

MIMO - A MONTHLY INFLATION MODEL*

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1. INTRODUCTION

This note presents a monthly inflation model for the Portuguese economy that was named *MIMO*. The main objective behind the construction of *MIMO* was to develop a framework that could be used, simultaneously, for analysis and projection of monthly inflation rates. This goal was achieved by means of a simple framework that relies on a partial equilibrium approach and operates according to rather naïve price-setting theoretical mechanisms, in which several impacts have been left out. For instance, second-round effects associated with movements in macroeconomic fundamentals are fully absent and this may be of the utmost importance if the projections are for longer horizons. *MIMO* should thus be seen as an additional tool behind any comprehensive analysis of inflation dynamics or any fully-fledge inflation projection exercise, where second-round effects have to be considered.

The inflation models that have been published rely on several mechanisms on how final consumer prices are set. *MIMO* relies on a bottom-up approach, which implies that the overall inflation rate is obtained as the aggregation of its components, namely unprocessed food, processed food, non-energy industrial goods, energy goods and services prices.¹

Each component contains two major groups of items: goods or services whose prices are market determined; and goods or services whose prices are to a large extent influenced by government or national regulators decisions (for instance, tobacco or electricity prices). In the former case, each subcomponent is modeled through an equation with an error-correction mechanism that depends on macroeconomic determinants; in the later case, the remaining items are taken as exogenous, which implies that macroeconomic determinants have no impact on their price dynamics. Furthermore, the two major groups of products of each component are assumed to evolve solely according to their own price dynamics. For example, market-determined prices of processed food items have no effect on any price that is basically determined by regulations or on any other inflation component.

All equations used in the projection and analysis of inflation are based on monthly data. Since the main macroeconomic fundamentals with an important impact on inflation (in particular wages, output, employment and imports deflator) are only available on a quarterly basis, these data are initially disaggregated into a monthly frequency. This higher frequency has some advantages in the context of a inflation projection exercise, allowing for instance to properly incorporate all monthly data that is being disclosed and to easily trace back the contribution of each macroeconomic determinant; that would not be possible in a lower frequency model (for instance in a quarterly or annual model).

* The analyses, opinions and findings of this article represent the views of the authors, they are not necessarily those of the Banco de Portugal.

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(1) Among the different types of models used for inflation forecasting see for example, Moser, Rumler and Scharler (2004), Vlaar and den Reijer (2004), Bandt, Michaux, Bruneau and Flageollet (2007) and Adolfson, Laséen, Lindé and Villani (2007). For a discussion on using a bottom-up approach, as opposed to a top-down approach, see Espasa and Albacete (2007).

This note is structured as follows: Section two presents the general framework of *MIMO*; Section three presents the price-setting theoretical framework behind those prices that are market determined; Section four reports the estimated equations and clarifies the forecasting procedure for those prices which are not market-based; Section five reports the impact of permanent shocks on the main forcing variables of the model, namely unit labour costs and non-energy goods import prices, and also the impact of a temporary innovation in the equation residuals, which corresponds to the way the model deals with a monthly projection error. In Section six, the overall inflation rate registered during 1998-2007 is decomposed and analyzed using *MIMO*. Finally, Section 7 presents the main conclusions as well as some directions for further research.

2. AN OVERVIEW OF *MIMO*

MIMO relies on a bottom-up approach in which the inflation rate is derived from its components, namely unprocessed food (UF), processed food (PF), non-energy industrial goods (NEIG), energy goods (NRG) and services (SRV). These components are in line with the definitions embodied in the Harmonized Index of Consumer Prices (HICP).² The *MIMO* database reads HICP data from January 1996 onwards and uses the most disaggregated dataset that is publicly available (namely, the 2 digit Classification of Individual Consumption According to Purpose (COICOP) disaggregation). Inflation developments are mainly driven by domestic production costs and by prices of imported goods, which implies that all equations represent the adjustment of domestic consumer prices to the evolution of these macroeconomic fundamentals. However, one must take into account that there is a number of consumer prices that cannot be considered as market prices. In *MIMO*, these prices are treated separately. To deal with this setup, each HICP component was split according to the following taxonomy:

Marked-based prices: Includes all goods or services prices that are largely determined by a market based price-setting mechanism that ultimately results from supply and demand interactions;

“Administered” and “Quasi-administered” prices: Includes all goods or services prices that cannot be considered market-based prices. An item is classified as Administered (ADM) if its price is to a large extent determined by government or national regulators decisions, such as electricity prices; an item is classified as quasi-administered (QADM) if its price does not fully comply with the above definition, but is still significantly influenced by exogenous decisions so that it would be erroneous to classify it as a market-based price, such as tobacco prices.

Each ADM and QADM is taken separately in the projection and analysis of inflation. They are fully exogenous for the pure model-based projection, meaning that macroeconomic fundamentals do not help explain and have no impact on their evolution. This refinement is crucial since all equations are assumed to describe the price-setting mechanism of market agents operating in the production and retail trade of goods and services, according to their cost minimization problem. If one includes prices of goods and services that are largely set by exogenous procedures, this may blunder the functional forms of the economic relationships and create potentially spurious results.

Besides HICP data, the *MIMO* database includes domestic production costs and import prices of the Portuguese economy, nominal exchange rates and oil and non-oil commodity prices. Regarding energy items, the database retrieves information from DGEG - Direcção Geral de Energia e Geologia.³

(2) The definitions of each component may be found in European Commission (Eurostat) (2001) and in metainformation disclosed on the internet by the Eurostat.

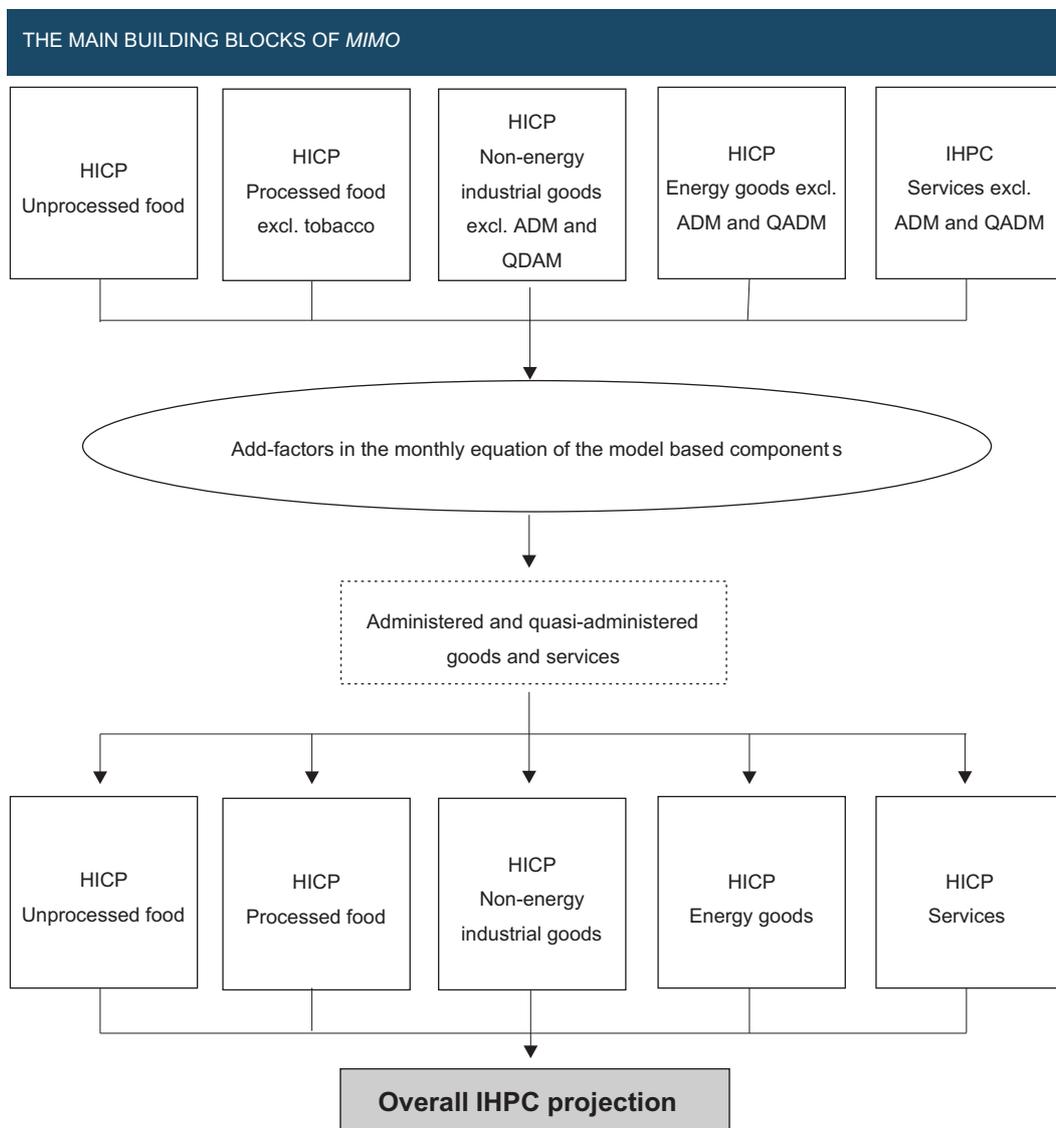
(3) Further information may be found at www.dgge.pt

Given that some of these time series are only available at a quarterly frequency, they have to be disaggregated into a monthly frequency.⁴

The projection process scheme is presented in Chart 1. It is assumed from the outset that no indirect effects exist and thus there is no interaction between prices of each component. To ensure that the automatic equations outcome is not unreasonable, special account should be taken of the evolution of the equation residuals, in particular their recent behaviour, and of the evolution of the error-correction term. In particular, if there is a persistent deviation from the long-run solution in the recent past, one should interpret this feature and act accordingly.

Therefore, judgemental elements - the “Add-factors in the monthly equations of the model based components” - always play some role in an inflation projection exercises. Any model is only able to reflect

Chart 1



(4) The method that is used for the monthly disaggregation of quarterly data is the cubic spline available in the PC-TROLL software. Further information may be found at <http://www.hendyplan.com/trolloverview.htm>

the information contained in the forcing variables. However, there are always pieces of information that cannot be reflected in the initial database. Typical examples may be, for instance, the announcement in 2000 that the 2004 Football European Championship would take place in Portugal. In this case, one should expect a sizeable impact in accommodation services prices. However, this information was not present in the forcing variables, since it was only to be expected an increase in profit margins in view of the unusual favourable demand conditions. Since this temporary enlargement of profit margins could have been anticipated from the outset, one should add-factor the services equation appropriately. Another typical example is an anticipated announcement of indirect tax changes. Finally, another situation where judgement plays a role is when the equation outcome is not reasonable because consumer prices are substantially apart from its long-run equilibrium values and therefore inflation is being totally driven by the error-correction term. Whenever the reversion of the profit margin to its historical mean is not likely, one must include a judgmental element in the equation by means of an adjustment throughout the projection horizon, in order to avoid unreasonable projections.

Once we have a reasonable projection coming from the monthly equations of the model for all subcomponents, we simply add the exogenous projections of ADM and QADM prices.

3. A VERY SIMPLE PRICE-SETTING PROBLEM

MIMO relies on a partial equilibrium approach that operates according to rather naïve price-setting theoretical mechanisms, in which several impacts have been left out, namely those that could only be captured in a general equilibrium model. All feedback from consumer prices to other macroeconomic variables is totally absent. In particular, inflation is projected and analysed as if wages, employment and output were fully exogenous and clearly, the longer the projections horizons, the more important becomes the likely impact of second-round effects. The model should thus be seen as an additional tool behind any comprehensive analysis of inflation dynamics or any fully-fledged inflation projection exercise, where second-round effects have to be considered.

MIMO assumes that the retailer of consumption items operates in a monopolistic competition environment where the presence of indirect taxes affects the final prices paid by the consumers. The cost minimisation problem of the retailer is given by the following setup:

$$\min_{Y_t^H, Y_t^F} P_t^H \cdot Y_t^H + P_t^F \cdot Y_t^F \tag{1}$$

$$Y_t = A (Y_t^H)^\alpha (Y_t^F)^{1-\alpha} \tag{2}$$

P_t^H and P_t^F are the price of home (H) and foreign (F) intermediate inputs, respectively, used in the production of the final consumer good or service (Y_t). Assuming perfect competition in the inputs market, P_t^H and P_t^F are taken as given by the retailer. Y_t^H and Y_t^F are the quantities of home and foreign intermediate inputs required to produce the amount of the final consumer good or service (set exogenously). For simplicity, assume also that A is just a scaling factor.⁵

The optimal demand of Y_t^H and Y_t^F can be recovered from first order conditions:

(5) A more general framework would require that A measures productivity in the production of the final consumer good or service and that A could evolve in time according to some law of motion. The study of the cost minimization problem of the firm, or the profit maximization, may be found in several textbooks, including, for instance, Tirole (1988).

$$Y_t^H = \alpha \left(\frac{P_t^H}{MC_t} \right)^{-1} Y_t \quad (3)$$

$$Y_t^F = (1-\alpha) \left(\frac{P_t^F}{MC_t} \right)^{-1} Y_t \quad (4)$$

where MC_t is the Lagrange multiplier that stands for marginal cost of the final consumption good or service under consideration. Under perfect competition, the final price paid by consumers, P_t , is simply equal to the marginal cost, i.e. $P_t = MC_t$. In a context of monopolistic competition and indirect taxation on final consumer goods and services, P_t must be expressed as a mark-up over marginal costs. Replacing (3) and (4) in (2) we can work out the following condition for the marginal cost:

$$MC_t = \frac{1}{A} \frac{(P_t^H)^\alpha \cdot (P_t^F)^{1-\alpha}}{\alpha^\alpha \cdot (1-\alpha)^{1-\alpha}} \quad (5)$$

Assuming that τ_t is the indirect tax rate and Ω_t is the pre-tax mark-up over marginal costs, has the following expression under monopolistic competition:

$$P_t = (1+\tau_t) \cdot (1+\Omega_t) \cdot MC_t = (1+\tau_t) \cdot (1+\Omega_t) \cdot \frac{(P_t^H)^\alpha \cdot (P_t^F)^{1-\alpha}}{A \cdot \alpha^\alpha \cdot (1-\alpha)^{1-\alpha}} \quad (6)$$

The price equation (6) is used in *MIMO* as the long-run yardstick of the HICP subcomponents price equations. Taking logs on (6), we get:⁶

$$p_t \approx \tau_t + \Omega_t - \alpha - \ln \alpha - (1-\alpha) \ln(1-\alpha) + \alpha \cdot p_t^H + (1-\alpha) \cdot p_t^F \approx \mathbb{C} + \alpha \cdot p_t^H + (1-\alpha) \cdot p_t^F + \varepsilon_t \quad (7)$$

where

$$\tau_t + \Omega_t - \alpha - \ln \alpha - (1-\alpha) \ln(1-\alpha) \equiv \mathbb{C} + \varepsilon_t \quad (8)$$

and

$$\mathbb{C} = \bar{\tau} + \bar{\Omega} - \alpha - \ln \alpha - (1-\alpha) \ln(1-\alpha) \quad (9)$$

$$\varepsilon_t = \varepsilon_t^\tau + \varepsilon_t^\Omega \quad (10)$$

Note that $\bar{\tau}$ and $\bar{\Omega}$ are not time-dependent and simply represent the steady-state levels of indirect taxes and markups, respectively. Conversely, ε_t evolves in time, which can be caused by two alternative structural shocks: indirect taxation (ε_t^τ) or mark-up shocks (ε_t^Ω). Since indirect tax shocks can be easily identified due to the fact that changes in the tax system are known, then we can identify mark-up shocks, provided that measurement errors in marginal cost determinants are negligible.

In short, the following equation can be estimated by OLS, relying on the superconsistency of this estimator in the context of cointegrated time series presented in Engel and Granger (1987):

(6) Lowercase characters represent the logarithms of the variables represented by the corresponding uppercase characters.

$$p_t = C + \alpha \cdot p_t^H + (1 - \alpha) \cdot p_t^F + \varepsilon_t \quad (11)$$

In *MIMO*, the above equilibrium relationship is embedded in an error-correction term equation with the following specification:

$$\Delta p_t = S_t + A(L)\Delta p_{t-1} + B(L)\Delta p_t^H + C(L)\Delta p_t^F - \lambda(p_{t-1} - C - \alpha \cdot p_{t-1}^H - (1 - \alpha) \cdot p_{t-1}^F) + u_t \quad (12)$$

where S_t are seasonal centered dummy variables that account for eventual seasonality in profit margins and $A(L)$, $B(L)$ and $C(L)$ are lag polynomials and L is the lag operator. This specification can be estimated using OLS, provided that there exists a cointegration vector $[C \ \alpha]$ that renders the error correction term $[p_t - C - \alpha \cdot p_t^H - (1 - \alpha) \cdot p_t^F]$ stationary.

One should also highlight that the above error correction mechanism can also be rationalized against a background where the representative firm solves an intertemporal profit maximization problem, where prices are subject to quadratic adjustments costs and inflation expectations are adaptive and based on the past behaviour of domestic and foreign intermediate goods inflation.⁷ In practice, the short-run dynamics captures the fluctuation of profit margins, stemming from the gradual adjustment of prices to shocks in the marginal costs, imposed by the significant costs of an abrupt shift in prices, under the assumption of an unchanged tax rate. Note that the theoretical framework does not consider the existence of indirect effects between consumer prices of different groups of items.

The empirical implementation of (12) requires that one must choose appropriate price indicators both for domestic and foreign intermediate inputs, i.e. P_t^H and P_t^F , respectively. In the case of P_t^F , non-energy goods import prices seem a natural choice. The P_t^H is usually captured by the value-added deflator at basic prices or by unit labour costs. The current equations use unit labour costs of the private sector given that its behaviour seems less prone to eventual measurement errors and clearly accountable in terms of compensation per employee and productivity developments. The choice between value-added deflator and unit labour costs is not relevant if mark-ups over prices of domestic intermediate inputs evolve broadly in line with the mark-ups over the prices of consumer goods retailer; or, alternatively, domestic intermediate inputs are produced in perfect competition and the value-added deflator is a constant mark-up over unit labour costs. The main implication from using unit labour costs instead of the value-added deflator is that one is not able to identify changes in retailers' profit margins. Once unit labour costs are used, profit margins include not only the retailer margin but also intermediate goods producers' margin unless we assume that intermediate goods are produced in perfect competition, in which case the these producers' profit margin is zero.

4. THE FRAMEWORK OF *MIMO*

Following the nomenclature introduced in Section 2, the framework of *MIMO* is made of two blocks. The first block deals with the market-based prices and is presented in Section 4.1, which include UF, PF, NEIG and SRV items, and Section 4.2, which only includes energy items. As already mentioned, this model-based block does not include ADM or QADM prices, which will be presented in Section 4.3 and contains no indirect effects from developments in ADM or QADM inflation or any interaction between the HICP subcomponents.

(7) The profit maximization problem, where prices are subject to quadratic adjustments costs, has been used in recent general equilibrium models. See, for example, Smets and Wouters (2003).

4.1. HICP excluding energy

The equations of the non-energy items of the HICP have the form presented in (12). A general-to-specific modelling approach was followed and all variables that were not statistically significant were simply excluded from the final specification. A summary of the final results is reported in Table 1. All variables are in logs, Δp_{t-i} represents the first difference of p with lag i , and $p = \{UF, PF, NEIG, SERV\}$. Recall from (12) that \mathbb{C} is the constant in the error-correction term, λ is the coefficient associated with the error-correction term and that α_1 measures the importance of domestically generated inflation pressures, which implies that $(1 - \alpha_1)$ is linked to the importance of external inflation pressures. All equations use unit labour costs (ULC) of the private sector as P^H and import deflator of non-energy goods (PMX) as P^F .

The results presented in Table 1 reveal that, in the long run, the model-based block of *MIMO* attaches a lower importance to ULC developments in the case of UF, PF and NEIG, than in the case of SRV. The former group attaches a weight between 48 and 59 per cent to ULC developments, whereas in the case of services' prices this figure increases to 77 per cent. Given that the services items include a larger percentage of non-tradables, in comparison with the goods' aggregates, the results are consistent with the traditional view that services are more sheltered from developments in international prices and more correlated with domestic inflation pressures than the goods' component.⁸ The λ coefficients, which measure the degree of adjustment towards the long-run equilibrium, range between 0.06 and 0.12, which corresponds to an average adjustment period to permanent shocks of between 8 and 16 months.

Table 1

	P_t			
	Unprocessed food (UF)	Processed food (PF)	Non-energy indust. goods (NEIG)	Services (SERV)
Weights on overall HICP (per cent)	11.3	8.4	27.9	25.9
\mathbb{C}	4.92	5.00	5.00	3.63
$-\lambda$	0.12	0.06	0.06	0.08
α_1	0.48	0.59	0.55	0.77
Δy_{t-1}		0.25	0.08	0.12
Δy_{t-3}	0.16			
Δulc_{t-1}			0.07	
S_t				
Jan	0.61	0.25	-3.27	-0.10
Feb	-0.26	0.01	-0.31	0.65
Mar	-0.44	0.11	3.66	0.10
Apr	0.29	0.02	-0.01	0.29
May	0.31	0.06	-0.01	0.04
Jun	0.03	-0.08	-0.33	0.12
Jul	0.16	-0.09	-1.37	-0.03
Aug	0.45	-0.08	-1.43	-0.01
Sep	-1.18	0.01	2.46	-0.03
Oct	-0.52	0.00	0.60	-0.34
Nov	-0.16	0.10	-0.01	-0.34
Dec	0.70	-0.31	-0.01	-0.34

(8) In the case of services prices, a deterministic time trend was also found to be statistically significant. In part, this trend is capturing domestic costs of producing this basket that are not accounted for by the ULC indicator that is being used, which is an aggregate of the whole private sector.

In the short-run, and besides the effects of lagged variables, the model-based block of *MIMO* is highly influenced by seasonal effects. This result was to be expected. Recall from (12) that the seasonal effects are included in \mathbb{S}_t . The HICP is clearly subject to a severe seasonal profile and primarily due to the sales and promotions season that affects NEIG prices. Notwithstanding, seasonality is also evident in unprocessed food prices mainly due to the fact that some fruits and vegetables supply is clearly seasonal and this is reflected in their prices. To account for the seasonality of the HICP, one obvious option could have been to remove it from the raw data using a standard seasonal adjustment procedure. However, this may not be straightforward or even desirable since Portugal has seen several seasonal regimes over the last years, not only due to changing behaviors of economic agents but also due to methodological changes in the computation of the HICP. In addition, it is well known that one should not neglect that most seasonal filters may remove more than seasonality, as pointed out in Thomas and Wallis (1971). The procedure that was followed was based on using centered dummy variables during the estimation process. Throughout the estimation period, the relevant structural breaks in the seasonal pattern were taken into account.⁹

4.2. Energy

The only energy item that is not considered ADM or QADM, and which is therefore subject to an estimation procedure is designated “Fuels and Lubricants for personal transport equipment”. This item accounts for 5 per cent of the overall HICP and 55 per cent of the total energy component. The projections of Fuels and Lubricants prices involve two stages. The first stage consists in decomposing this item into a tax-related fraction, which is affected by taxes on oil products and Value Added Tax (VAT) rates; and a fraction that excludes taxes. The most relevant petroleum products under projection are the prices of “Euro-super 95” and of “Gas oil”. This refinement is highly relevant since the only fraction of energy item of the HICP that is subject to a modelling procedure is for Fuels and Lubricants prices excluding taxes. These equations project the evolution of gas oil and gasoline as a function of recent developments in oil prices in euros, considering a degree of transmission that amounts to about 80 per cent of the change in oil prices. This incomplete transmission from oil prices to fuel prices excluding taxes might reflect the fact that imported oil and other costs indexed to oil price account for 80 per cent of the refining and distribution costs and profit margins. It is assumed that the remaining costs are frozen throughout the projection horizon.¹⁰ Therefore, given that there is no error-correction term in the equations, all shocks, either permanent or temporary, have a permanent effect on the price level, are they oil price shocks or unanticipated shocks to refining margins. This matter will be analysed further in Section 5.

The tax-related fraction of the Fuels and Lubricants item is treated separately and represents a second stage of the projection processed of this item. In particular, changes in specific taxes on oil products and VAT rates are assumed to evolve according to fiscal policy measures already approved in legal terms or specified in sufficient detail. If no information is available, the level of all taxes is maintained unchanged throughout any relevant projection horizon.

(9) The structural break in NEIG prices as from January 2006 onwards, due to methodological changes, was analyzed in the Spring 2007 Economic Bulletin of Banco de Portugal (See “Box 2. Methodological changes in the computation of the HICP”). Table 1 only presents the seasonal pattern that is in effect for projection purposes and established from the available data as from January 2006 onwards. As new data is disclosed, the revaluation of this seasonal pattern should be insured.

(10) More information on these prices is available on http://ec.europa.eu/energy/oil/bulletin/index_en.htm. The full impact of oil prices on the overall inflation rate is however not limited to its impact on these petroleum products prices. Gas prices, which are also included in the energy component, but are ADM items, also follow oil price developments (See Section 4.3).

Finally, it should be noted that, by assumption, changes in energy prices, for instance due to oil price shocks, do not produce indirect effects in other HICP components or second-round effects through their impact on other variables (for instance, on wages).

4.3. Administered and quasi-administered prices

ADM and QADM prices represent around 20 per cent of the overall HICP. The definition of the ADM items, which correspond to around 15 per cent of the overall HICP, requires that the price of these goods and services is directly set or significantly influenced by the government or defined by national regulators. For instance, prices of public transports and electricity prices are two typical examples.

The QADM basket, which corresponds to about 5 per cent of the overall HICP, defines situations where although there is not a formal compliance with the ADM items criteria, an inspection of its price dynamics reveals that, apparently, they are not market-determined and thus should not be included in the list of items that can be subject to a model-based projection. A clear example is tobacco prices, which accounts for around 2 per cent of HICP.

Both ADM and QADM are fully exogenous in *MIMO*. For projection purposes, they are treated in the same manner and in accordance to all available information (for instance, the State Budget or the Stability and Growth Programme). In the absence of any information, which is usually the case for longer forecast horizons, these prices are assumed to evolve in line with an average of the most recent period for which there is available information. Gas prices are, in this context, a special case. In *MIMO*, the price dynamics of gas prices are assumed to evolve in line with the average rates of change of oil prices in euro terms, over a period of about 12-months.

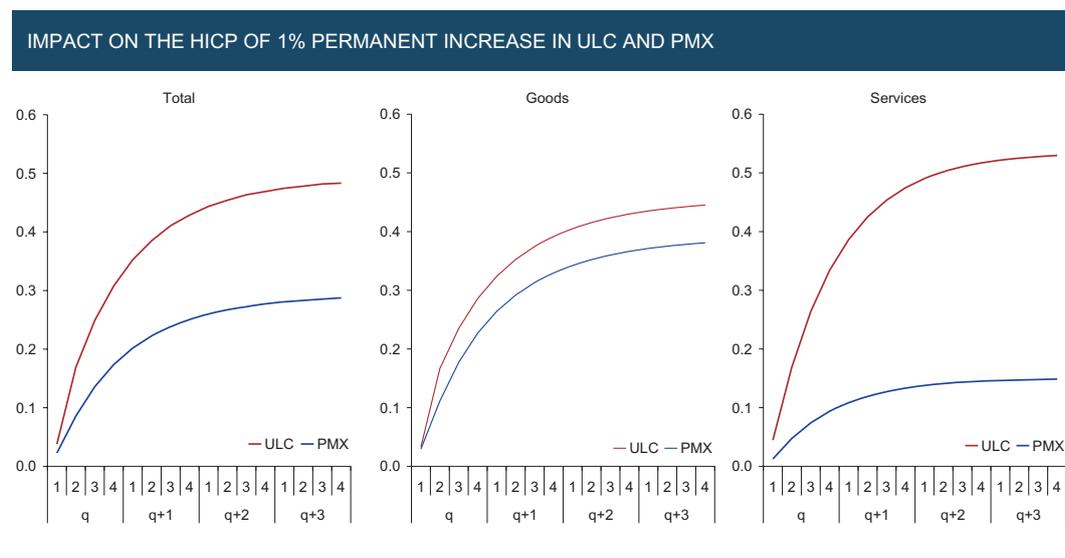
5. THE IMPACT OF SHOCKS IN *MIMO*

The properties and price dynamics built in *MIMO* can be summarised by its response to shocks. This Section reports the impacts on inflation of permanent shocks on its forcing variables and also the impacts due to unanticipated temporary innovations in inflation. The shocks were performed on one particular month and on the block of *MIMO* presented in Sections 4.1 and 4.2. In order to simplify the results interpretation, the reported impacts refer to overall services, overall goods and overall HICP in quarterly terms.

Regarding the effects on HICP stemming from a permanent increase in the long-run determinants of inflation, the results are presented on Chart 2. This figure shows the response of the consumer price levels to a 1 per cent permanent shock on unit labour costs and on non-energy goods import prices. After two years, the unit labour cost shock increases the overall HICP level by 0.43 per cent, while the effect of the import price shock amounts to almost 0.25 per cent, i.e., values relatively close to their respective long-term impacts (which amount to 0.5 and 0.3 per cent, respectively). This implies that, after two years, there has been an almost complete pass-through of home and foreign input prices to consumer prices.

The timing of the pass-through is also similar across shocks and components. For both simulation exercises, around 60 per cent of the effect on the price levels takes place until the end of the first year after the shock; this increases to almost 90 per cent by the end of the following year. On quarterly terms, the largest impact takes place on the quarter immediately after the shock. The impact in terms of inflation rate also reaches a peak at this horizon, as the gradual adjustment takes place through the error-correction term (see Section 4.1). This time length is consistent with the view that the perception of the

Chart 2

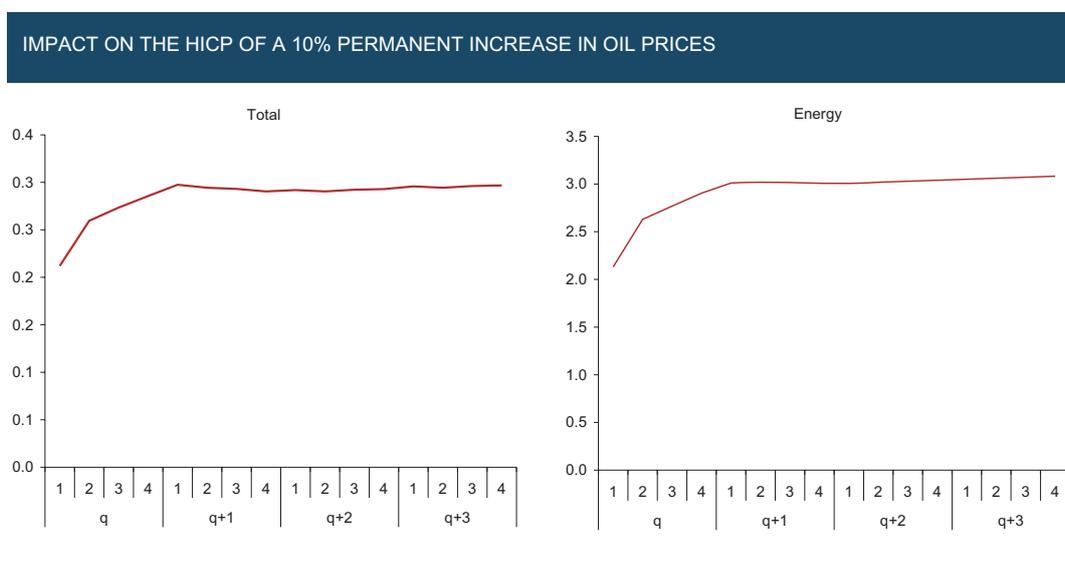


shock by the firms and the corresponding change in prices occurs with some lag, due to operating conditions that include the possible presence of nominal rigidities.

Although the timing of pass-through is similar across components, the level of the impact on goods and services prices differs for each of the shocks, as the response of services prices to an increase in unit labour costs is stronger than in the case of the goods component, due to the larger share of non-tradables in services, which increases the importance of domestic costs in the final price. The opposite happens in the case of the import price shock, which has a larger impact on goods' prices. Chart 2 also shows the way how the HICP level evolves to its expected long-run effect.

Regarding oil price shocks, Chart 3 reports the impact of a permanent 10 per cent increase in this commodity price on consumer price levels. *MIMO* considers only direct effects and, furthermore, oil price movements affect, exclusively, pre-tax fuel and lubricant prices and gas prices. Note also that oil materials and costs indexed to oil are assumed to represent 80 per cent of the overall costs of the refining

Chart 3



and distribution firms. Almost 90 per cent of the full pass-through takes place on the quarter in which the shock occurs. Over time, the impact of shock takes place through lagged effects due to the assumed price setting mechanism of gas prices described in Section 4. At the end of the second year after the shock, the impact amounts to an increase of 3 per cent on energy prices and of 0.3 per cent in headline HICP, which is the full long-term impact of the shock. Electricity and solid fuels prices, which account for about 30 per cent of the energy component, are assumed to be fully exogenous.

In the case of monthly inflation forecasts, the impact of unanticipated innovations in inflation is particularly important. During inflation projection exercises, for instance, new monthly data may be released and this incoming information must be reflected in updated projections. This shock was only implemented on the non-energy components of *MIMO*.

The outcome of a 1 per cent shock on the price level of all goods excluding energy in a particular month is depicted in Chart 4; the outcome for services is depicted in Figure Chart 5. The results show that a

Chart 4

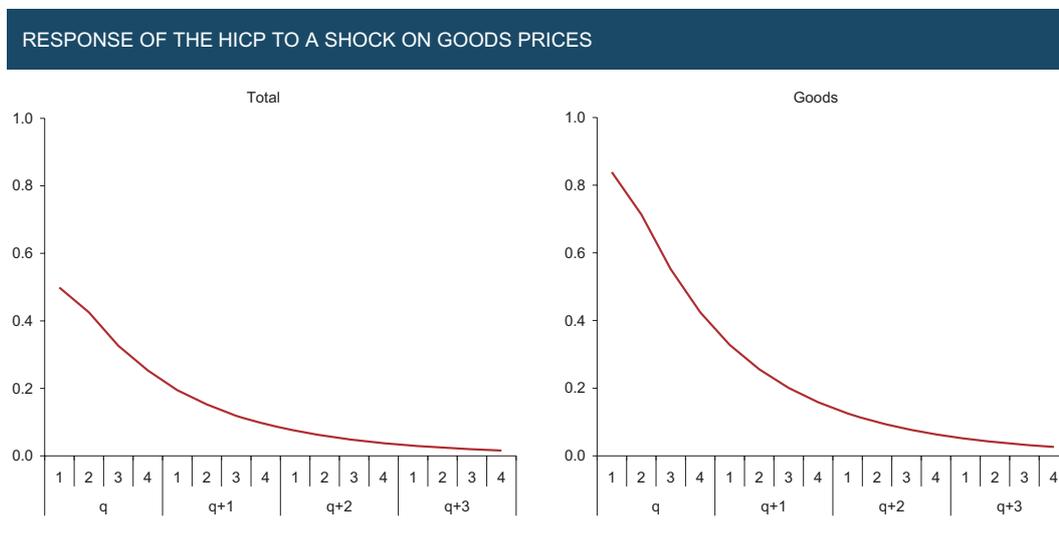
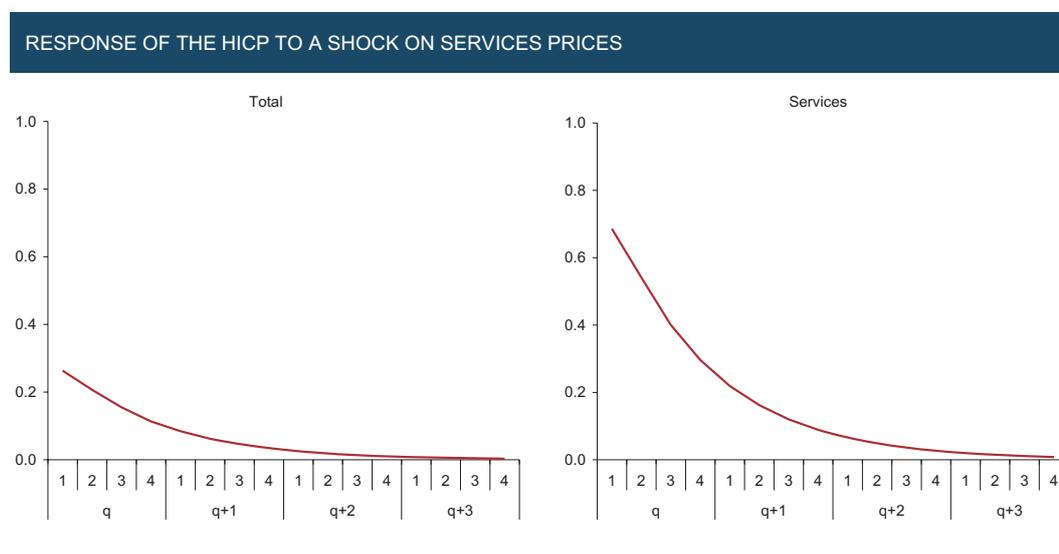


Chart 5



temporary shock fades away monotonically and gradually over time. At the end of the second year following the shock, its impact is almost nil, following a similar pattern across components.

6. INFLATION USING ANALYSIS *MIMO*

One of the main objectives behind the construction of *MIMO* was to develop a framework that could be used for the analysis of the monthly inflation rate. This section decomposes the overall inflation rate over the period 1998-2007 into the main driving forces included in *MIMO*. There are several conclusions that can be drawn from this exercise, although the partial equilibrium nature of the model calls for some caution in the analysis. Among the most severe drawbacks of this approach is the impossibility to trace back the importance of a given structural shock. For instance, suppose that one wants to analyze the full impact of an increase in oil prices. Besides affecting energy prices and therefore the overall inflation rate, the oil price increase may also create inflation expectations that translate into wage pressures and higher unit labour costs. This second-round effect, that would surely feedback into the overall inflation rate, is fully absent. In this case, the full impact of higher oil prices would be underestimated and part of the increase in the inflation would be attributed in *MIMO* to higher unit labour costs.

In this section, the monthly inflation rate is decomposed into the contributions associated to:

- i. Non-energy goods import prices (PMX);
- ii. Unit labour costs in the private sector (ULC);
- III. Energy prices (NRG);
- iv. Administered and quasi-administered goods prices excluding energy components (ADM and QADM);
- v. Other factors (it includes indirect tax changes, changes in profit margins and all measurement errors) (OTH).

In order to compute the contribution of PMX and ULC to the overall HICP inflation, we use the impulse response functions presented in Section 5. The contribution of the forcing variable $X \in \{ULC, PMX, NRG, ADM, QADM\}$ for period t inflation, C_t^X , can be computed as:

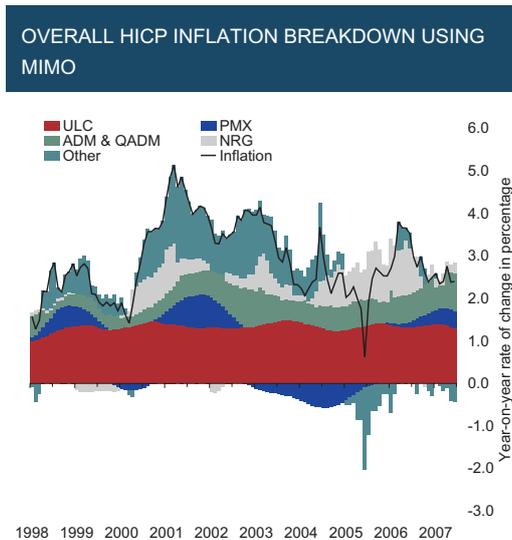
$$C_t^X = \begin{cases} \sum_{j=0}^J \Phi_j^X X_{t-j} & \text{for } X = ULC, PMX \\ \omega^X \cdot X_t & \text{for } X = NRG, ADM \& QADM \end{cases}$$

where X_{t-j} is the change of the forcing variable in period $t-j$ and Φ_j is the impact on overall HICP inflation j periods after a 1 per cent shock in variable ULC or PMX in period $t-j$. In the remaining cases, note that ω^X is just the weight of the component X in the overall HICP.

Between January 1998 and June 2007, the inflation rate in the Portuguese economy stood, on average, around 2.9 per cent (Chart 6). According to the results obtained from the above-mentioned decomposition procedure, the inflation rate has been largely supported by the steady growth in ULC, which contributed on average 1.4 percentage points (p.p.) per year. It should be mentioned that the evolution of ULC during this period may have been conditioned by second round effects that are not being identified, as previously mentioned.

The inflation of ADM and QADM prices excluding energy goods accounts for 0.5 p.p. while energy items contributed 0.4 p.p.. PMX contributed with a meagre 0.1 p.p. The remaining 0.5 p.p. are likely to

Chart 6



Source: Eurostat and authors calculations.

reflect the increase in VAT standard rate from 17 to 21 per cent and the widening of profit margins in this period.

The use of ULC as the price indicators for the domestic intermediate input allows that its evolution may be decomposed into the evolution of compensation per employee and productivity. During the period under analysis, the contribution of ULC reflects basically the strong growth in compensation per employee, which has outpaced labour productivity growth and created inflationary pressures on the domestic side. In addition, the steady contribution of ADM and QADM prices, in particular after 2001, reflects a number of fiscal measures on the revenue side, namely the sizeable increase in tobacco taxes and a rise in the co-payments of consumers for some services that are publicly provided or subsidised (for instance, education, hospital services and pharmaceutical products, public transport prices, water supply and sewage services).

The intra-annual profile of the inflation rate is mainly determined by the evolution of energy prices, non-energy goods import prices and the residual component. In the case of the energy goods contribution, its evolution was shaped both by the evolution of oil prices, that recorded a very substantial increase in this period, and by the increase in taxes on fuels. The accumulated impact of these effects is evident in Figure 6 after 2001. Before this year, fuel prices were fully administered and the impacts of oil price changes were absorbed in profit margins of oil refining companies.

Concerning non-energy goods import prices, they exhibited a very low average growth in this period, since the positive growth rates recorded until 2002 were followed by a sustained decline in these prices from 2003 until 2006, which is likely to have been influenced by the increased competition in international goods markets from new trading partners with low unit production costs, namely Eastern European countries and Far Eastern countries with a particular emphasis on China. The period of stronger decline in these prices coincided with the last stage of the implementation of the Multi-Fibre Agreement that determined the opening EU borders to clothes and textile imports from China.

The residual component is likely to reflect the contribution of VAT changes and profit margins growth, apart from measurement errors. In the beginning of this period, private consumption exhibited growth rates well above those of GDP, which might be an indication that demand side pressures were mount-

ing and that profit margins would tend to widen. This might have contributed to the evolution of the residual component in the period 2000–2003. Thereafter, the VAT standard rate increased from 17 to 19 per cent in June 2003, before increasing to 21 per cent in July 2005. Taking into account the weight of all items in the consumer basket that are subject to the standard VAT rate, the estimated direct impact of an increase of 2 pp on the level of the overall HICP stands at around 0.7 per cent in both cases. This rise in the VAT standard rate may contribute to explain the evolution of the residual component during the 2003 recession. In addition, the impact of the 2004 European Football Championship must be highlighted, as it is sharply reflected in the evolution of profit margins in 2004 and 2005. This impact blunders the evidence on the impact of the VAT standard rate increase in 2005.

7. CONCLUSIONS

This article presents *MIMO*, a monthly inflation projection model for the Portuguese economy that relies on a bottom-up approach. *MIMO* also allows for the decomposition of inflation according to the contribution of each one of its main driving forces.

However, one must highlight that *MIMO* is subject to a number of caveats. The main caveat is that *MIMO* is a partial equilibrium model where unit labour costs and import prices are treated as exogenous, when in fact labour costs are likely to reflect the recent evolution of consumer prices.

In addition, *MIMO* relies on the assumption that there are no spillovers among HICP components and that administered or quasi-administered prices do not affect market-based prices. These assumptions might reveal too stringent, in particular in what concerns the orthogonality of other HICP components with respect to energy goods prices and in what concerns the exogeneity of wages at longer projection horizons. These caveats suggest that the results presented in this article, in particular the decomposition of the inflation rate into several contributions, should be taken cautiously. Moreover, the use of *MIMO* in the production of monthly inflation forecasts for longer horizons must be supplemented by other instruments that might help in circumventing the partial equilibrium features.

In view of the caveats of *MIMO*, a number of improvements and refinements can be implemented. A deeper understanding of the propagation mechanisms of innovations in each HICP component to other components would be a clear improvement, allowing for a richer and more accurate projection model. This might be particularly important in the case of energy prices, since indirect effects on other components are likely to be non-negligible. Moreover, one can also exploit disaggregated information on commodity prices and industrial production price indices to evaluate if these time series contain information that is not yet reflected in the information set that is being used, therefore leading to more accurate forecasts and to a deeper understanding of the transmission channels of commodity price shocks. Finally, a regular reassessment of the seasonal patterns according to the most up-to-date information should be ensured.

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