the Moroccan economy is largely impacted by the international context through the export demand, among other variables.

The equation is written as follows:

$$\hat{y}_t = \alpha_1 \cdot \hat{y}_{t-1} + \alpha_2 \cdot \hat{r}_{t-1} + \alpha_3 \cdot y_t^* + \varepsilon_t^y \quad (1)$$

Where \hat{y}_t is the deviation of the output from its trend level, \hat{r}_t is the real interest rate gap and y_t^* is the Euro zone (12 countries) output gap that we consider as the foreign output gap, since they are by far the key trade partners. We do not consider the exchange rate as an exogenous variable, since its impact is most likely insignificant because Morocco currently follows a fixed exchange regime.

The coefficient α_2 reflects the transmission mechanism of monetary policy on the output gap level. Theoretically, interest rate should have a negative effect on the output gap. Thus, if it is in a high level, investors and borrowers will be

discouraged and the real activity will lose pace. Inversely, an expansionary policy implied by a low level of interest rate stimulates investment and production.

4.2. The Price-setting Equation

The supply side of the model is represented through a Phillips curve which allows describing inflation dynamics. The backbone of Phillips equation developments belong to the line of New Keynesian framework. Several versions of this equation have sensitive similarities with the aggregation of the firms' optimization program; it is possible for it to be traced back to microeconomic foundations.

We introduce in this model a hybrid version that introduces both forward-looking and backward-looking expectations. Thus, inflation is explained by the output gap, economic agents' expectations and the real exchange rate.

$$\Pi_t = \beta_1 \cdot \pi_{t-1} + (1 - \beta_1) \cdot \pi_{t+6}^e + \beta_2 \cdot \hat{y}_t + \beta_3 \cdot \hat{s}_t + \varepsilon_t^\pi \quad (2)$$

[Where π_t is the gap between the inflation mean and the inflation rate measured by $\pi_t = \log(\text{cpi}_t - \text{cpi}_{t-4}) * 100$.] ⁴

We computed the expected inflation as the moving average of the six quarters to come, because as a rule-of-thumb in Morocco, monetary policy and the inflation transmission mechanism are only effective after a period of 6 quarters. The parameter β_1 identifies the nature of the economy. As a matter of fact, a "speedboat economy" means that the weight of the lead term is more important than the lag term; in other words, β_1 is below 0.5. Consequently, the central bank could be considered as credible at the eyes of the economic agents, or probably, it is the existence of price flexibility in the economy that would be the cause of such phenomenon; hence, merely a subtle deviation in interest rate would cause a significant variation in inflation. The other case, i.e. "aircraft economy", implies that only accumulated adjustments in interest rate could move inflation toward the target⁵. As a hypothesis, we state that the Moroccan economy is most likely an "aircraft" one, essentially because of the existence of significant rigidities in many of its aspects. This assumption is even more strengthened when assessing the persistence of inflation.

The coefficient β_2 is the central bank's sacrifice ratio, defined as the total output loss that is generated by a variation in trend inflation⁶. It is supposed to be positive, for two particular reasons: in the literature, a positive output gap drives an upward pressure on inflation, and, in conformity with the sacrifice ratio theory, when reducing inflationary tensions, the central bank likely "sacrifices" a part of the output level and *vice versa*. As for the parameter β_3 , it captures the degree of the pass-through. Said differently, it's the real exchange rate transmission mechanism impact on domestic prices. In principle, a small open economy is characterized by a high pass-through since the economy's structure is less developed and largely exposed to foreign price variations.

4.3. The Monetary Policy Rule

We suppose that the central bank uses the weighted average of the nominal interest rate as an operational target. The central bank would set the interest rate, with taking into account the output gap, in order to achieve the equilibrium level of the inflation rate. We have come up against the fact that Bank-Al-Maghrib does not follow an inflation targeting regime, therefore, we are obliged to establish the target either as the trend level, or the mean value, i.e. around 2.1 percent. Plus, the sovereign bank does not follow an explicit monetary policy rule, so we attempt to capture the reaction function with a Taylor-type rule as follows:

$$i_t = \theta_1 i_{t-1} + (1 - \theta_1) [\theta_2 (\pi_{t+6}^e - \pi^T) + \theta_3 \cdot \hat{y}_t] + \varepsilon_t^i \quad (3)$$

Where i_t is the nominal interest rate gap and π^T is the inflation target. We define the inflation target as the logarithm of the average value of the inflation for the period 1996-2010. θ_1 Is a smoothing parameter, which suggests that the interest rate is set gradually in reaction to inflation⁷. In other words, the monetary policy is observed as inertial, and the interest rate does not fully accommodate a shock in the period it occurs.

θ_2 indicates the degree of the central bank's intervention which goes in line with the nature of the economy. Actually, in an "aircraft economy", as in our case, only accumulated adjustments of the interest rate can reduce inflationary pressure; hence, that implies a low θ_2 . On the other hand; a "speedboat economy" requires a sudden and drastic reaction.

In contrast with several other monetary rules (see Parrado, 2004b) among others], our interest rule excludes the exchange rate, because the Moroccan economy operates with a fixed exchange regime and the central bank does not manage the exchange rate in order to achieve a given inflation target. Countries and zones with flexible regimes such as Canada, the US, and the Euro zone are usually bound to use their interest rate once there is a significant variation of the exchange rate. In most cases, their central banks actually have an exchange rate target, aside from the inflation target.

Unlike these countries, the Moroccan exchange rate is exogenously pegged on the Euro (80 percent) and US dollar (20 percent). Moreover, the capital account is relatively closed. Therefore, the exchange rate is far from being determined by the differential between foreign and domestic interest rates as emphasized in the uncovered interest parity (UIP)⁸. We combine, to a certain extent, the conclusions of Benigno *et al.* (2007) Obstfeld & Rogoff (1996) saying that pegging the domestic currency on a foreign one does not suppose that the interest rate rule should be the same, because pegging the interest rate would only lead to instability and not to a steady exchange rate evolution⁹.

4.4. Model Calibration

We calibrate the model based on a twofold approach. Firstly, we establish a preliminary coefficient calibration based on the stylized facts of the Moroccan economy. It is worth observing that this type of models, in order to be useful for policy makers, needs to accommodate their perspective about the economy, which can be founded on their experience, other models for similar countries, or the discussions with other observers¹⁰. Secondly, we confront and adjust said calibration by estimating all equations one by one, i.e. not as a system. In this frame, we use both the generalized least squares (GLS). Then, we use the Generalised Moments Method (GMM) for benchmarking purposes to estimate the three blocks as simultaneous equations and compare with the GLS outputs.

This effort was deployed with the aim of building a structural macroeconomic model where each equation should have an interpretation that sticks to the economic intuition. In order to actually compute these behavioural equations and generate artificial series and simulate scenarios for monetary policy analysis, it is necessary to firstly choose specific parameter values for $\beta_1, \beta_2, \beta_3, \alpha_1, \alpha_2, \alpha_3, \theta_1, \theta_2$, and θ_3 .

We started with the information provided by our methodology so far, and then we proceeded with an iterative method by developing an initial working version of the model and assessing its outputs. Afterwards, we gradually adjusted the parameters' values until the model started generating artificial series that *imitate*, to a significant extent, the aspects of the Moroccan economy, the latter being represented by the actual data.

For the IS curve, we were inspired to a large extent from the GMM one-equation estimation result. We chose then 0.55 for the output gap lag term¹¹, with no lead term; we had attempted to approximate the latter by computing the moving average of six quarters future horizon and also by adding leads to the variable, but

all these attempts biased the model's outputs. The possible explanation would be the fact that expectations need to be extracted from population investigations.

In conformity with the theoretical literature, we gave a negative value (i.e. -0.002) to the coefficient of the interest rate. The size of our coefficient is significantly smaller than the ones observed in countries such as the Czech Republic, the USA, Canada and EU economies; its value in these countries varies between -0.1 and -0.2. Actually, we had tried similar parameterisation but the model's generated series were too volatile than the actual ones, as demonstrated in figure 2.A, chart 2.A.1. When following an iterative approach –following the economic intuition–, we came up with the conclusion that it is the -0.002 parameter that fits best the Moroccan macroeconomic framework. The difference between our parameter and what is mostly used in the aforementioned countries could be explained by the fact that the real activity in Morocco usually shows less dependency on the interest rate as demonstrated by several indicators, e.g. by the year 2010, the bankarization rate was barely at 47 percent; this rate did not even exceed 6 percent in rural areas.

The Phillips Curve's coefficients were mostly based on our own investigations. Thus, the persistence parameter with the one-lagged inflation was set around 0.54, with a forward looking expectations term of 0.46. The relationship between the real effective exchange rate and the inflation is perceived to be the pass-through channel; in this vein, our investigation has found out that the latter affects the domestic price index by 29 percent. As for the output gap, it is positively correlated with the inflation, with a 0.14 coefficient.

When tackling the policy rule that most represents the behaviour of the Moroccan central bank, we came up against several challenges, particularly the fact that Bank Al-Maghrib's key interest rate did not move much during the examined period. The main reason behind this fact would be that the intervention of the monetary authorities in the Kingdom is wisely based on the nature of the shocks generating inflationary pressures. Therefore, we first calibrated this block according to the standard Taylor rule version. However, when generating the models' artificial series, it seemed that the model over-evaluates to some extent the authorities' interest rate reaction. In figure 2.A (Chart 2.A.2) we compare between our own calibrations with that of the canonical Taylor rule used by the central bank. In this frame, both artificial series fluctuate along with the actual one; however, our version seems to better represent the reality, as the evolution of its generated series does not stray from the actual data's.

Table 1. *Final calibration of the model's parameters*

| Parameter | Parameter signification | value |
|------------|--|--------|
| α_1 | Output gap persistence; a high value means high persistence (0.95), a low value is synonym to more volatility (0.1). | 0.55 |
| α_2 | Actually, the real interest rate weight varies between -0.1 and -0.2, for extremely high or low dependency on the financial aspect of the economy. | -0.002 |
| α_3 | Foreign output gap weight, which typically does not go beyond the range between 0.1 and 0.5 | 0.099 |
| β_1 | Inflation persistence. It describes the respective shares of forward and backward looking expectations. The value varies between 0.4 (low persistence) and 0.9 (high persistence). The linear homogeneity condition : lag term + lead term = 1 | 0.54 |
| β_2 | The output gap impact on inflation. The value, usually varies between 0.1 (low impact and high sacrifice ratio) and 0.5(high impact and low sacrifice ratio) | 0.14 |
| β_3 | Reflects the share of the imported good in the consumption good basket. Generally, its value varies between 0.1 (for relatively closed economies) and 0.9 (for extremely open economies) | -0.29 |
| θ_1 | Policy rate persistence in Taylor rule. The value lies between 0 (no persistence in policy) and 0.8 (for high inertia). | 0.7 |
| θ_2 | The weight set by the central bank, of the differential between expected inflation and the target. It ranges on average between 0.3 and 1. | 0.2 |
| θ_3 | The weight set by the central bank, of the output gap in policy rule. Typically varies between 0.3 and 1. | 0.08 |

Thus, the final model through which we intent to make monetary analysis is as follows:

- *IS Curve:*

$$\hat{y}_t = 0.55 * \hat{y}_{t-1} - 0.002 * \hat{r}_{t-1} + 0.1 * y_t^* + \varepsilon_t^y$$

- *Phillips Curve:*

$$\pi_t = 0.54 * \pi_{t-1} + 0.46 * \pi_{t+6}^e + 0.14 * \hat{y}_t - 0.29 * \hat{s}_t + \varepsilon_t^\pi$$

- *Monetary Policy Rule:*

$$i_t = 0.7 * i_{t-1} + 0.3 * [0.2 * (\pi_{t+6}^e - \pi^T) + 0.08 * \hat{y}_t] + \varepsilon_t^i$$

With: $\pi^T = \log(\text{inflation mean}) = 0.43$

5. Simulation Exercises

Before examining the reaction of the main variables to a series of shocks, we first define the steady state values. The latter were computed so that there would be no secular growth rate, i.e. so that the real output coincides with its potential level (a nil output gap). The inflation's steady state value is the hypothetical inflation target (that we assumed to be the mean¹²), which implies an inflation gap equal to zero. The interest rate should be in its neutral level that we consider, in this instance, to be the trend; therefore, we took the gap to be zero as well. Furthermore, in this steady state, there should be no external disturbances, so we take the foreign output to be in its potential level¹³. We used the software platforms Eviews and Dynare (under Matlab) to confirm whether or not these values accurately represent the steady state, and the results were positive.

In this section, we simulate diverse shocks and scenarios on the economy's key variables and then assess how the endogenous variables react, notably the interest rate, seen that it hints the monetary authorities' behaviour according to the simulated situation. We first test how the economy reacts to a 1 percent variation in the policy rate, with the aim to compare with the theoretical and empirical evidence and make sure one last time that the model does not represent any misspecification. Then, we simulate a 1 percent output shock. Finally, we evaluate the potential impact of a 1 percent variation in the rational agents' expected inflation level.

5.1. The economy's sensitivity to a monetary policy shock

We assume that the monetary authorities decide to raise the key rate by 1 percent as to drive a downward influence on inflationary pressures. This decision would directly bring up the weighted average interest rate with approximately the same proportion. In figure 3, this scenario's outcomes are generated through the model.

The commercial bank interest rate, particularly the loan rate, is supposed to increase. This would lead to a decrease in liquidity, consumption and investment, which would drive a downward influence on the real activity, *ceteris paribus*. This explains the negative output gap as an impulse response, even though in a less important percentage. This decrease reaches its momentum around the third period, while inflation takes more time to fully react to the shock, i.e. from five to six quarters. A possible explanation of the latter would be the monetary policy transmission delay, known in the stylized facts to be exactly six quarters. The existence of price stickiness and expectations (dominated by the backward-looking component) prevents the price level from moving faster, thereby making the adjustment quite lengthy. Another explanation –that is not mutually exclusive with the first one, is that the Moroccan economy relies more on the real activity, which would provide strength to the demand transmission channel, and it is the negative variation in the output gap that gives more pace to the inflation decreasing path¹⁴.

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Through this first sensitivity test shock, the model seems to behave in conformity with the economic principles, and that monetary policy in Morocco influences both GDP and inflation dynamics. This follows perfectly the rules-of-thumb related to the interconnections between these three variables. Therefore, we can proceed to validly analyze other shocks.

5.2. The monetary policy after an output shock:

In figure 4, we simulate the effect of a 1 percent drop in the output gap. From the chart we notice that such a shock drives a disinflationary pressure on the prices level, as the latter reaches -0.15 percent after 2 quarters, then this pressure starts losing strength as the intensity of the negative gap shrinks until reaching back equilibrium after 9 periods. The persistence of inflation makes it take 3 more quarters before meeting with the initial state.

On the other hand, monetary authorities should reduce the interest rate if they want to trim down the shock's effect. That is exactly what we observe through the model's impulse responses. Then, as the real shock is dissipated, the interest rate should be adjusted; otherwise, the economy might face inflationary pressures while the banking system suffers from over-liquidity. This second round policy reaction can be verified in this case, since the interest rate is being raised as the output gap converges toward the steady state (or even, toward a positive value, which would lead eventually to higher inflation¹⁵). Whereas, monetary policy takes over 16 periods to join back its initial level which corroborates the inertial aspect discussed before.

When testing the effect of a positive shock in the output gap due to, say, an exports windfall, the model shows that it keeps the same logic when it comes to the relation between the three variables examined here, as they react the same way, just positively.

5.3. The Reaction to a Shock in Economic Agents' Expectations

Since 2006, Bank Al-Maghrib has chosen to communicate its monetary policy stance through monetary policy reports and quarterly notes. Since then, non-financial economic agents should supposedly become more aware of the inflation level and the course of actions made by the central bank when controlling the monetary and financial framework. Based on this assumption, we simulate the scenario where non-financial economic agents anticipate a higher inflation in the future¹⁶.

In this perspective, we evaluate the reaction of the variables of interest when there is a 1 percent increase in rational agents' expected inflation level (see figure 5). It is plausible to say that when anticipating inflation, agents can actually create inflation since they usually take steps to protect themselves from its effects by adjusting their prices. Hence, these inflationary expectations would lead to an amplification of the current price level, not in the same magnitude however; we observe a 0.46 percent increase (i.e. the proportion of forward-looking agents in the economy) in the inflation gap starting from the first quarter as an immediate reaction of the variable to the agents' change in behaviour before returning back to the steady state after approximately six periods. This phenomenon, along with the eventual inflationary tensions incoming within a six-quarter horizon, should lead monetary authorities to move up the interest rate from its neutral state, in a mild proportion though, i.e. +0.06 percent, rejoining back the equilibrium after 13 quarters. This adjustment in monetary policy is mostly with the aim to anticipate inflation expectations and consequently bypass it.

As regards to the real activity, the feedback is negligible (0.0007). We conclude that inflation expectations do not end up disturbing the real aspect of the economy if monetary authorities react with the right proportion at the right timing.

6. Concluding remarks and recommendations

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In the present paper, we specify a New Keynesian reduced-form macroeconomic model along the line of those used by a significant number of central banks. The purpose has been to provide an operational workhorse for monetary policy analysis in Morocco; the latter consists of three main blocks, i.e. an aggregate demand (IS curve), a price-setting (Phillips) curve and a Taylor-type monetary policy rule. And, diverse scenarios are simulated for analysing monetary policy transmission mechanisms, in the short run mostly.

Although the model contains only three blocks and encompasses few ingredients, its simplicity and flexibility enable it to be an efficient instrument of describing and analysing monetary policy transmission mechanisms. On the other hand, the equations are the aggregation of microeconomic optimization programs.

The model generates the same variables' movements as the actual ones. Moreover, it shows some gradualism in the behaviour of monetary policy makers, since the interest rate generally persists over longer periods than the other variables. When it comes to the agents' inflation expectations, we conclude that a variation in the latter do not end up disturbing the real activity if the monetary authorities react at the right time according to the transmission delay.

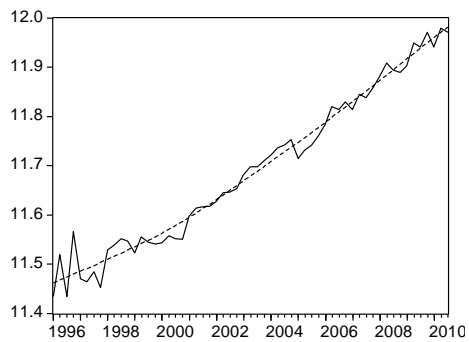
At last, since the small scale model we introduced in this paper fits in a relatively flexible generation of models, we emphasise the possibility for other researches to broaden the conceptualisation as well as the problems treated with such model. For that reason, we hint some possible extensions that could be developed based on our initial work:

- The inclusion of more blocks, and thus, more entities (government reaction function, exchange rate equation, labour market, investment, savings...);
- Adding employment variables as exogenous determinants of inflation dynamics or even the production level; testing therefore the assumption that such a correlation is significant in the Moroccan economic framework;
- Estimating potential output using a structural approach instead of a statistical one, namely through the production function method, thereby providing the model's construction with a larger economic foundation;
- Leading explicit sensitivity analysis for the calibrated parameters, in order to determine which variables are most affected when adjusting its correlation coefficient value. Researchers have the possibility to construct the model according to a parameterisation range instead of just a single calibration; thus, the impulse responses could be studied and compared in accordance with the chosen parameters;
- Or, identifying the model so that it drives forecasts; the latter could come from the combination of market expectations and the judgments of experts and policymakers (i.e. the semi structural basis).

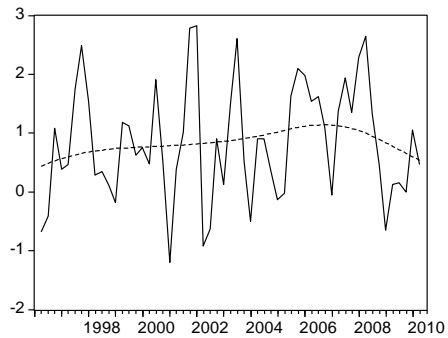
Notes

- ¹ In the Moroccan case, the central bank officially initiated a price stabilization strategy in 2006 (Bank-Al-Maghrib reports)
- ² The data is drawn from Bank-Al-Maghrib's website as well as the IFS's (IMF).
- ³ *i.e.* a null mean and a constant standard deviation.
- ⁴ CPI is the quarterly consumer Price index
- ⁵ See Berg *et al.* (2006b), p.11.
- ⁶ See Ball (1994)
- ⁷ See Gerlach-Kristen (2004)
- ⁸ An uncovered interest rate states that the exchange rate is a function of the difference between the foreign and domestic interest rate plus a risk premium: $s_t = s_{t+1} + (i_t^* - i_t) + Prem$
- ⁹ See Benigno *et al.* (2007).
- ¹⁰ See Berg, *et al.* (2006b).
- ¹¹ This mild persistence is consistent with the Moroccan stylized facts because GDP is tributary to agriculture that represents some volatility. Conceding a higher persistence would reduce the model's anchorage on the framework.
- ¹² We can't really consider an inflation trend during the 1996-2010 period since the consumer price index growth fluctuated around 2.1 percent in a stable pattern. This is the reason why we considered the mean to be the potential level and thus, the target.
- ¹³ Above in this document, the hypothesis of a small open economy has been retained; the equilibrium values of the variables are thus dependent on how close is the rest of the world to its potential growth rate.
- ¹⁴ See Claus *et al.* (2000).
- ¹⁵ The Speed limit is not taken into account since the data as well as the buckle of the empirical literature show no sign of such phenomenon.
- ¹⁶ When referring to rational anticipative agents, we speak about the 46 percent proportion of the population that is allegedly forward-looking, as represented by the coefficient $(1 - \beta_1)$ in the Phillips Curve equation above.

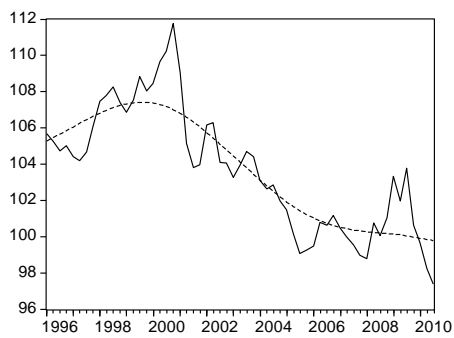
Appendix



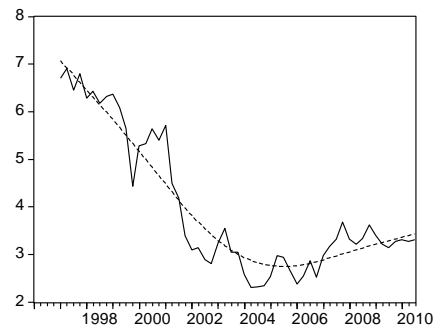
Graph 1: Log real global GDP



Graph 2: Log Inflation



Graph 3: Real exchange rate



Graph 4: Real interest rate

----- The variable's trend

Figure 1. The variables distribution

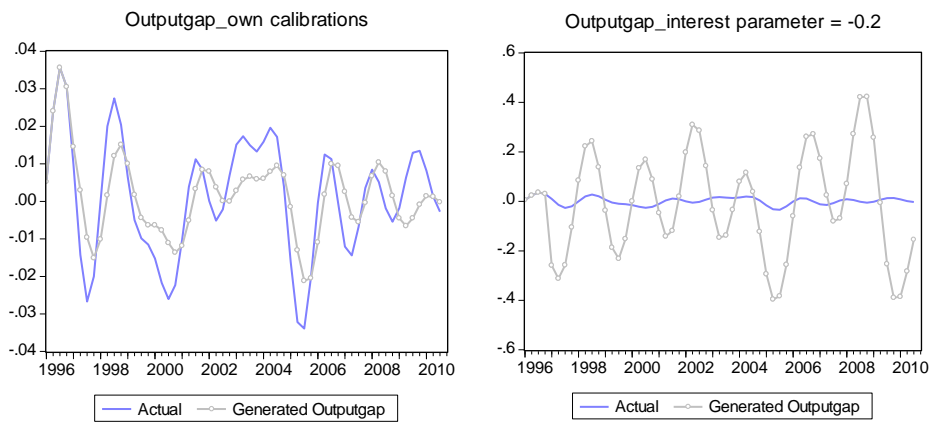


Chart 2.A.1: The IS Curve [interest rate parameter]

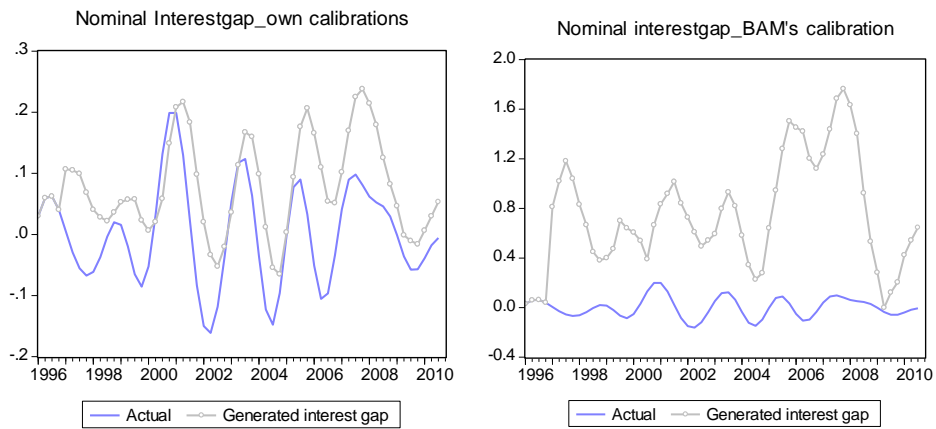


Chart 2.A.2: The Taylor Policy Rule [Inflation parameter]
 Figure 2.A: The model's generated series with different calibrations

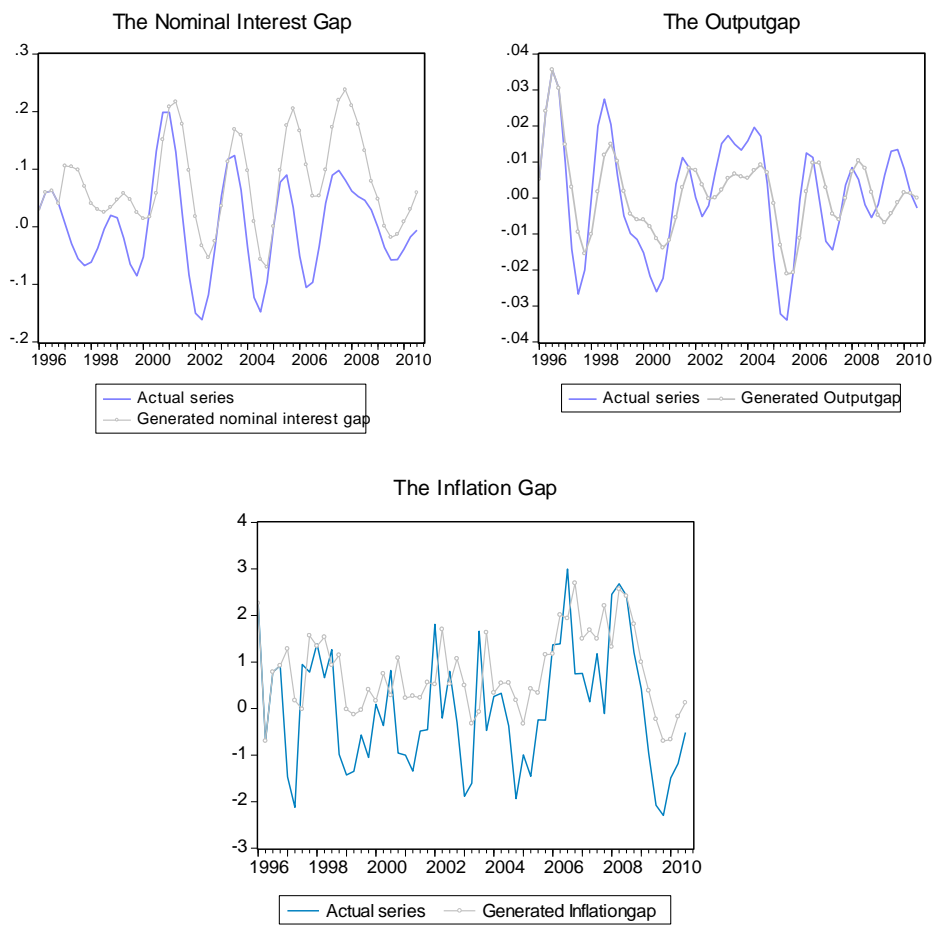


Figure 2.B: The final model's generated series

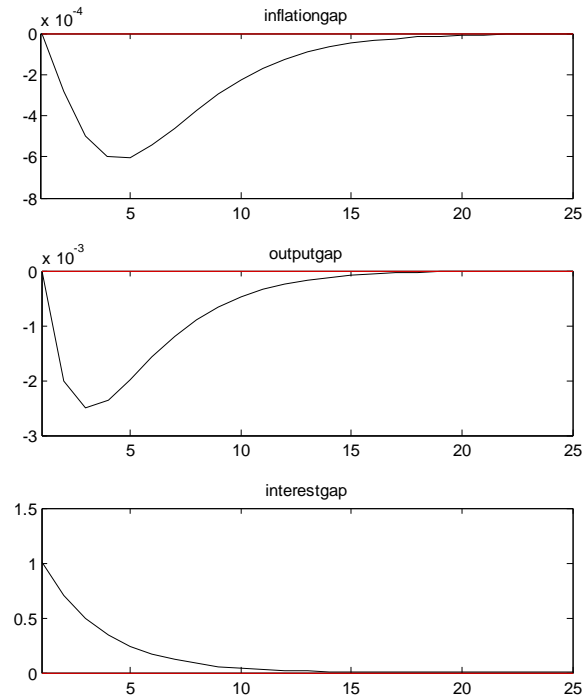


Figure 3: The variables' impulse responses to a monetary policy intervention ((Shock magnitude: $\Delta i = 1\%$)

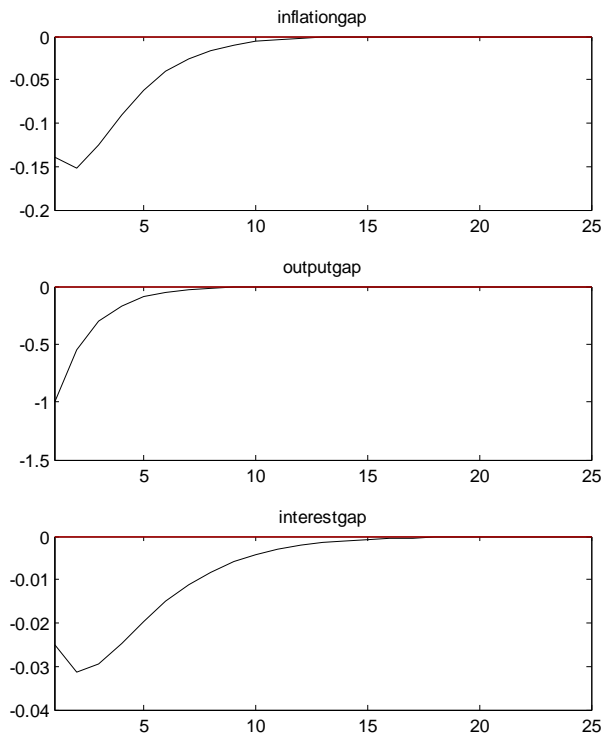


Figure 4: The variables' impulse responses to an output gap shock (Shock magnitude: $\Delta \hat{y} = -1\%$)

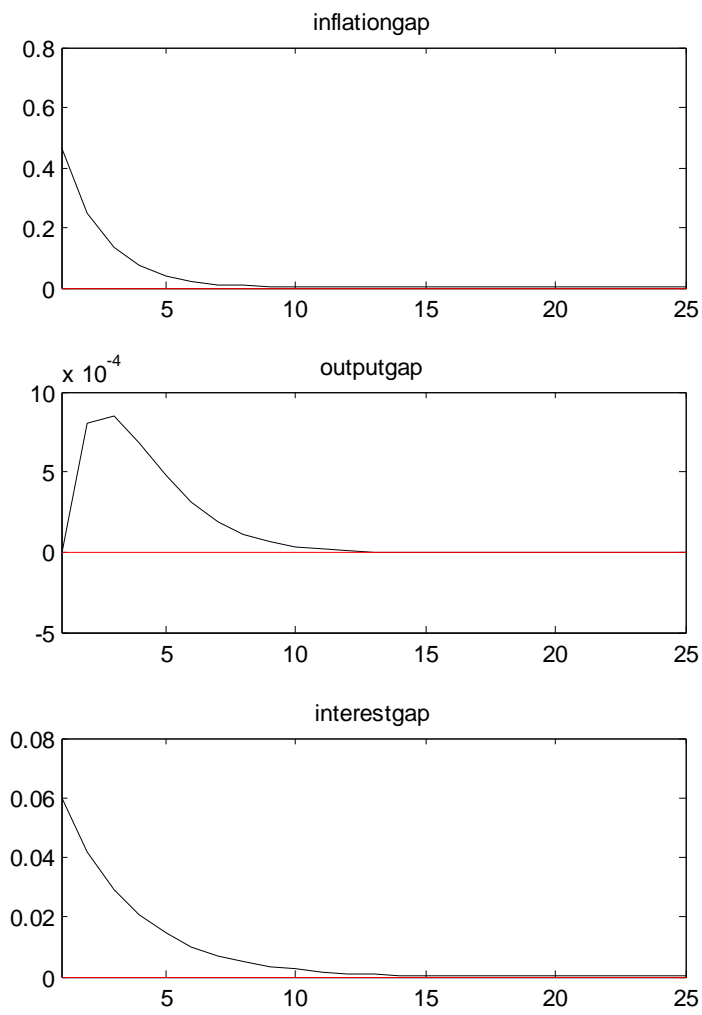


Figure 5: Impulse responses to a variation in the agents' inflation expectations (i.e. $\Delta \hat{\pi}^e = 1\%$)

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