The impact of exogenous shocks on the dynamics and persistence of inflation: a macroeconomic model-based approach for Greece*

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1. Introduction

Inflation dynamics is one of the most pivotal issues in modern macroeconomic theory and in practical debates about the formulation of monetary policy and macroeconomic policy in general. Both the European countries and the US experience persistent inflation, with protracted periods of high or low inflation. Moreover, the deviations of inflation from its long-run level (which is judged as "normal") are long-lasting and the return to that level is a gradual and slow process. Inflation persistence has immediate consequences for conducting monetary policy. The appropriate response of monetary authorities to exogenous shocks depends largely on their prior knowledge of the degree to which inflation is persistent.

The European Central Bank (ECB), whose primary objective is price stability, has taken a direct interest in issues relating to the linkages that exist between monetary policy, inflation persistence and exogenous economic shocks. In this context, it set up an extensive research network of expert economists, called the "Inflation Persistence Network" (IPN), the objective of which was to investigate and to develop the understanding of the mechanisms underlying the dynamics and persistence of inflation in the euro area and the determinants thereof, as well as firms' price-setting behav-

iour.[1] Inflation persistence was assessed from the standpoint of firms' price-setting policy, through the use of raw data at the product or service level, as well as from the standpoint of key macroeconomic linkages in the whole economy, through the use of a wide range of specialised macroeconomic models. This venture was a success, judging by the quality and quantity of the research work produced and the statistical information collected at the micro, macro and sectoral level.

For effectiveness reasons, a number of subgoals were set by the IPN and then small research groups were formed to focus on specific issues. Research Group 10 (RG10-Inflation Persistence in Macro Models) undertook the study of inflation persistence in the euro area by running a series of standard simulations with the structural models maintained at the Eurosystem central banks. In a first stage, RG10 designed the simulation exercises in collaboration with the ECB Working Group on Econometric Modelling (WGEM). These were subsequently performed in a uniform manner by the central banks of the euro area excluding Portugal. Following on from this, RG10 compiled the results and drew up a report (Berben *et al.,* 2005).

This paper presents the analytical results of the standard simulations for the Greek economy and then draws conclusions about the dynamics and persistence of inflation in Greece. In other words, it examines how various economic interventions and developments affecting demand and/or production costs (e.g. fiscal policy, productivity and indirect tax changes, etc.) are also likely to affect the dynamics and persistence of inflation. The main conclusion is that Greece belongs to a group of countries in which inflation, although it is generated by the

same exogenous shocks that generate inflation in the majority of the other euro area countries, exhibits higher persistence than in the euro area as a whole. The simulations mentioned earlier in this paragraph were performed using the quarterly econometric model for the Greek economy (the Greek-mcm),[2] which is maintained at the Economic Research Department of the Bank of Greece.

Subsequently, we attempt to empirically investigate the possible sources of inflation persistence by looking at how inflation responds to the same exogenous shocks referred to earlier when the values of certain structural parameters that are presumably linked to inflation persistence and dynamics are changed. Findings in the relevant section may lead to some useful conclusions regarding the conduct of structural policy, in so far as the latter also seeks to create an economy with lower inflation persistence where prices may respond quicker to economic conditions and more effectively fulfil their role in conveying information. Undoubtedly, bringing down the persistence of Greek inflation to euro area levels would enhance the beneficial effects of the implementation of the single monetary policy.

The structure of the paper is the following: the next section summarises the main conclusions drawn by the IPN both at the micro and the macro level.

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1 Establishing the IPN and the Monetary Transmission Network has been one of the most important initiatives of the ECB. It is aimed at producing an extensive research work, with the contribution of researchers from all national central banks of the Eurosystem and the ECB, in collaboration with distinguished experts in related fields drawn from the academic and research communities. The outcomes of the research work conducted by the two networks are published in the Working Paper Series of the ECB.
2 For a detailed description of the model, see Sideris and Zonzilos (2005).

Section 3 presents the methodology and hypotheses underlying the analysis, as well as the design of the five core simulations performed. It also sets out and assesses the statistics used in the empirical part of the paper to estimate the degree of inflation persistence. Section 4 analyses the empirical results for Greece in comparison with those for the euro area as a whole. Section 5 identifies the possible sources of inflation persistence, by conducting a number of additional simulations using an alternative set of structural economic parameters, and draws conclusions on what implications there may be for structural policy. The last section summarises conclusions.

2. Main conclusions of the IPN regarding inflation persistence in the countries of the euro area

The IPN defined inflation persistence as the tendency of inflation to gradually and sluggishly return to its long-run equilibrium following an exogenous shock. It subsequently distinguished three main sources of inflation persistence:[3] (i) persistence due to the persistence of inflation determinants (extrinsic persistence), (ii) dependence on past inflation due to firms' price-setting behaviour (intrinsic persistence) and (iii) persistence due to the formation of inflation expectations (expectations-based persistence).

The conclusions of the IPN research groups regarding the dynamics and persistence of inflation in the euro area can be summarised as follows:[4]

A. At the micro level

- In the euro area, retail prices change on average once every year. This is clearly less frequent than in the US, where a price change occurs about every two quarters.

- Price increases and price decreases are almost equally frequent and sizeable in all euro area countries and clearly exceed the average inflation rate.

- There is a pronounced heterogeneity across sectors and products in terms of price rigidity. Energy and unprocessed food prices change much more frequently than services and durables prices.

- There is no evidence of any particular downward price rigidity, except perhaps in the services sector, where price decreases are more infrequent.

- Explicit or implicit contracts among firms are the main source of rigidity in producer prices, with price adjustment ("menu") costs and information costs playing a rather minor role.

B. At the macro level

- There are asymmetries in the response of prices and their adjustment to cost versus demand factors. In particular, prices respond more strongly to cost increases rather than decreases, while they respond more to a fall in demand than to a rise.

- Micro-founded macro models (notably New-Keynesian Phillips curve models) generally imply little persistence in inflation in response to exo-

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3 For a more extensive discussion of these issues, see Angeloni et al. (2004).

4 The terms "micro level" and "macro level" are not used here in the strict sense of the terms but only to introduce some grouping of the results. Hence, some of the results could fit into both categories.

genous shocks, especially under stable monetary regimes.

• The simulations performed with the macroeconomic models of the Eurosystem central banks showed little persistence in inflation in response to a wide range of exogenous shocks, with the exception of the fiscal shock.

• Numerous studies, based on different sorts of structural models, find that the degree of intrinsic inflation persistence has dropped in recent years. The existence of a stable monetary regime also seems to contribute in this direction.

• In the euro area, inflation persistence is rather limited and almost identical to that found in the US, whereas price rigidity (based on the frequency of price changes) is higher.

3. Design and description of simulations and empirical measures of inflation persistence

This section presents the hypotheses underlying the analysis, as well as the design of the five core simulations which were actually adopted and run by the national central banks using their own structural models. The results of these simulations were used by RG10 to investigate inflation persistence. Following this presentation, the statistics used in the empirical part of the paper to measure the persistence in the response of inflation to the various exogenous shocks are outlined and assessed.

3.1 Selection and design of simulations

The simulations were chosen on the basis of the preliminary investigation and identification of cost sources which can reasonably be expected to considerably affect the persistence and dynamics of inflation in the short to medium term. In addition, a simulation of an exogenous change in government consumption was performed to explore the impact of demand on inflation persistence. Another selection criterion was the criterion of explicit specification, which sought to ensure that simulations could be performed in a similar manner in all participating countries, as well as the need to guarantee the greatest possible uniformity and comparability of results. Specifically, the shocks that were actually selected and run can be listed as follows (the results of these exercises are presented as percentage deviations from baseline in Section 4):

1. *Fiscal shock:* a permanent (within a five-year window) increase in government consumption by 1% of real GDP.

2. *Oil price shock:* a permanent increase in oil prices by 10%.

3. *Total factor productivity shock:* a temporary increase in total factor productivity, initially leading to a 1% increase from baseline real GDP, with a gradual return to base according to a decay rate of the shock of 0.9 (autoregressive pattern).

4. *Indirect tax shock:* a permanent increase in the indirect tax rate by one percentage point.

5. *Social security cost:* a permanent increase in the social security contribution rate by one percentage point.

The above shocks were run by each central bank of the Eurosystem in isolated mode, with the pol-

icy rules of the respective national models assumed to be switched off. The results were subsequently collected by RG10 and reshaped to reflect the hypothesis that a Taylor rule operates in the euro area and that the nominal exchange rate of the euro is determined by UIP (uncovered interest parity),[5] while additionally trade spillover effects were also taken into account in the simulations.[6] This further elaboration of the raw results aimed to integrate them into a policy environment with cross-country spillover effects. The reshaped results were then used to derive figures for the euro area as a whole.[7]

3.2 Empirical measures of inflation persistence

In the empirical part of the paper, the results of the simulations are presented and analysed by means of a graphic representation of the path followed (in terms of deviations from baseline) by the rates of change in the private consumption and the GDP deflator after the various exogenous shocks. Also, the degree of inflation persistence is estimated using a number of measures which will be outlined further below.

In general, the persistence measures used try to summarise in a single value how fast or slowly inflation converges to, or diverges from, its initial (baseline) path after an exogenous shock. Three different measures of inflation persistence were estimated in this regard. The first (HL) describes the number of periods (quarters) it takes for the response of inflation to permanently subside below half its initial response. Owing to the fact that the initial response of inflation may be either positive or negative and also because the response function is likely to oscillate between positive and negative values moving towards or

away from zero, HL is defined by both the initial and the subsequent absolute values of this function. The second measure (Tmax) gives the length of time (in quarters) before the inflation response reaches its maximum value (in absolute terms). Lastly, the third measure (WR) can be defined as the ratio of the weighted sum of absolute deviations from baseline, with linearly increasing weights, to the corresponding weighted sum of these deviations, with linearly decreasing weights. In case absolute deviations, according to this definition, reach their peak values in the first half of the 20-period window considered and decline thereafter, WR is less than 1, whereas the opposite occurs when the highest deviations are mainly concentrated in the second instead of the first half of this window. A WR value of around 1 implies a relatively uniform or symmetric inflation response in the window considered, and thus it is somehow difficult to tell whether such response converges or diverges.[8]

All the foregoing measures try to summarise in a single statistic the features of inflation dynamics and persistence following an exogenous shock, which is obviously difficult and rather simplistic. In some cases, the proposed measures may even convey an inconclusive or even misleading pic-

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5 The future nominal exchange rate depends on the spread between foreign and domestic interest rates, as well as on the risk premium.
6 To approximate results including monetary policy and trade spillover effects, each central bank was requested to run an additional set of simulations in isolated mode. These involved the following shocks: a change in short-term interest rates, a change in international demand, a change in the exchange rate and a change in international prices).
7 A detailed description of this procedure is given in Berben *et al.* (2005).
8 WR extends the persistence measure proposed in Lunneman and Matha (2004) by allowing for the form and the value range of the response function.

ture of inflation persistence. Such statistics can inevitably capture only a part of the whole dynamic response of inflation. For example, a very low value of Twax implies that the maximum deviation from baseline occurred immediately after the shock and gives no indication of whether high inflation is to persist or will somehow converge towards its baseline levels (monotonic convergence, exponential convergence, fluctuating convergence, etc.).

Hence, such statistics should be used as simply indicative of the persistence in the response of inflation to exogenous influences and, preferably, in conjunction with the study of the plot of the response function over the 20-period window considered.
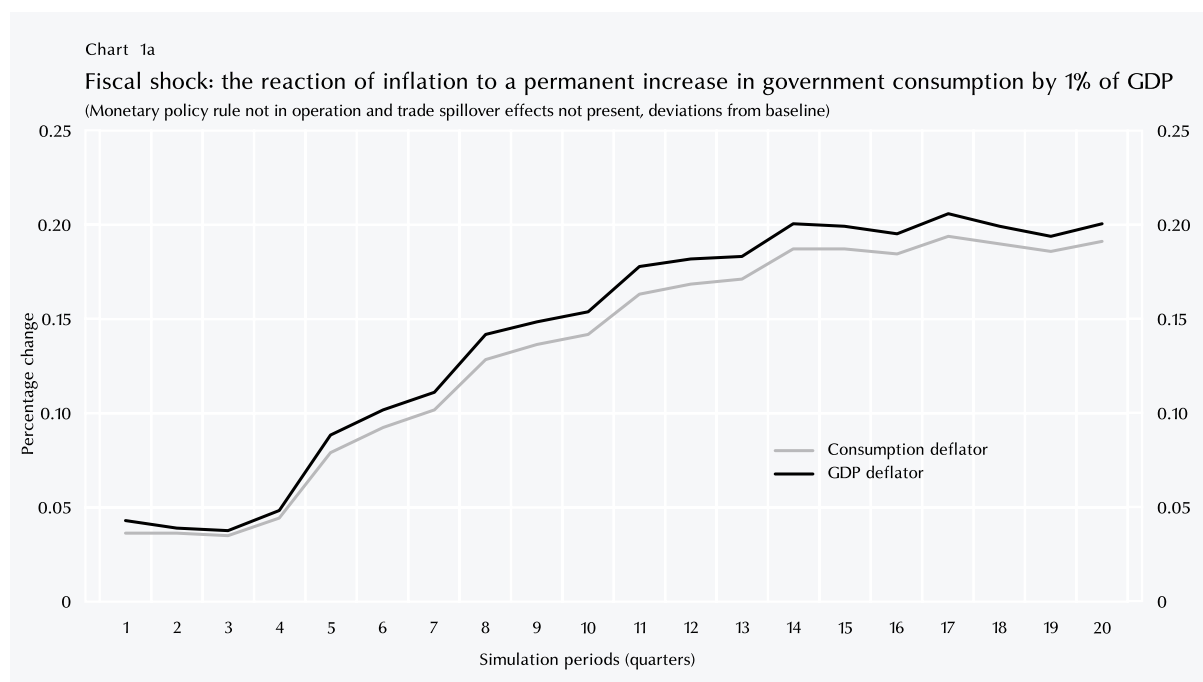
4. Empirical results

The simulation exercises described in section 3.1 were run using the quarterly econometric model (the Greek-mcm) of the Economic Research Department of the Bank of Greece. The Greek-mcm is one of the models that make up the multi-country model of the ECB.[9] It is structured so that, during its operation, it is linked to the other models of the Eurosystem central banks. It can also operate in an isolated mode however, as it does in the simulations conducted herein.

The quarterly econometric model of the Bank of Greece is a typical total supply and demand model. In the short term, output is driven by demand, while its long-run equilibrium is determined by supply factors. Factor (capital and labour) demand functions and the total short-run supply curve of the Greek economy are derived in

a consistent manner by resolving the maximisation problem of a representative firm which operates under imperfect competition and uses a Cobb-Douglas production technology. Deviations from the long-run equilibrium set in motion a stock-flow adjustment mechanism, which, combined with the change in the relative prices of domestic versus foreign tradable production, drives back output to its potential level, thereby ensuring a match between supply and demand. The application of a Taylor rule, alone or in combination with a fiscal rule, speeds up this process.

As discussed in detail in the previous section, five different shocks were performed using the quarterly econometric model of the Bank of Greece. Each simulation had a five-year horizon (in quarters), or 5 x 4 = 20 quarters. Also, for each of them alternative hypotheses were made regarding the operation of some monetary policy rule, the resulting endogenous exchange rate through UIP, as well as the existence of trade spillover effects. The analytical results of each simulation under the alternative hypotheses are reported in the following paragraphs. In particular, the focus is on the study of the percentage deviations of the private consumption and the GDP deflator from the baseline scenario (the scenario in which there is no exogenous shock) over a 20-quarter period after each exogenous shock. The inflation persistence measures defined in the previous section were also estimated on the basis of these deviations (as these had been calculated for

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9 The multi-country model of the ECB (MCM) is made up of the national econometric models of the euro area. It is designed so that all its national components share the greatest possible common structure. It normally operates in linked mode (i.e. with all its national components linked together) and with euro area-wide policy rules.

Chart 1a

Fiscal shock: the reaction of inflation to a permanent increase in government consumption by 1% of GDP

(Monetary policy rule not in operation and trade spillover effects not present, deviations from baseline)

Greece and the euro area) and they too will be presented below.

Chart 1a illustrates the impact of the fiscal shock on the GDP and the consumption deflator. In particular, it shows the difference between the rates of change in the two deflators following a permanent increase in government consumption by 1% of GDP and in the absence of a monetary rule and trade spillover effects. The response of inflation to this exogenous shock is similar, whether measured by the GDP deflator or the consumption deflator, although in the latter case it is slightly higher in absolute terms. Specifically, it is loose in the first four quarters of the simulation window, almost steadily building up thereafter. The highest deviation of inflation rates occurs after 17 quarters and there is no clear indication of any subsequent decline. Hence, all evidence seems to suggest that this specific type of fiscal shock, the demand shock, leads to highly persistent and deviating

inflation. Allowing for a monetary rule and trade spillover effects does not seem to alter the character of inflation persistence during the entire simulation period (see Chart 1b),[10] at least as indicated by the figures of Table 1, which gives the values of the three estimated persistence measures.[11] Indeed, HL and Tmax take their highest possible value (20) and WR largely exceeds 1, recording a

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10 Indeed, conducting the simulations in an environment of policy rules and trade spillover effects does not seem to modify our main conclusions regarding inflation persistence. In greater detail, the inclusion of trade spillover effects in the calculations leaves practically unchanged the results of the simulations, whereas if an endogenous euro area monetary rule is additionally switched on, then the response of inflation is in general slightly dampened, as would be expected. For this reason, we will henceforth present the results of each simulation under all alternative hypotheses (full scenario).

11 The Annex table gives for each simulation (under all alternative intermediate hypotheses) the values of persistence measures, as estimated for Greece and the euro area. Table 1 presents how these figures change when examining the full scenario under all final hypotheses, i.e. when a monetary rule, trade spillover effects and a UIP condition for the exchange rate are included in calculations.
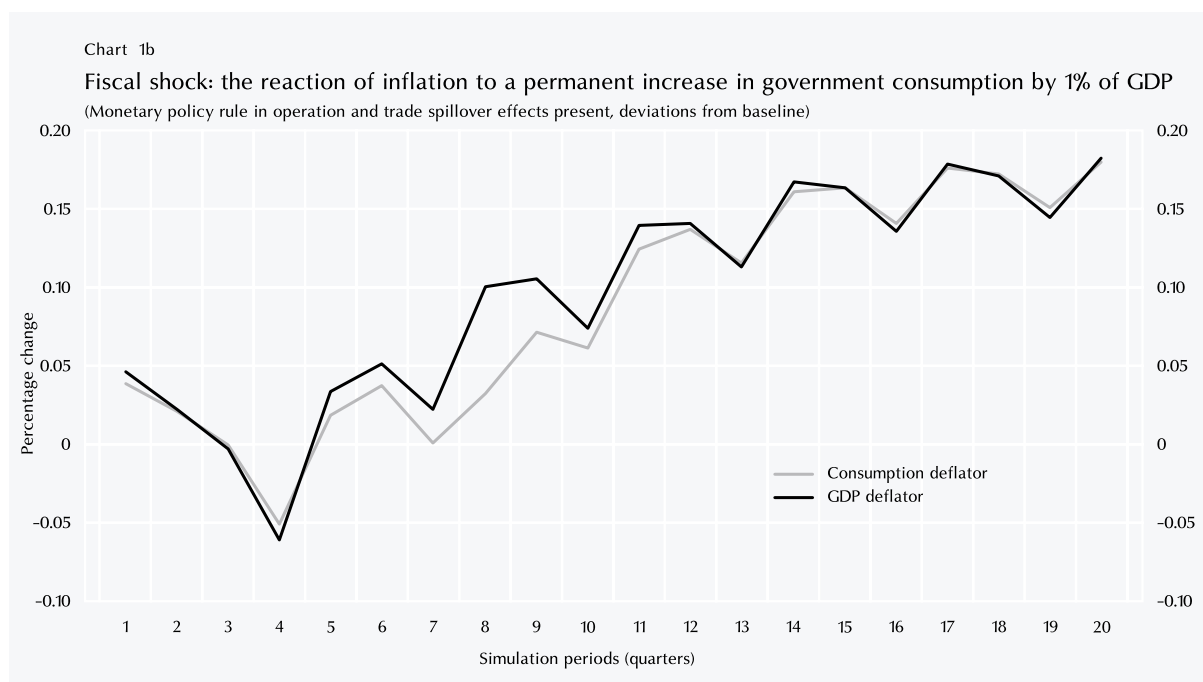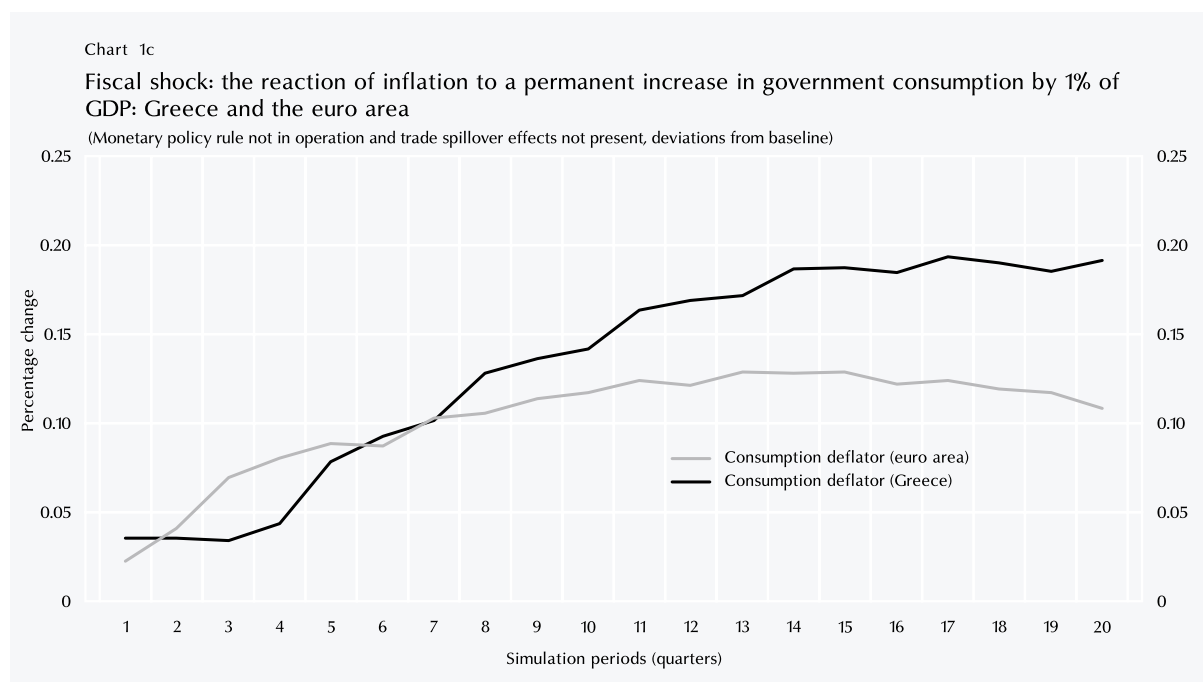
Chart 1b

Fiscal shock: the reaction of inflation to a permanent increase in government consumption by 1% of GDP

(Monetary policy rule in operation and trade spillover effects present, deviations from baseline)

Percentage change

Simulation periods (quarters)

— Consumption deflator
— GDP deflator

Table 1

Measures of inflation persistence in Greece and in the euro area

Exogenous shock	Deflator	Greece			Euro area		
		HL	Tmax	WR	HL	Tmax	WR
Fiscal	Consumption deflator	20	20	2.0	20	11	1.2
shock	GDP deflator	20	20	1.8	11	1	1.0
Oil price	Consumption deflator	14	7	0.6	2	1	0.4
shock	GDP deflator	14	4	0.5	3	1	0.4
Total factor	Consumption deflator	20	8	0.9	15	1	0.8
productivity shock	GDP deflator	20	8	0.9	10	1	0.7
Indirect tax	Consumption deflator	1	1	0.8	1	1	0.2
shock	GDP deflator	1	1	0.7	1	1	0.2
Social security	Consumption deflator	20	9	1.2	7	2	0.5
contribution shock	GDP deflator	20	8	1.2	2	1	0.4

high degree of inflation persistence for Greece following this specific shock.

A similar conclusion arises for the large majority of the other euro area countries and for the euro area as whole. In the euro area, the rate of change in the private consumption deflator constantly rises until it reaches a peak after 11 quarters, and thereafter stays high, although slowly declining, until the end of the simulation window. The GDP deflator follows a similar path. After returning to its baseline value for just one period after the initial shock, it

Chart 1c

Fiscal shock: the reaction of inflation to a permanent increase in government consumption by 1% of GDP: Greece and the euro area

(Monetary policy rule not in operation and trade spillover effects not present, deviations from baseline)

subsequently deviates from it until the 11th quarter and thereafter stays high, albeit falling.[12]

The values of persistence measures (presented in Table 1 and in the Annex table) suggest that the persistence in the response of inflation to the fiscal shock is stronger in Greece than in the euro area. The same conclusion can be drawn from the data in Chart 1c which presents the response of the consumption deflator to the fiscal shock in Greece compared with euro area.
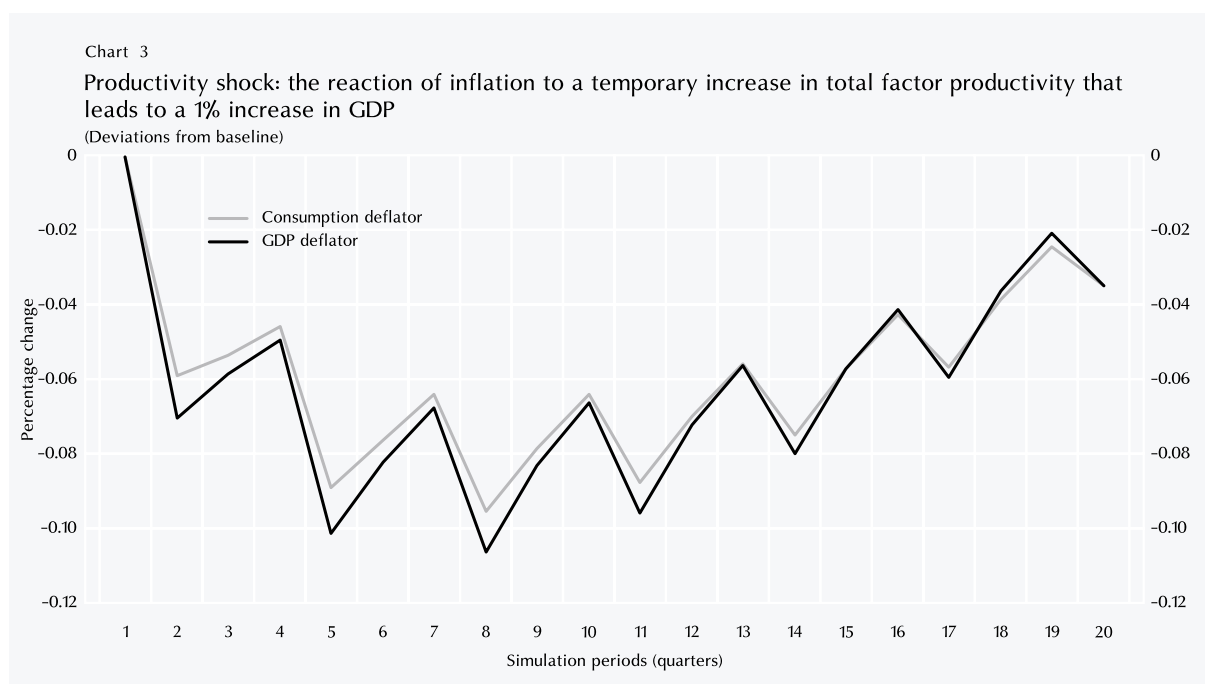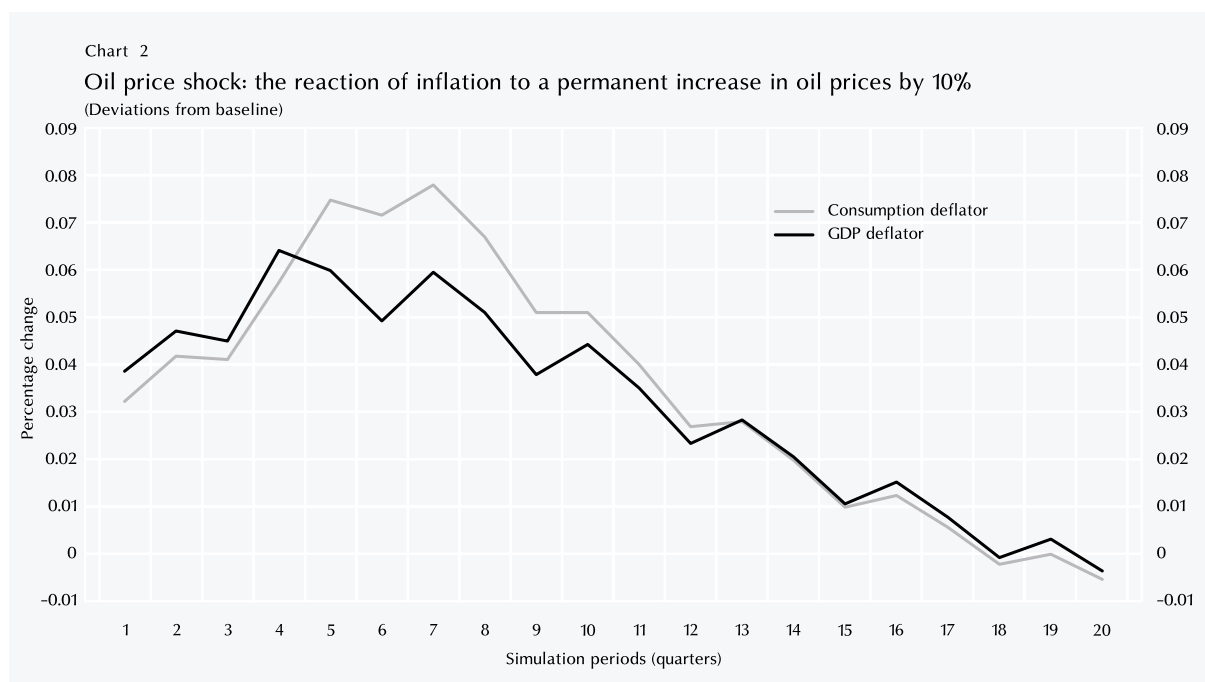
Inflation response to an oil price shock involving a permanent increase in oil prices by 10% is "rather persistent but not deviating", as indicated by the outcomes of the second simulation. The rates of change in the GDP and the consumption deflator rise and stay high approximately until the mid-point of the simulation window. Thereafter, however, they seem to return to their base values (see Chart 2). The rates of change in the GDP and the consumption deflator

reach their peak values after 7 and 2 periods respectively, while it takes at least 14 periods for the deviation of these deflators to subside below 50% of their initial deviation (Tmax and HL measures, Table 1). In almost all euro area countries, the response of inflation to the oil price shock can be described as non-persistent. At the euro area aggregate level, both deflators converge constantly — and rather rapidly — towards their baseline values,[13] as also indicated by the low values of all estimated persistence measures.

A similar pattern is observed in the response of Greek inflation to a total factor productivity shock

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[12] The initial reduction of the deviation of the GDP deflator from 0.16% in period (quarter) 1 to 0.004% in period 2 is the reason for the rather misleading picture conveyed by the persistence measures in Table 1 (HL = 11, Tmax = 1 and WR = 1.0). Should these measures be estimated for the period thereafter, they will clearly record a high degree of inflation persistence similar to that recorded by the consumption deflator.

[13] This casts some doubt on whether all models are able to reflect in a representative manner the whole range of supply-side effects exerted by oil price changes.

Chart 2

Oil price shock: the reaction of inflation to a permanent increase in oil prices by 10%
(Deviations from baseline)

Chart 3

Productivity shock: the reaction of inflation to a temporary increase in total factor productivity that leads to a 1% increase in GDP
(Deviations from baseline)

initially leading to a 1% increase in real GDP. As can be seen in Chart 3, inflation, whether measured by the GDP or the consumption deflator, gradually falls until the mid-point of the simulation window and thereafter converges towards its baseline levels without ever reaching them. Hence, the values of the deflators' response function, as well as those of the estimated measures, place Greece —together

Chart 4

Indirect tax shock: the reaction of inflation to a permanent increase in the indirect tax rate by one percentage point
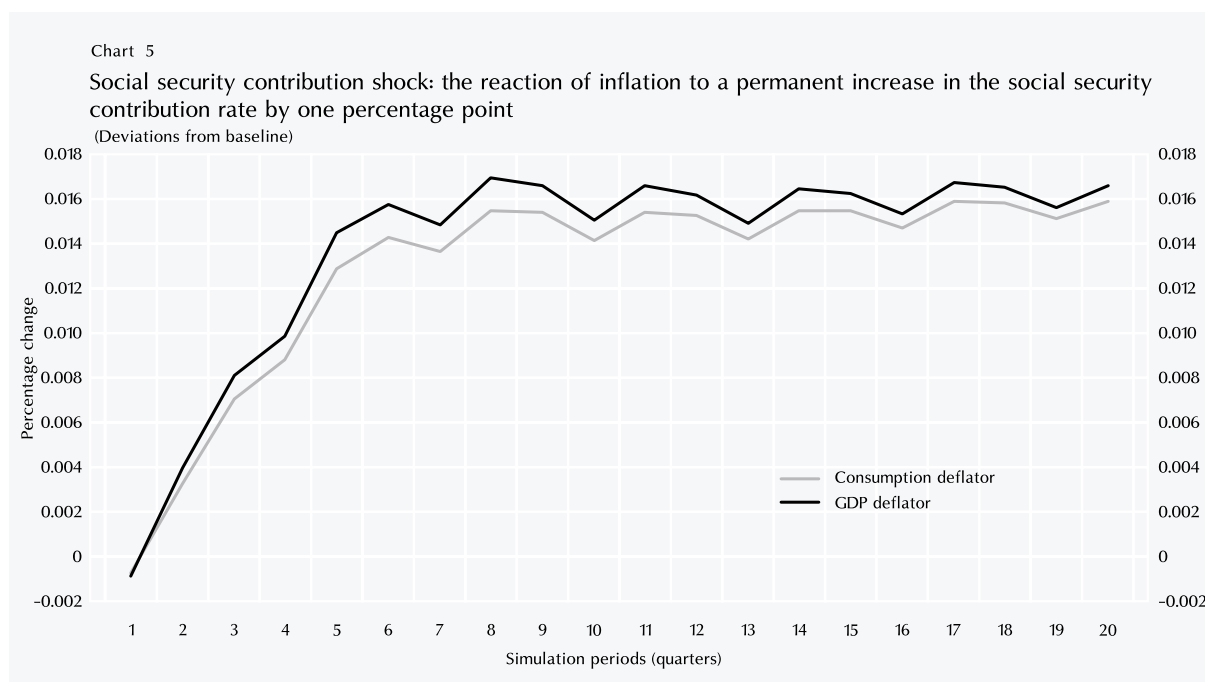(Deviations from baseline)
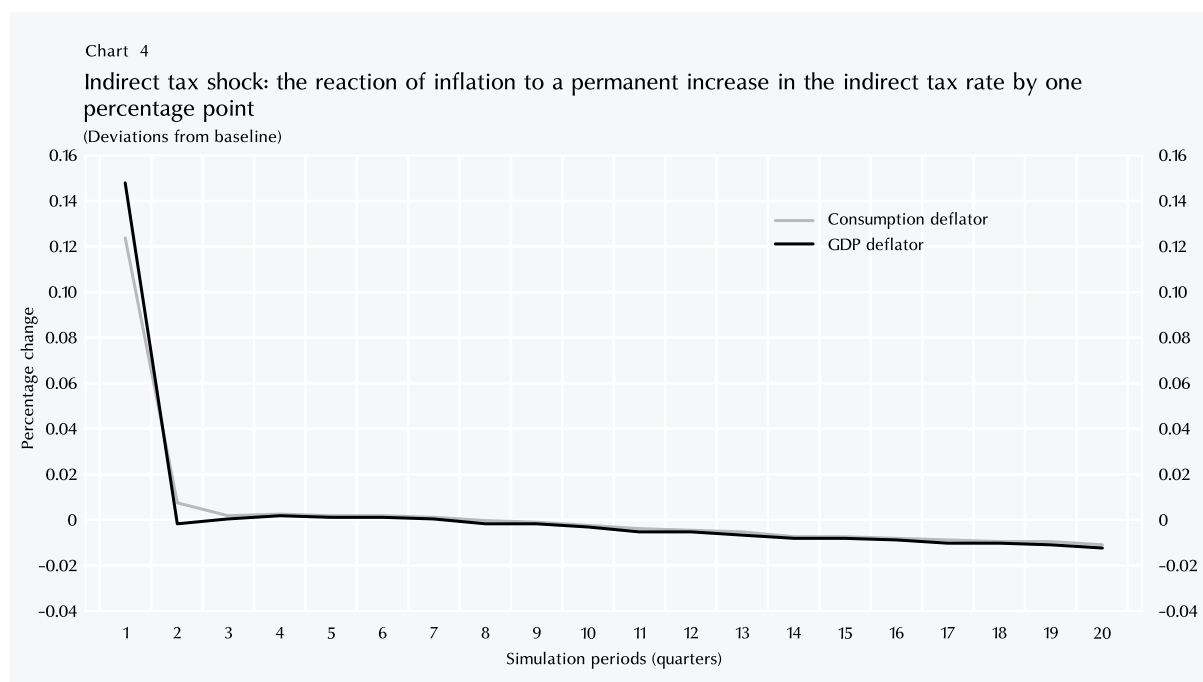
with Austria, Germany, Italy and the Netherlands — in a group of countries in which the deflating impact of the increase in productivity exhibits relative persistence. The response of euro area inflation to the said shock seems to be also alike and relatively persistent. Specifically, while it steadily converges, it keeps staying off baseline levels during most of the simulation window.

The indirect tax shock, which involves a 1% increase in the indirect tax rate, seeks to investigate how inflation responds to an exogenous change in the gap between consumer and producer prices. In other words, it examines how an increase in marginal costs that is not driven by wage growth may affect inflation. According to the results of the simulation, the permanent change in the indirect tax rate does not induce persistent inflation in the Greek economy (see Chart 4 and Table 1). Indeed, the increase in the indirect tax rate by 1% seems to generate sharp

cost-push inflation only in period 1, as the rates of change in both deflators already stand close to their respective baseline levels in period 2.[14] This suggests that inflation lacks persistence, given that wage costs remain unaffected. Both deflators converge towards their baseline values immediately after their initial response, while the values of the estimated persistence measures are lower compared with any other shock considered.

Lastly, the results of the social security shock point out that the permanent change in the employers' social security contribution rate can induce persistent inflation in the Greek economy. Indeed, as a result of the 1% increase in social security contributions, both inflation indicators rise continuously

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14 With the exception of the high initial response of inflation over the first quarter, a deviation from baseline values can be seen notably in the second half of the simulation horizon, but even that does not exceed 0.012% in absolute terms.

Chart 5

Social security contribution shock: the reaction of inflation to a permanent increase in the social security contribution rate by one percentage point

(Deviations from baseline)

Simulation periods (quarters)

during the first half of the simulation window and remain at the same high levels thereafter (Chart 5). The GDP deflator follows a similar path to that of the consumption deflator, but the response of the former is relatively more pronounced. The response of inflation to the shock in question is relatively persistent in some other euro area countries too, including Belgium, Germany and Spain. In the euro area as a whole, the deviation of both deflators from baseline, although it is quickly limited compared with its initial level, continues to remain significant during the first half of the simulation window. However, as it further declines thereafter, both deflators return very close to their respective baseline levels.

5. Possible sources of inflation persistence

This section investigates the possible sources of the relatively higher persistence of inflation in

Greece. According to Berben *et al.* (2005), and also on the basis of the subjective assessments by the proprietors of the national structural models, the possible sources of inflation persistence should be sought among factors that relate to the functioning of the final product market, the structure and characteristics of the labour market, institutional change and the response of wages to changes in the unemployment rate. In particular, as regards the characteristics of the labour market, we find that the determinants of wage responsiveness to changes in the unemployment rate (e.g. the amount and duration of the unemployment benefit, the bargaining power of trade unions) can sometimes explain the cross-country differences observed in the persistence of the inflation response to the fiscal shock. The almost zero degree of wage responsiveness to changes in the unemployment rate may account, to some extent, for the relatively high persistence of inflation in Greece compared with other countries.

This may also be the case in the rest of the exogenous shocks, with the exception of the change in indirect taxes.

In several countries, the degree of persistence in the response of inflation to changes in productivity and production costs is likely to relate to the wage and unit labour costs responsiveness to these changes. By contrast, in most countries, mark-ups and import prices are not thought to be important regarding inflation persistence. An exception should be made for import prices in the scenario of an exogenous increase in oil prices.

This paper goes a little deeper, trying to empirically assess the validity of the foregoing, shall we say, value statements through the conduct of a series of additional simulations for Greece under alternative values of certain vital-to-inflation persistence structural parameters of this economy. It thus explores, within the framework of the same exogenous shocks referred to earlier (namely the fiscal shock, the indirect tax shock, etc.) how a change in some structural characteristic of the product or labour market may affect inflation persistence. Such structural characteristics include for example: the degree of competition in the domestic market, the response of employment to changes in overall demand and real wages, the responsiveness of wages to price changes, the wage-unemployment elasticity, the degree of autocorrelation of inflation, the formation of expectations, etc.
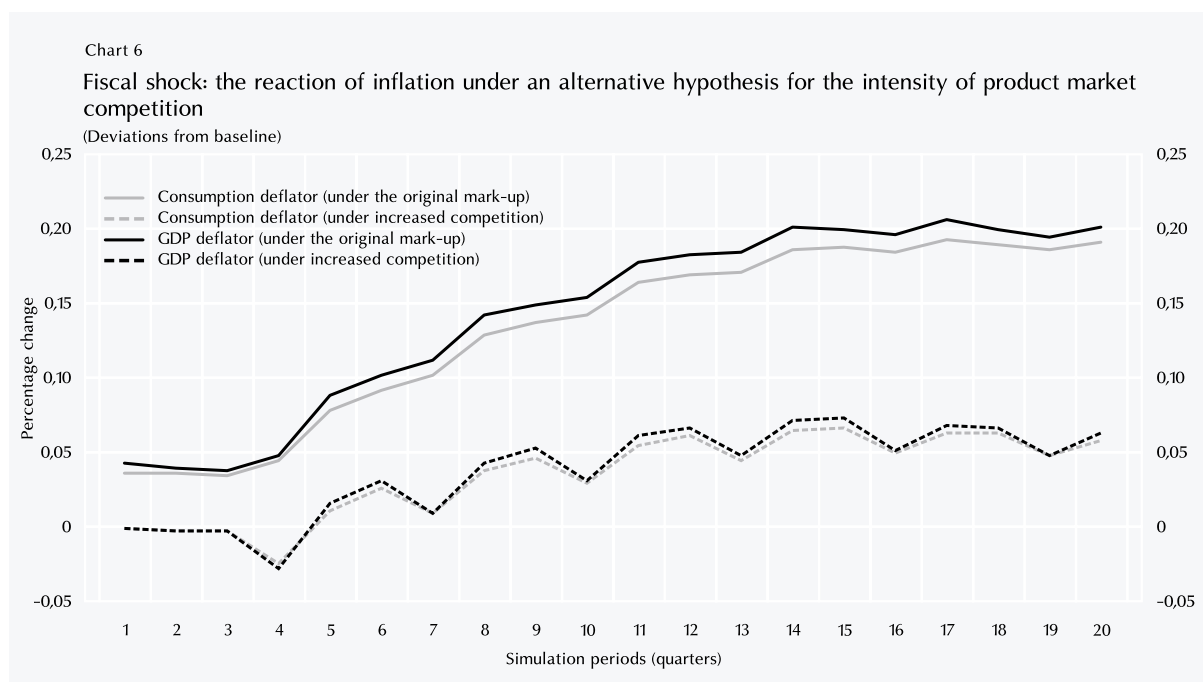
It is not possible to accurately identify and isolate the channels that account for the persistence of inflation in Greece, nor to conduct here an empirical analysis similar to the analysis of monetary policy transmission[15] carried out within the

Eurosystem.[16] To a certain extent, however, the empirical analysis and the alternative simulations presented below provide some evidence on which parameters and mechanisms may be responsible for the relatively higher persistence of inflation in Greece. Also, they help determine the possible implications of structural interventions, as well as decide which direction these interventions should take to gradually reduce inflation persistence to levels similar to those observed in the euro area. Indeed, the efficiency of monetary policy could be significantly improved with the creation of an economy in which the price mechanism responds immediately to economic change. In addition, our findings in this section may lead to some conclusions about the stance of structural policy. It should be noted though that they depend directly on the properties of the econometric model used and thus a different specification of this model, especially as far as wage-price dynamics are concerned, could modify the numerical results.

We argue that the degree of competition in the product market is likely to affect persistence in the response of inflation to the various exogenous shocks. In the employed quarterly macroeconomic model of the Bank of Greece, it is assumed that, in the short run, the representative firm operates in monopolistic competition and that it sets the price for its product by applying a fixed

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15 On monetary policy transmission and influence channels, see: (i) Van Els *et al.* (2003): euro area and (ii) Zonzilos (2002): Greece.
16 This is because the persistence and dynamics of inflation are the outcome of nominal and real rigidities which are found across all markets of the economy. Identifying which channels generate persistence would require the system to be entirely redefined and the lags that are presumably responsible for these rigidities to be eliminated. Any such change, however, would render the alternative simulations incomparable.

Chart 6

Fiscal shock: the reaction of inflation under an alternative hypothesis for the intensity of product market competition

(Deviations from baseline)

Legend:
- Consumption deflator (under the original mark-up)
- Consumption deflator (under increased competition)
- GDP deflator (under the original mark-up)
- GDP deflator (under increased competition)

Y-axis (both sides): Percentage change — -0,05, 0, 0,05, 0,10, 0,15, 0,20, 0,25
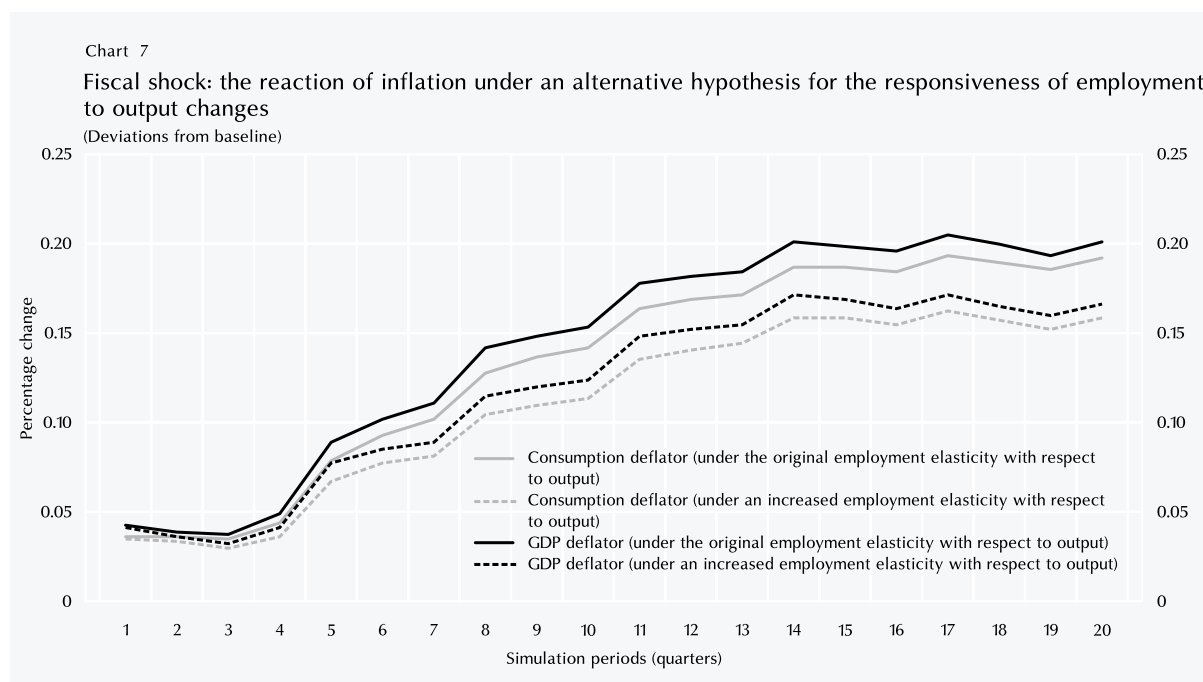
X-axis: Simulation periods (quarters) — 1 to 20

mark-up to the variable marginal cost. The mark-up parameter, which also essentially denotes the distance from full competition in the product market, is estimated at 1.8 for the Greek economy. In the light of these elements, we repeated the five core simulations by reducing this parameter by around 10% to 1.6, thereby assuming a greater degree of competition for the Greek economy.[17] The results of the fiscal shock simulations, under both the original and the alternative value of the mark-up parameter, are presented in Chart 6. It is clear that inflation persistence, and particularly its responsiveness to the permanent exogenous increase in government consumption, would be markedly lower if the Greek economy operated under more competitive conditions. In other words, all evidence seems to suggest that increasing competition in the product market could by itself mitigate the persistence of Greek inflation. Similar is the case for the other exogenous shocks too.

In the employment function of the quarterly econometric model of the Bank of Greece total output elasticity of employment is rather low (0.15). The poor responsiveness of labour demand to output change is one of the main setbacks to employment which does not seem to keep up with the high growth rates enjoyed by the Greek economy in recent years. It was therefore felt advisable to explore whether possible structural interventions in the labour market[18] intended to make employment more sensitive to output changes would also affect persistence in

[17] The mark-up in principle affects the price level, but it is also inversely associated with demand elasticity, which in turn affects the level of the real equilibrium wage. The simulation in question takes into account both the change in the mark-up and the resulting change in demand elasticity. Nevertheless, given that the mark-up parameter is a "pure" number and that its exact level is devoid of any structural content, this alternative simulation reflects no particular structural intervention of any extent.

[18] Such are, for example, interventions aimed at simplifying the regulatory framework governing employment and lay-offs in enterprises.

Chart 7

Fiscal shock: the reaction of inflation under an alternative hypothesis for the responsiveness of employment to output changes

(Deviations from baseline)

— Consumption deflator (under the original employment elasticity with respect to output)

---- Consumption deflator (under an increased employment elasticity with respect to output)

— GDP deflator (under the original employment elasticity with respect to output)

---- GDP deflator (under an increased employment elasticity with respect to output)
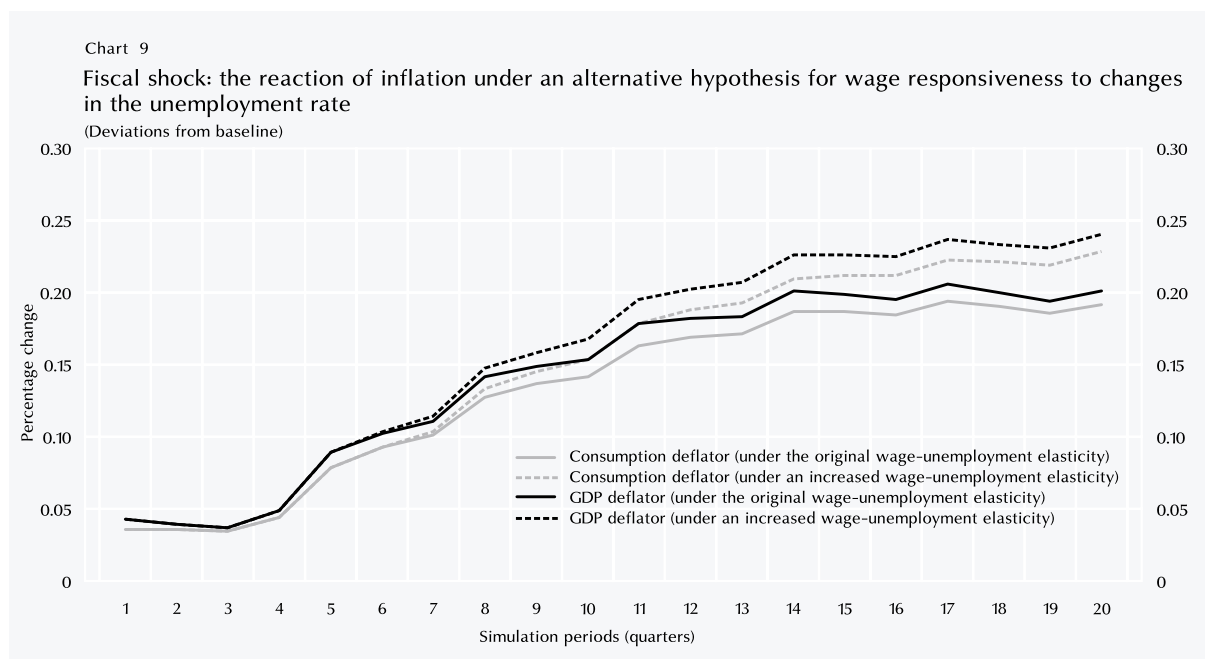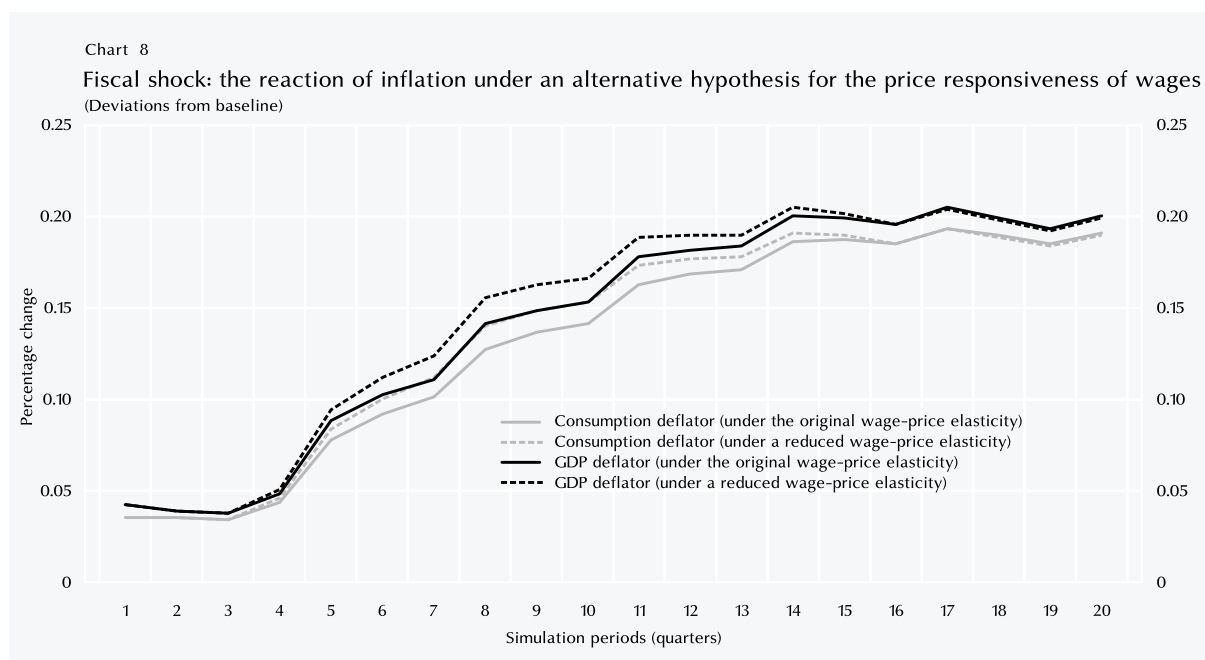
Simulation periods (quarters)

the response of inflation to exogenous shocks. The results of the new fiscal shock simulation, which was conducted with double the level of the relevant elasticity, showed a slight drop in inflation persistence (see Chart 7). This improvement seems, however, rather negligible compared with that achieved by increasing competition in the product market, as analysed in the preceding paragraph.

The wage function of the macroeconomic model used rests on the hypothesis that, in the long term, real wages are equal to labour productivity. In the short term, however, wages may deviate from their long-run equilibrium due to movements in the unemployment rate (short-run Phillips curve effects), some adjustment in production costs or changes in the bargaining power of employees relative to employers. For instance, a drop in the unemployment rate, because it decreases the chances of being or

remaining unemployed, may boost wages. Indeed, in the employed model, the rate of change in wages is positively correlated to the year-on-year rates of change in wages and prices, as well as to the rate of change in productivity. A very small negative correlation between wages and the unemployment rate is also recorded, implying the existence of some short-run Phillips curve in the Greek economy.

To assess the extent to which the adjustment of wages to price movements and the wage-unemployment relationship generate persistence, we ran two further simulations. In the first, the elasticity of wages with respect to previous period inflation was reduced to about half its original level, or from 0.378 to 0.20 (see Chart 8). In the second, the loose relationship between wages and the unemployment rate was tightened by a doubling of the respective coefficient (see Chart 9). As can be seen in both charts (which present the

Chart 8

Fiscal shock: the reaction of inflation under an alternative hypothesis for the price responsiveness of wages
(Deviations from baseline)

Consumption deflator (under the original wage-price elasticity)
Consumption deflator (under a reduced wage-price elasticity)
GDP deflator (under the original wage-price elasticity)
GDP deflator (under a reduced wage-price elasticity)

Percentage change

Simulation periods (quarters)

Chart 9

Fiscal shock: the reaction of inflation under an alternative hypothesis for wage responsiveness to changes in the unemployment rate
(Deviations from baseline)

Consumption deflator (under the original wage-unemployment elasticity)
Consumption deflator (under an increased wage-unemployment elasticity)
GDP deflator (under the original wage-unemployment elasticity)
GDP deflator (under an increased wage-unemployment elasticity)

Percentage change

Simulation periods (quarters)

results of the exogenous fiscal shock), changing the values of these parameters has no material effect on the persistence in the response of inflation. Similar is the case for the other exogenous shocks considered.[19]

From the simulations discussed above it is clear that the main responsibility for the relatively

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[19] The results of these simulations are available on request from the authors.

Chart 10

Fiscal shock: the reaction of inflation under an alternative hypothesis for price endogeneity
(Deviations from baseline)

Consumption deflator (under the original price endogeneity)
Consumption deflator (under a reduced price endogeneity)
GDP deflator (under the original price endogeneity)
GDP deflator (under a reduced price endogeneity)

Simulation periods (quarters)
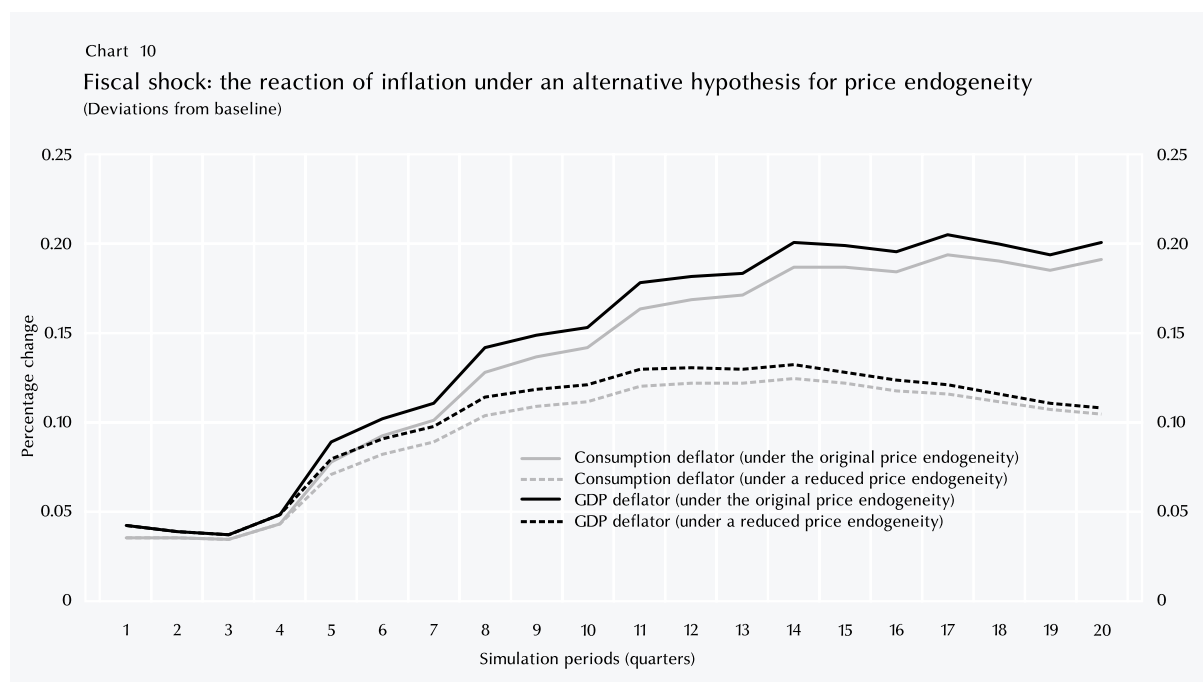
higher persistence of inflation in Greece cannot be attributed to some structural characteristic of the labour market. This does not mean, however, that labour market conditions or wage growth are not significant factors in accounting for the evolution of Greek inflation. The importance of unit labour costs as determinants of inflation persistence was also demonstrated by the results of the simulation which is concerned with a permanent increase in social security contributions (see Chart 5). The key role played by labour costs in determining the level of inflation is also empirically supported by a set of simulations which have been recently run by the Bank of Greece.[20] It should be stressed, however, that the conclusions reached here refer only to the persistence in the response of inflation to exogenous shocks, not to its actual levels.

By contrast, we maintain that increasing the competition in the product market seems to markedly limit inflation persistence. Furthermore, almost all the IPN studies on inflation persistence, conducted with all kinds of models, conclude that the historical path of inflation also largely determines its persistence. According to Hondroyiannis and Lazaretou (2004), the Greek inflation too depends heavily on its past series (time series dependence). This conclusion is underpinned by our findings. Indeed, we repeated the fiscal shock by reducing the degree of time series dependence. Chart 10 shows the drastic impact of this specific intervention on the persistence of inflation. If there is a significant backward-looking component to the formation of inflationary expectations, then, to reduce inflation persistence, it is essential that these expectations should be anchored at low levels.

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20 Bank of Greece, *Monetary Policy – Interim Report,* October 2005, pp. 132-35.

6. Summary and conclusions

The issues pertaining to inflation and notably to the response of prices to changes in the various economic parameters are of particular interest at least within the Eurosystem. In this regard, the European Central Bank, in co-operation with the national central banks of the euro area, has recently set up an ad hoc network to focus on inflation persistence. In the frame of this network, price changes were assessed from the standpoint of firms' price-setting policy, through the use of raw data at the product, service or corporate level, as well as from the standpoint of macroeconomic relationships in the whole economy, through the use of specialised macroeconomic models. The latter was also the case in this paper, the objective of which was to investigate the response of Greek inflation to different types of changes in economic conditions that affect demand, production costs and/or supply conditions, as well as the persistence of this response. Besides this investigation, we also attempted a diagnostic analysis of the possible sources of inflation persistence, by conducting a series of standard simulations under alternative values of critical-to-inflation persistence structural parameters of the Greek economy.

Our analysis showed that the permanent increase in government consumption (the fiscal shock) generates more persistent (and rather accelerating) inflation than any other exogenous shock. The implementation of an endogenous monetary policy in the form of a monetary rule and/or the existence of trade spillover effects seem unable to alter the character of inflation persistence during the entire simulation window. It should be noted that this conclusion does not only apply to Greece, but also to the large majority of the other euro area countries and to the euro area as a whole. Inflation caused in Greece by the permanent increase in oil prices can be characterised as "persistent but not accelerating"; the GDP and the consumption deflator remain at high levels or rise until the mid-point of the simulation window and converge towards their baseline levels thereafter. By contrast, in almost all the rest of the euro area, the response of inflation to this shock lacks persistence. Turning again to Greece, a similar pattern to the one just described can be found in the response of inflation to the change in total factor productivity; indeed, while inflation declines until the mid-point of the simulation window, thereafter it gradually returns to its baseline levels. In Greece, in most of the other euro area countries and in the euro area as a whole, the permanent change in the indirect tax rate does not lead to persistent inflation, as wage costs remain unaffected. By contrast, the permanent change in the employers' social security contribution rate and the resulting change in labour costs induce persistent inflation both in Greece and in several other euro area countries.

Our investigation of the possible determinants of inflation persistence in Greece through the conduct of a series of alternative simulations concluded that the primary source of inflation persistence in Greece is the lack of competition. If this is so, policies aimed at reinforcing and securing free competition in various markets can be expected to considerably help in mitigating inflation persistence in Greece.

Paradoxically, a number of structural parameters that chiefly relate to the functioning of the labour market, e.g. the speed of employment response

to changes in output and overall demand, the price responsiveness of wages, the wage-unemployment elasticity, etc. do not seem important in explaining the relatively higher persistence of Greek inflation. But, this in no case means that labour market conditions and wage growth do not play a significant part in the evolution of Greek inflation which continues to exceed that of the euro area. Besides, the crucial role played in inflation persistence by unit labour costs was evidenced by the outcomes of the simulation which was concerned with the effects of a permanent increase in social security contributions. Moreover, the importance of labour costs in

determining inflation levels (see footnote 20) has also been corroborated by a number of simulations recently run by the Bank of Greece. It should be stressed, though, that the conclusions reached here refer only to the persistence in the response of inflation to exogenous shocks, not to its actual levels.

Furthermore, in Greece as in most of its euro area counterparts, inflation persistence is found to be mainly intrinsic. Hence, central banks have a crucial role to play in anchoring inflationary expectations at low levels if inflation persistence is to be mitigated.

Measures of inflation persistence in Greece and in the euro area (under alternative simulation settings)

Exogenous shock	Deflator	Original data			With trade spillover effects			With trade spillover effects and a monetary policy rule in operation, UIP condition for the exchange rate not in operation		
		HL	Tmax	WR	HL	Tmax	WR	HL	Tmax	WR
A. GREECE										
Fiscal	Consumption deflator	20	17	1.6	20	20	1.7	20	17	1.6
shock	GDP deflator	20	17	1.6	20	17	1.6	20	14	1.5
Oil price	Consumption deflator	14	7	0.5	14	7	0.5	13	7	0.5
shock	GDP deflator	14	4	0.5	13	4	0.5	13	4	0.5
Total factor	Consumption deflator	20	8	0.9	20	8	0.9	20	8	0.9
productivity shock	GDP deflator	20	8	0.9	20	8	0.9	20	8	0.9
Indirect tax	Consumption deflator	1	1	0.5	1	1	0.7	1	1	0.9
shock	GDP deflator	1	1	0.5	1	1	0.7	1	1	0.9
Social security	Consumption deflator	20	20	1.3	20	8	1.2	20	8	1.0
contribution shock	GDP deflator	20	8	1.3	20	8	1.2	20	5	1.0
B. EURO AREA										
Fiscal	Consumption deflator	20	15	1.3	20	15	1.3	20	9	0.9
shock	GDP deflator	20	14	1.2	20	14	1.2	20	7	0.8
Oil price	Consumption deflator	2	1	0.3	2	1	0.4	2	1	0.4
shock	GDP deflator	8	1	0.4	4	1	0.4	3	1	0.4
Total factor	Consumption deflator	18	1	0.8	18	1	0.8	12	1	0.7
productivity shock	GDP deflator	17	2	0.8	17	2	0.8	11	2	0.7
Indirect tax	Consumption deflator	1	1	0.2	1	1	0.2	1	1	0.2
shock	GDP deflator	1	1	0.2	1	1	0.2	1	1	0.2
Social security	Consumption deflator	10	2	0.6	8	2	0.6	7	2	0.4
contribution shock	GDP deflator	7	2	0.5	7	2	0.5	2	2	0.3

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