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RESEARCH ARTICLE

# Monetary Conditions Index: Empirical Study

Naitdouch Kaoutar[1], Maarouf Abdelouahab[2]

[1,2]Phd Student at Faculty of Law and Social Sciences Agdal mohamed V University of Rabat - Morocco

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***Corresponding Author:**

naitdouch@um5.ac.ma

**ABSTRACT**

The purpose of this study is to construct a monetary conditions index (MCI) for the Moroccan economy based on the real exchange rate and the real interest rate, in order to estimate the respective importance of each of these two variables in the orientation of monetary policy and hence the impact of this policy on real activity and the level of inflation. The results obtained, based on a Structural VAR using quarterly data from the 1st quarter of 2000 to the 4th quarter of 2019, show us the role of the exchange rate is apparent when the index focuses on the variation of the inflation rate, whereas the demand equation is mainly driven by the variation of the interest rate.

## INTODUCTION

In an open economy, the effectiveness of any economic policy lies in its ability to influence the real economy, through the appropriate instruments. The interest rate alone remains insufficient to assess the impact of monetary policy on economic activity, and on the general price level. It is important to take into account other variables, especially the real effective exchange rate, as an indicator of the economy's competitiveness and its effects on the internal and external macroeconomic balance. To measure this joint influence, most central banks try to construct a Monetary Condition Indicators (MCI), where we combine the two variables, and attributing to each one a weight proportional to its influence on a target variable, such as the output gap or the inflation rate. The variation of the MCI is, by definition, the sum of the variations of each instrument, weighted by coefficients representing the impact of each of them on the real economy.

This reduced form of the MCI can be transformed to a larger form by adding other variables to the equation; central banks tend to develop another index called the Monetary and Financial Conditions Index (MFCI), based on theories about the transmission channels mechanisms of monetary policy. Generally, the index is used, either as a target of monetary policy (this is the case of the central banks of Canada and New Zealand), or as an intermediate variable, capable of guiding the monetary authorities in the implementation of their policy. Changes in the index are equivalent to the loosening or tightening of monetary conditions.

The aim of this paper is to construct a MCI for the Moroccan economy, based on observed series for the period of 2000-2019. Its application will allow us to detect the inflationary pressures through aggregate demand, but also, help the financial markets assess the stance of monetary policy.

The rest of the document is organized as follows: the second section is dedicated to the presentation of the theoretical foundations of the MCI with some empirical evidence in the field. The third section discusses the methodology and data used in the construction of the MCI for the Moroccan case. The fourth section will be discussing the results obtained. The last section concludes.

### Theoretical foundations of the monetary conditions index

The instruments used by the central bank aim to achieve a specific target, whether it's aprice or output stability. These instruments are used to manipulate the variation of their main goals, but it doesn't have a direct and immediate influence on our target variable, for this reason, central banks are forced to use other indicators to conduct their monetary policy. Therefore, a risk of uncertainty occurs, and manifests itself in different forms. Thiessen (1994)[1]highlighted the types of uncertainty that can arise in monetary policy, among them, the uncertainty that comes when the market ignores the central bank's intention, or misinterprets its behavior when an unexpected exogenous shock occurs, while this divergence in perception of the shock should not exist. Moreover, several central banks seek to reduce this uncertainty by clarifying their strategies, and adopting a policy that encourages transparency and clarity.

Many central banks adopted intermediate and operational targets like the Canadian case, but with the disturbance in the financial markets and the strong connection existing between multiple economies, new variables are taken into consideration and disturb the target's path. Some central banks eventually abandoned this approach, and operated without resorting to an intermediate target, until the establishment of a Monetary Conditions Index, first initiated by the central bank of Canada.

### Monetary conditions index and monetary policy transmission mechanism

The Bank of Canada and the Federal Reserve of New Zealand were the first to use this index in the conduct of their monetary policy as an operational target, shortly after, other financial institutions and international organizations chose to use it as a simple indicator of monetary policy, the latter has found success with some institutions, but others have criticized it sufficiently, because of some lacks of performance in the empirical model.

First of all, it's necessary to take a step back in order to understand the composition of this index. By definition, the latter is a synthesis of the effects of the interest rate and the exchange rate on aggregate demand. The choice of these two variables comes from the transmission channels of monetary policy, in other words, when the monetary authorities choose to manipulate the short-term interest rate to conduct their monetary policy, this action triggers some reactions that take place, first in the financial markets, which is then reflected in the expenditure, then the level of production, employment, and then finally on the price level. This sequence is what we call the transmission channel of monetary policy; it is at the same time the basis for the development of the monetary conditions index. The literature provides us different empirical evidence on this issue. Several transmission channels have been identified, most of them are asset prices channels, more particularly the interest rate, which comes from the Keynesian model IS-LM. This channel operates through the demand for real assets, when the central bank chooses to increase itsrate, there will be a rise in the short-term interest rates, the economic agents are going to choose savings over investment, and consequently, we will be facing a downturn in the real activity.

Many others channels has been identified in the literature, especially with the evolution of financial markets recently, among those channels, we mention the exchange rate channel; with the financial and economic openness of many advanced and developing countries, and the transition to a more flexible exchange rate regime; a variation of the latter can affect real activity through international competitiveness of the local production, and therefore, alters the level of exportations, production and price level.

The identification of other transmission channels did not prevent researchers from using the monetary conditions index in a different way. Mishkin et al. (2001)[2]had their own vision of the subject, they identified new channels, known as non-neoclassical channels[3], among them we can mention the credit channel, which emphasizes the asymmetry problems from which the financial markets suffer. Banks are capable of reducing the asymmetry problems because they are able to increase the quantity of loans available and extend it to certain categories of borrowers. When

[1]See Thiessen.G , 1994 for more theoretical work about uncertainty.

[2]See Mishkin et al (2001) for global reviews about transmission channel of monetary policy.

[3] The neoclassical channels are the channels mentioned in the reduced form of the MCI (interest rate and exchange rate channel).

monetary policy is expansionary, the net position of companies (corporate balance sheet) improves through rising share prices, and therefore the asymmetry problems are reduced, and then the access to credit will make the household consumption and business investment rise.

The interest rate and exchange rate channels are the most used by researchers and academics, whereas the other channels are still ambiguous and hard to model empirically. This paper is limited to the construction of the reduced form of the MCI, including only the interest rate and the exchange rate.

**Definition and interpretation of the index of monetary conditions**

The first founders of the index intended in principle to take into consideration the transmission channels of monetary policy, both the Bank of Canada and the Federal Reserve of New Zealand, adopt the MCI in its standard form, where the interest rate and the exchange rate are included with respect to their equilibrium level, the latter had been taken into consideration in order to demonstrate the degree of loosening or tightening of monetary conditions, the value of the index does not have a specific economic interpretation, the point is to compare the level of the current MCI and the desirable MCI to see the evolution of the monetary conditions (tightening or easing). If, for example, an economy suffers from an expansionary demand shock, the central bank will seek to tighten monetary conditions in order to dampen the real activity. When she will adjust her instrument, we will be facing an increase in short-term interest rates and an appreciation of the local currency, hence an increase in the MCI, depending on the market reaction. In the literature, the MCI is presented in the following form:

$$MCI\ (v) = \beta_r(r_t - r_n) + \beta_q(q_t - q_n)$$

The two coefficients represent the weights of each variable on the target variable (v). The ratio $\beta r/\beta q$ reflects the relative impact of the exchange rate and the interest rate on the target. Some studies consider this ratio as the degree of openness of the economy, and implement it as the weight of the exchange rate, without going through the estimation process[4].

A part from this, we mention that the choice of the methodology in the evaluation of the evolution of monetary conditions is crucial. Batini and al (2002)[5]put in value three approaches which are used to estimate the weights relative to the MCI, first, by implementing one demand equation, where the GDP is a function of several variables, the interest rateand the exchange rate, and secondly, we use a price equation known as the Phillips curve, which relies on the price level or the inflation rate as the dependent variable. Another approach is to estimate the relative weights using the application of a VAR model, based on several equations rather than one, the latter includes endogenous variables and their lags,it is referred to a dynamic MCI, and the coefficients are obtained through the impulse responses functions, this method is known for its performance.

The MCI has been calculated in many different ways because it is manipulated in different ways. Since the first implementation by the bank of Canada as an operational target, other financial institutions describe it as a simple indicator to provide information about the monetary policy stance.

The estimation of the coefficients is one of the main challenges to manipulate the index, and skew the results about the reality of the effects produced by asset prices. Erika et al (1996)[6] highlighted the various shortcomings in the reduced-form models, (constraints of stationary, endogeneity of variables, inconstancy of parameters, bias of omitted variables etc),the choice of the model, plays a crucial role in determining the relative weights. Generally, the real effective exchange rate is the most used indicator, for other asset prices, we often choose stock prices, house prices, stock market indices, the choice depends on the availability of the data and the nature of the economy. In the case of the Bank of Canada, a study published by Freedman (1994)[7], where the interest rate chosen was the of 90-day commercial paper, based mainly on the model of Duguay (1994)[8], by estimating a demand equation, the result found explains that a 1% increase in interest rates changes GDP by 0.4%

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[4]See Stevens (1998) for theoretical work on monetary conditions index.
[5]See Batini et al (2002) for dynamic monetary conditions indexes.
[6]See Eika et al (1996) for implementing a Monetary Condition Index.
[7]See Freedman, C. (1994) for The Use of Indicators and of the Monetary Conditions Index.
[8]See Duguay.P (1994) for transmission channel of monetary policy.

in the same direction, while an exchange rate appreciation of 1% changes GDP 0.15%. While for the euro zone, Adrien Verdelhan(1998)[9]opted for the 3-month interbank rate, as a consequence, he finds different results, where his ratio is 1/10.

A study by Good hart and Hoffman (2001)[10], they calculated their index from two empirical approaches, the first is an IS demand equation and a Phillips curve equation, with the output gap and the rate of inflation respectively as the dependent variables, and the second is a VAR approach. Therefore, the results are significant for most variables using both methods, the VAR model allows us to have the effects of each variable following an asset price shock. The effect of the output gap in the face of an interest rate shock is felt after 5 quarters, while inflation reacts until the twelfth quarter, on the other hand, the effect of the exchange rate on inflation is much more significant than the output gap, this was also found by Gauthier (2004)[11]leading to similar results for the Canadian case.

Until now, the monetary authorities are content to use the MCI in its reduced form, despite its limits, the financial institutions adopt a larger form, which involves other variables, mainly financial indicators, based on the new transmission channels identified.

**Construction of a monetary conditions index for the Moroccan economy.**

The aim of this empirical study is to construct, for the Moroccan economy, a monetary condition index based on interest rate and real exchange rate using real data from 2000 to 2019.

## METHODOLOGYAND DATA

In this section, we propose the use of a structural VAR using real data for the Moroccan economy, the choice of this method is based on the performance of the SVAR models in monetary policies in general and the impulse response functions in particular. It has become a popular tool among economists and researchers in the analysis of monetary transmission mechanism and sources of business cycles fluctuations. One of the advantages of the structural model compared to the standard model, is working with contemporaneous relations between the variables, when a simple VAR reject this hypothesis. Despite its performance, it comes with a crucial issue which to impose some restrictions on the models based on the actual theory.

Let's first begin with a standard VAR model:

$$A(L)y_t = u_t \quad avec \quad A(L) = \sum_{t=0}^{p} A_t L^t$$

With A(L) is the polynomial matrix, L = Lag operator, $y_t$= vector of dependent variables.

The vector of dependent variables is represented by a serie of quarterly data of real interest rates (tmp_reel) and real exchange rate (tcer), and the output gap (gap) for the first model, and using the inflation rate instead of the output gap in the second model.

$u_{it}$= the serie of innovations which is supposed to be a linear combination of economic shocks.

$u_{it} = \beta e_t$.

The matrix is represented as follows:

$$\begin{matrix} u_t^{tmp} \\ u_t^{tcer} \\ u_t^{gap/inf} \end{matrix} = \begin{matrix} 1 & \beta_{12} & \beta_{13} \\ \beta_{21} & 1 & \beta_{23} \\ \beta_{31} & \beta_{32} & 1 \end{matrix} \times \begin{matrix} e_t^{tmp} \\ e_t^{tcer} \\ e_t^{gap/inf} \end{matrix}$$

To study the contemporaneous relations, we define the number of restrictions required to get a just-identified model, using the following formula:$n = \frac{k\ (k-1)}{2}$ with k number of endogenous variables. Therefore, the number of restrictions we need in our models is three (3).

Giving these points, we start formulating our restrictions, based on theoretical knowledge:

[9]See Verdelhan (1998) for the construction of MCI.
[10]See Goodhart et al (2001) for more details on monetary and financial conditions.
[11]See Gauthier et al (2004) for global overview on monetary conditions.

First restriction: we start with the interest rate and its effect on the output gap (inflation rate), according to the theory, a shock of interest rate on the output gap (inflation rate) is one of the main reasons of this study, the effect cannot be equal to 0, rather than the effect of the output gap (inflation rate) on the interest rate.($\beta_{13} = 0 \; and \; \beta_{31} \neq 0$).

Second restriction: the same idea for the effect of exchange rate on the outputgap (inflation), according to the literature, a shock of exchange rate can have an important impact on the variables of interests..($\beta_{23} = 0 \; and \; \beta_{32} \neq 0$).

Third restriction: These two variables can be highly correlated, but in our study, we assume that an external shock (fluctuations of the exchange rate) is not going to alter the level of the interest rate, but when there is a monetary shock, it will have an immediate reaction on the exchange rate. ($\beta_{12} = 0 \; and \; \beta_{21} \neq 0$).

In essence, we can rewrite the restrictions as:

$$u_t^{tmp} = e_t^{tmp}$$

$$u_t^{tcer} = \beta_{21} e_t^{tmp} + e_t^{tcer}$$

$$u_t^{gap/inf} = \beta_{31} e_t^{tmp} + \beta_{32} e_t^{tcer} + e_t^{gap/inf}$$

Which is equivalent to:

$$\begin{matrix} u_t^{tmp} \\ u_t^{tcer} \\ u_t^{gap/inf} \end{matrix} = \begin{matrix} 1 & 0 & 0 \\ \beta_{21} & 1 & 0 \\ \beta_{31} & \beta_{32} & 1 \end{matrix} \times \begin{matrix} e_t^{tmp} \\ e_t^{tcer} \\ e_t^{gap/inf} \end{matrix}$$

The model uses quarterly data from the 1st quarter of 2000 to the 4th quarter of 2019, taken from "Manar stat" database. The main independent variables we used in this paper are:

The output gap, which is calculated from real GDP and by using the HP filter,

The inflation rate, which is calculated using the consumer price index,

The real interest rate is calculated from deflating the weighted average rate,

the real exchange rate is already provided.

Before starting the estimation process, we need to verify the stationarity and the absence of co integration between the variables. By using a unit root test, we conclude that the output gap and the real interest rate are stationary in level; otherwise the real exchange rate and the inflation rate are stationary in first difference.

**Table 1. Results of the Augmented Dickey Fuller Test.**

| **Variables** | **Unit root test** | **Stationnarity** | **Order of integration** |
|---|---|---|---|
| Output gap | Stationary in level | -- | I(0) |
| Inflation rate | Non stationary | Stationary in first difference | I(1) |
| Real interest rate | Stationary in level | -- | I(0) |
| Real exchange rate | Non stationary | Stationary in first difference | I(1) |

Regarding the cointegration, we can certify that there is no risk of cointegration because of the different integration orders.

During the estimation process, we adopt two different models, using the real exchange rate and the real interest rate in both models, but we will study the impact on the output gap at first, and on the inflation rate.

## RESULTS AND INTERPRETATIONS

After carrying out the preliminary tests before validating our model, we try to fix the optimal number of lags of our models, according to the selection criteria, we obtain 5 lags for the demand equation and 4 lags for the price equation[12].

We start to estimate the unconstrained VAR model[13] and checking its stability before estimating the structural impulse response functions[14]. This study of the Impulse Response Functions strengthens the analysis of the sensitivity of the variables between them, the shock is artificially introduced in order to analyze the importance of the disturbances caused during a modification (generally of one unit) of the variables of the model, we can assess their impact on the other variables of the system both statically (at a given period) and dynamically (at a continuous period).

The first shockis an interest rate shock, the output gap fluctuates slightly until it goes down after five quarters, but it reaches up a high level after almost two years. Apart from this, the reaction of the inflation rate to this shock is instantaneous, and goes down immediately until it goes up after almost a year and a half. These reactions are expected and remain consistent with the theory of the monetary policy transmission channels, where a rise in interest rates implies a fall in inflation and output.

Similarly, the output gap fluctuates negatively following the exchange rate shock; while the inflation rate experiences a delayed decline and does not react immediately. An appreciation of the exchange rate leads to a fall in the prices of imported goods compared to local goods, but this manifests itself after a few quarters.

The results obtained through the impulse response functions show us that the magnitude of the shocks on the inflation rate is more important than shocks on the output gap.

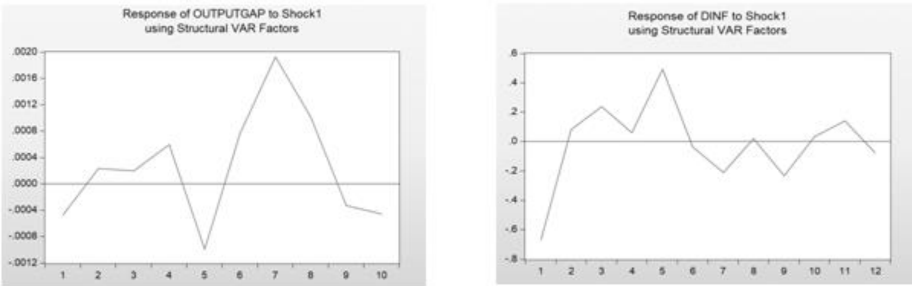


**Figure 1. Reaction of the output gap and the inflation rate to the monetary shock**

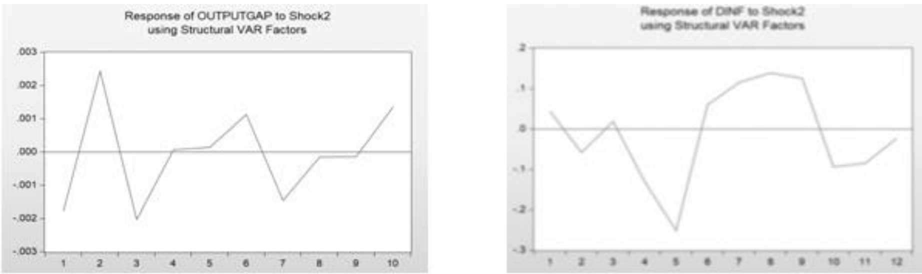


**Figure 2. Reaction of the outputgap and the inflation rate to the external shock**

### The determination of the neutral levels of the real interest rate and the real exchange rate

To complete the construction of our index, we definitely need to fix the neutral levels of both variables, otherwise stated, we apply the HP filter to determine the equilibrium level of each of the two variables, and we compare them to the real level.

[12]See Appendix table 1: Lag length criteria fo

[13] The unconstrained VAR model is a VA

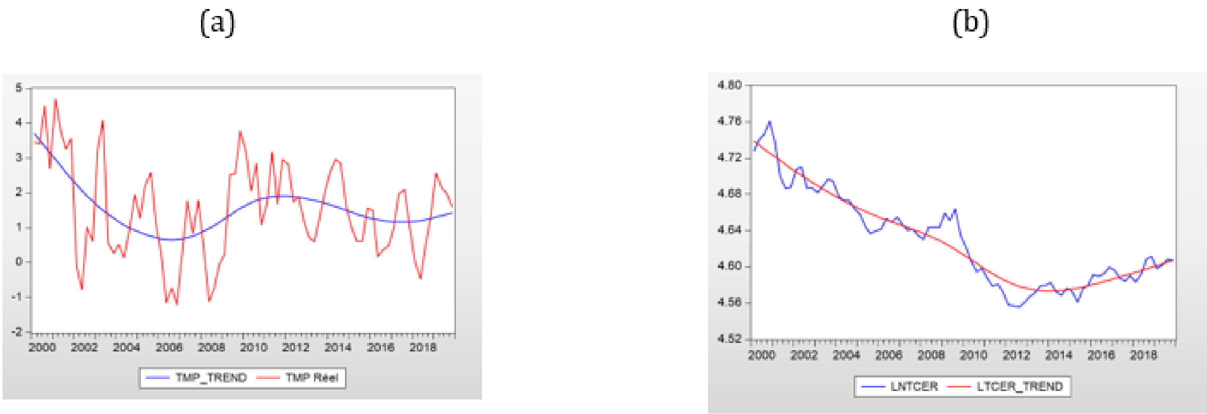


**Figure 3. Variability of the interest rate and the exchange rate and their neutral level**

The interest rate experiences significant crisis or the Euro crisis in a similar manner, the real effective exchange rate should have followed its equilibrium path, with periods of net appreciation (2001, 2009) and depreciation (2012) (Figure 3 (b)), but the latter is smoothly fluctuating, mainly because of the adopted exchange rate regime.

**The derivation of the monetary conditions index**

After identifying the different variables used in the construction of the monetary conditions index, it can be represented as follows:

$$MCI = \propto_1 (r_t - r_n) + \propto_2 (q_t - q_n)$$

The variables $r_t$and $q_t$ are the real interest rate and the real exchange rate, with $r_n$ and $q_n$ their neutral level respectively.

In order to obtain the index weights from the estimated results, the first method is referring to the one introduced by Good hart and Hofmann (2001)[15], where the relative weights are calculated from the average impact of a shock on each asset during a certain period. Based on this methodology, Andrzej Toroj (2008)[16] used the cumulative impulse responses[17] to derive the relative weights for each variable. By following this methodology, we obtain the following coefficients.

For the first model, using the output gap as our variable of interest, the weight of the real interest rate is estimated to 94%, while the weight related to the real exchange rate is equal to 6%. The MCI ratio is equal to 0,064 (0,06/0,94) ; which means that an increase of one point of interest rate will need an increase of 0,064 points of exchange rate, to make the monetary conditions at an optimal level.

$$MCI = 0{,}94(r_t - r_n) - 0{,}06(q_t - q_n)$$

When the inflation rate is taken into account as the dependent variable, the weight of the exchange rate becomes more important (48%) compared to the first model, whereas the weight of the interest rate is equal to (52%). The MCI ratio becomes more important and equals to 0,92.

$$MCI = 0{,}52(r_t - r_n) + 0{,}48(q_t - q_n)$$

Although these two indices oscillate in the same direction, the one based on the output gap fluctuates more sharply than the one based on the inflation rate (Figure 4).

In general, monetary conditions in Morocco have seen some periods of loosening, particularly during 2002-2003 when interest rates observed a remarkable drop, a second period is right after the financial crisis between 2008-2009, when the central bank chose to lower its rates to stimulate activity.

[15] See Goodhart et al (2001) for more details on monetary and financial conditions.
[16] See Andrzej Torój (2008) for an overview on estimation methods of MCI
[17] See Appendix table 4: the accumulated response functions of both models.

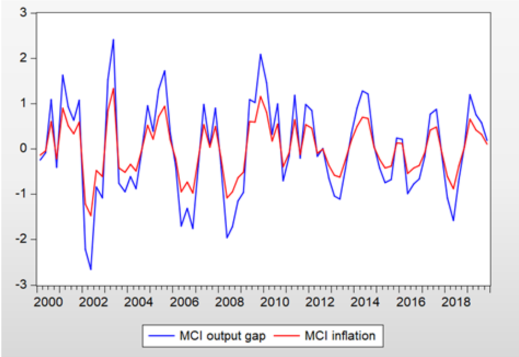


**Figure 4. Variation of the monetary conditions index for the Moroccan economy**

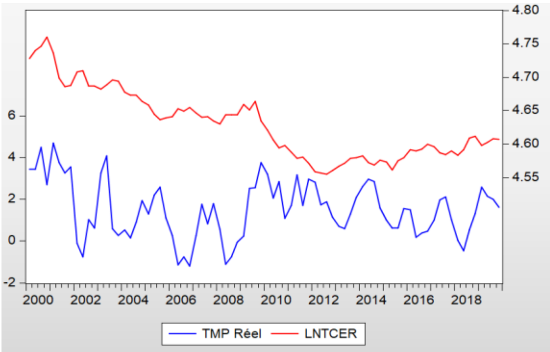


**Figure 5. Variation of the real interest rate and the real exchange rate**

We try to compare some periods that were marked by a sharp drop in the interest rate and the exchange rate, for example, in 2008Q2, the level of the interest rate reached its minimum

while the exchange rate was stable, a second period, during the 3rd quarter of 2012, the interest rate reaches a positive value (1,9) while we recorded the minimum level of the exchange rate during this period, and finally, the last period, 2018Q2 where the interest rate was negative, in opposition to the level of the exchange rate. This table summarizes the different values at the different periods:

**Table 2. The estimated values of the MCI during 2008-2018.**

| PERIODS | TMP level | TCER level | MCI (output gap) | MCI (inflation) |
|---|---|---|---|---|
| 2008Q2 | -1.1 | 4.65 | -2 | -1.1 |
| 2012Q3 | 1.9 | 4.55 | 0 | 0 |
| 2018Q2 | -0.5 | 4.60 | -1.6 | -0.9 |

We conclude that the MCI based on the demand equation is driven by the weight of interest rate (94%), what makes the monetary conditions much loosened, differing from the index based on the price equation, where the conditions are more tightened, because of the weight of the exchange rate (48%).According to these models, the weight of the exchange rate can be noticed through the price equation, whereas in the demand equation, the weight is meaningless, those results are close to the results stated by Good hart and Hoffman (2001)[18] and Gauthier (2004)[19].

The results obtained show that the exchange rate channel is verified, but only in certain cases, the role played by the real exchange rate in the orientation of the monetary policy is present, especially when we focus on the inflation rate as a target, despite the exchange rate regime adopted by the authorities. In addition to the interest rate channel which is always verified in both models. The monetary conditions index can be used as an indicator in the implementation of the monetary policy, the integration of the exchange rate in our model turns out to be helpful.

## CONCLUSION

Monetary conditions represent the combined effect of interest rates and the exchange rate on the economy. The target of this paper is, therefore to construct a Monetary Conditions Index for the

[18]See Goodhart et al (2001) for more details on monetary and financial conditions.
[19]See Gauthier et al (2004) for global overview on monetary conditions.

Moroccan case, by estimating the impact of the real interest rate and exchange rate on the economic activity and the inflation rate, in order to reveal the orientation of the monetary policy.

The monetary policy in Morocco is mainly driven by fluctuations in the interest rate. The loosening of the monetary conditions during several periods is mainly due to the decline in the real interest rate, when the variation of the exchange rate remainsstable, especially when the index is based on the demand equation. Differing from the index based on the price equation, where the exchange rate has a more important weight, hence, the variation of the MCI relies on both variables. The exchange rate is considered, according to this study, as an important factor because it has a direct impact on the inflation rate rather the output gap.

During the past few years, most of central banks build their monetary policy upon the interest rate channel, which is considered as a verified and effective channel, but with the impressive evolution of the capital markets across the world, many researchers and academics tried to shed some light on other transmission channels, apart from the exchange rate, the literature provides more theories on the transmission channels linked to monetary policy, the new neoclassical channels introduced by Boivin(2010)[20]. Several financial indicators, likely to modify the decisions of the authorities in matters of monetary policy, can be included in the construction of the index. As a result, the MCI reflects the dynamics linked to the authorities' decisions on monetary policy, but also the dynamics of the financial sector which is not under control of the central bank.

Despite the various studies carried out on the MCI, the latter has been criticized, the construction of the MCI is sensitive to the choice of methodology and the variables. The new large scale macro econometric models often used by central banks and international organizations are known for their performance but also for their complexity in handling them.

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Conflict of interest: On behalf of all authors, the corresponding author states that there is no conflict of interest.

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# APPENDIX[i]

**Table 1. Lag length criteria for the models (a) for the demand equation and (b) for the price equation**

(a) (b)

VAR Lag Order Selection Criteria
Endogenous variables: TMP_REEL DLTCER OUTPUTGAP
Exogenous variables: C
Date: 12/29/21 Time: 18:59
Sample: 2000Q1 2019Q4
Included observations: 72

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 340.8003 | NA | 1.69e-08 | -9.383340 | -9.288479 | -9.345576 |
| 1 | 361.4928 | 39.08594 | 1.22e-08 | -9.708134 | -9.328689* | -9.557076 |
| 2 | 371.3041 | 17.71491 | 1.20e-08 | -9.730671 | -9.066643 | -9.466319 |
| 3 | 380.9759 | 16.65697 | 1.18e-08 | -9.749331 | -8.800721 | -9.371687 |
| 4 | 397.3291 | 26.80104 | 9.66e-09 | -9.953586 | -8.720392 | -9.462648 |
| 5 | 420.2128 | 35.59693* | 6.64e-09* | -10.33925* | -8.821468 | -9.735014* |
| 6 | 424.2011 | 5.871594 | 7.75e-09 | -10.20003 | -8.397670 | -9.482505 |
| 7 | 428.0799 | 5.387194 | 9.14e-09 | -10.05777 | -7.970830 | -9.226956 |

VAR Lag Order Selection Criteria
Endogenous variables: TMP_REEL DLTCER DINF
Exogenous variables: C
Date: 12/29/21 Time: 19:00
Sample: 2000Q1 2019Q4
Included observations: 72

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 33.41257 | NA | 8.62e-05 | -0.844794 | -0.749933 | -0.807029 |
| 1 | 175.1785 | 267.7802 | 2.16e-06 | -4.532737 | -4.153293* | -4.381679 |
| 2 | 182.0958 | 12.48946 | 2.29e-06 | -4.474883 | -3.810855 | -4.210531 |
| 3 | 194.7927 | 21.86699 | 2.07e-06 | -4.577576 | -3.628965 | -4.199931 |
| 4 | 219.8400 | 41.04973* | 1.34e-06* | -5.023334* | -3.790140 | -4.532396* |
| 5 | 226.3960 | 10.19813 | 1.45e-06 | -4.955444 | -3.437666 | -4.351212 |
| 6 | 232.5506 | 9.060936 | 1.59e-06 | -4.876405 | -3.074044 | -4.158880 |
| 7 | 241.5534 | 12.50391 | 1.63e-06 | -4.876483 | -2.789539 | -4.045665 |

**Table 2. Stability tests of the estimated models**

Roots of Characteristic Polynomial
Endogenous variables: TMP_REEL DLTCER OUTPUTGAP
Exogenous variables: C
Lag specification: 1 5
Date: 12/29/21 Time: 19:41

| Root | Modulus |
|---|---|
| 0.700443 - 0.576014i | 0.906870 |
| 0.700443 + 0.576014i | 0.906870 |
| -0.900237 | 0.900237 |
| -0.582708 - 0.664497i | 0.883802 |
| -0.582708 + 0.664497i | 0.883802 |
| 0.835491 | 0.835491 |
| 0.547992 - 0.583660i | 0.800596 |
| 0.547992 + 0.583660i | 0.800596 |
| -0.035302 - 0.795051i | 0.795835 |
| -0.035302 + 0.795051i | 0.795835 |
| 0.292823 - 0.721016i | 0.778210 |
| 0.292823 + 0.721016i | 0.778210 |
| -0.522964 - 0.193692i | 0.557681 |
| -0.522964 + 0.193692i | 0.557681 |
| 0.514682 | 0.514682 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

Roots of Characteristic Polynomial
Endogenous variables: TMP_REEL DLTCER DINF
Exogenous variables: C
Lag specification: 1 4
Date: 12/29/21 Time: 19:42

| Root | Modulus |
|---|---|
| -0.603094 - 0.674025i | 0.904451 |
| -0.603094 + 0.674025i | 0.904451 |
| 0.594305 - 0.555460i | 0.813471 |
| 0.594305 + 0.555460i | 0.813471 |
| 0.343347 - 0.734203i | 0.810519 |
| 0.343347 + 0.734203i | 0.810519 |
| -0.606044 | 0.606044 |
| 0.480686 - 0.141018i | 0.500944 |
| 0.480686 + 0.141018i | 0.500944 |
| -0.482989 | 0.482989 |
| 0.175239 - 0.276593i | 0.327433 |
| 0.175239 + 0.276593i | 0.327433 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

**Table 3. Estimation of the structural VAR models**

(a)

Structural VAR Estimates
Date: 12/29/21 Time: 18:52
Sample (adjusted): 2001Q3 2019Q4
Included observations: 74 after adjustments
Estimation method: Maximum likelihood via Newton-Raphson (analytic derivatives)
Convergence achieved after 15 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I

A =

| | | |
|---|---|---|
| 1 | 0 | 0 |
| C(1) | 1 | 0 |
| C(2) | C(3) | 1 |

B =

| | | |
|---|---|---|
| C(4) | 0 | 0 |
| 0 | C(5) | 0 |
| 0 | 0 | C(6) |

| | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 0.007653 | 0.001097 | 6.975493 | 0.0000 |
| C(2) | 0.002490 | 0.002166 | 1.149746 | 0.2502 |
| C(3) | 0.244948 | 0.178235 | 1.374300 | 0.1693 |
| C(4) | 0.761473 | 0.062593 | 12.16552 | 0.0000 |
| C(5) | 0.007187 | 0.000591 | 12.16552 | 0.0000 |
| C(6) | 0.011019 | 0.000906 | 12.16552 | 0.0000 |
| Log likelihood | 403.9930 | | | |

Estimated A matrix:

| | | |
|---|---|---|
| 1.000000 | 0.000000 | 0.000000 |
| 0.007653 | 1.000000 | 0.000000 |
| 0.002490 | 0.244948 | 1.000000 |

Estimated B matrix:

| | | |
|---|---|---|
| 0.761473 | 0.000000 | 0.000000 |
| 0.000000 | 0.007187 | 0.000000 |
| 0.000000 | 0.000000 | 0.011019 |

(b)

Structural VAR Estimates
Date: 12/29/21 Time: 18:49
Sample (adjusted): 2001Q2 2019Q4
Included observations: 75 after adjustments
Estimation method: Maximum likelihood via Newton-Raphson (analytic derivatives)
Convergence achieved after 20 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I

A =

| | | |
|---|---|---|
| 1 | 0 | 0 |
| C(1) | 1 | 0 |
| C(2) | C(3) | 1 |

B =

| | | |
|---|---|---|
| C(4) | 0 | 0 |
| 0 | C(5) | 0 |
| 0 | 0 | C(6) |

| | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 0.007057 | 0.001209 | 5.835114 | 0.0000 |
| C(2) | 0.832051 | 0.033413 | 24.90211 | 0.0000 |
| C(3) | -5.367625 | 2.645713 | -2.028801 | 0.0425 |
| C(4) | 0.767322 | 0.062652 | 12.24745 | 0.0000 |
| C(5) | 0.008037 | 0.000656 | 12.24745 | 0.0000 |
| C(6) | 0.184138 | 0.015035 | 12.24745 | 0.0000 |
| Log likelihood | 189.2893 | | | |

Estimated A matrix:

| | | |
|---|---|---|
| 1.000000 | 0.000000 | 0.000000 |
| 0.007057 | 1.000000 | 0.000000 |
| 0.832051 | -5.367625 | 1.000000 |

Estimated B matrix:

| | | |
|---|---|---|
| 0.767322 | 0.000000 | 0.000000 |
| 0.000000 | 0.008037 | 0.000000 |
| 0.000000 | 0.000000 | 0.184138 |

**Table 4: The accumulated response functions of the models**

(a)

| Period | Shock1 | Shock2 |
|---|---|---|
| 1 | -0.000469 | -0.001760 |
| 2 | -0.000235 | 0.000679 |
| 3 | -4.05E-05 | -0.001357 |
| 4 | 0.000557 | -0.001298 |
| 5 | -0.000432 | -0.001165 |
| 6 | 0.000332 | -3.67E-05 |
| 7 | 0.002259 | -0.001497 |
| 8 | 0.003267 | -0.001648 |
| 9 | 0.002938 | -0.001792 |
| 10 | 0.002483 | -0.000454 |
| 11 | 0.001381 | -0.000312 |
| 12 | 0.000942 | 6.39E-05 |

Factorization: Structural

(b)

| Period | Shock1 | Shock2 |
|---|---|---|
| 1 | -0.667517 | 0.043137 |
| 2 | -0.585552 | -0.015338 |
| 3 | -0.348680 | 0.002646 |
| 4 | -0.286999 | -0.126625 |
| 5 | 0.205381 | -0.378479 |
| 6 | 0.170568 | -0.319563 |
| 7 | -0.040005 | -0.204112 |
| 8 | -0.019919 | -0.065703 |
| 9 | -0.251642 | 0.059572 |
| 10 | -0.220867 | -0.033868 |
| 11 | -0.079190 | -0.119031 |
| 12 | -0.155403 | -0.143165 |

Factorization: Structural

[i] the “a” model is estimated with output gap and the “b” model is estimated using the inflation rate.