

A Policy-Sensible Benchmark Core Inflation Measure.  
An Application to US and Euro Area Data \*

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Core —or underlying— inflation indicators feature prominently in the economic debate and in central banks' external communication and internal policy discussions. Notwithstanding their popularity, whether core inflation measures should play a role in the monetary policy-making process is questionable. Indeed, given that most of them are based exclusively on statistical criteria, a firm theoretical justification is generally lacking, and their usefulness for policy-making purposes has never been subject to scrutiny. In this paper, we propose an approach to build a benchmark measure of core inflation that aims at overcoming those limitations. Our benchmark measure is derived on the basis of a criterion that explicitly treats core inflation as an artificial concept whose usefulness, if any, rests solely with its been helpful to defuse future inflationary pressures and hence to improve monetary policy effectiveness. Accordingly, our measure of core inflation is built on the basis of the solution to a standard optimal monetary policy problem. Using that measure as a yardstick, the performance and policy usefulness of other, popular core inflation indicators may be appraised. The approach is applied to US and euro area data. The results suggest that, for the US, quick-and-dirty popular core inflation indicators fare satisfactorily well compared with the benchmark; however, an optimizing monetary policymaker that was to react to overall, “untreated” inflation would perform just as well. By contrast, the performance of those indicators seems to be rather disappointing in the case of the euro area.

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# 1 Introduction

Similarly to a number of other macroeconomic phenomena, overall inflation is often conveniently thought of as being the observable outcome of two sets of unobservable driving forces: on the one side, price developments are (viewed as being) driven by a set of long-lasting factors, whose influence is likely to persist for at least some time into the future; on the other side, aggregate price dynamics also reflects the vagaries in a number of volatile factors, whose effects are expected to be short-lived. The former components of overall inflation are arguably valuable when it comes to predicting future price dynamics; by contrast, the latter should better be ignored, as the information they carry amounts to short-term noise and hence is of little relevance for predicting the future.

While a rigorous, universally accepted definition of core inflation is not available, virtually all core inflation indicators are obtained by filtering actual inflation in order to construct measures that are unaffected by the relatively high-frequency noise stemming from the more erratic components of currently observed inflation. Being purified of that noise, those measures are presumed to be better suited to cast light on future inflationary developments, hence providing useful guidance for monetary policy decision-making aiming at defusing inflationary pressures that are likely to arise in the future. The ultimate justification for developing core inflation measures is thus normative: any such measure is of interest to the extent that it makes it easier to identify potential inflationary risks and hence to keep future price dynamics under control.

In the recent literature various measures of core (or underlying) inflation have been proposed, that differ in the way transient noise is defined and removed. Most methods, however, share one main feature, in that they are constructed by applying (cross-section or time-series) filters to available information. In many cases, the construction of core inflation indicators is relatively simple, which makes them an ideal tool for communication with the public.

However, whether core inflation indicators should play a role in the monetary policy decision-making process—whether they would prove valuable in that context—has not been subjected to systematic scrutiny.

Indeed, while the concept of core inflation is apparently well defined and intuitively appealing, its practical policy usefulness has often been questioned on at least two accounts: first, being exclusively based on statistical criteria, existing core inflation measures lack a firm theoretical justification; second, there appears to be no generally accepted and

intuitively plausible criterion to assess the policy usefulness of competing core inflation measures directly. Both criticisms are indeed well taken. It is striking that, while one of the main justifications for building core inflation measures rests with their supposed ability to help the policy decision-making process, this requirement does not normally play any role at all in the construction of indicators of underlying inflation.

In this paper we propose an approach to build a benchmark measure of core inflation that aims at tackling the latter limitation directly. Our measure is derived on the basis of a criterion that treats core inflation as an artificial concept whose usefulness, if any, rests solely with its being helpful to defuse inflationary pressures that may be in the pipeline.

To put this idea into practice, we consider a monetary policymaker whose goal is that of optimizing a standard welfare function whose arguments are overall inflation and, possibly, the output gap and a measure of instrument volatility. In most of the literature, the policymaker is assumed to react to the state of the economy using a simple rule *à la* Taylor whose standard arguments are the current inflation rate (or its future expected values), the output gap and lagged values of the policy instrument.<sup>1</sup> We depart from that standard specification and assume instead that the policymaker may selectively respond to sectoral inflationary developments. We thus allow for more flexibility as to the way in which the information conveyed by the components of overall inflation may be exploited for policy-making purposes. Once the policymaker's optimization problem is solved, we build our core inflation measure as a linear combination of the various inflation components, the weights being a function of the optimized values of the parameters in the policymaker's reaction function. This differs from other core inflation measures, which are normally built using weights selected on the basis of statistical criteria. By contrast, the measure we build is explicitly based on economic criteria and is, at least in principle, more sensible from a policy-making viewpoint. That measure may thus be used as a benchmark to appraise the policy usefulness of alternative core inflation indicators.

The approach described above is then used to build a benchmark indicator of core inflation for the US and euro area economies, and to evaluate the performance of a few, popular core inflation indicators that feature prominently in the economic debate and in central banks' external communication as well as internal discussion.

We first estimate, for both economies, a simple, backward-looking multi-sectoral model—which for the US closely resembles, in both its appearance and main features, the model

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<sup>1</sup>The rationale for relying on (sub-optimal) simple rules rests on their being relatively more robust across different models, as shown by several authors; see, e.g., the papers collected in Taylor (1999).

of Rudebusch and Svensson (1999). However, the model developed here departs from Rudebusch and Svensson’s (1999) in that it describes separately the dynamics of prices in four sectors: industrial goods; services; energy; food.<sup>2</sup> For the US, the impulse responses of the multi-sectoral model to a number of standard shocks are, in most cases, very much in line with those of Rudebusch and Svensson’s (1999) —one difference being that policy effectiveness appears to be somewhat more muted in our model, presumably reflecting the greater difficulty of simultaneously controlling possibly diverging sectoral inflation rates. For the euro area, the properties of the model are consistent with the wealth of evidence collected in Angeloni *et al.* (2003).

Optimising a standard loss function (whose arguments are overall inflation, the output gap and the volatility of the policy instrument) subject to the rule being an extended Taylor-type one (including the four sectoral inflation rates, instead of aggregate inflation only, as well as the other standard ingredients, i.e., the output gap and the lagged interest rate) delivers the sets of weights that are then used to compute our core inflation measure. A few sensitivity checks are also performed.

The rule derived as sketchily described above is then used as a benchmark to appraise the performance of alternative popular underlying inflation indicators that can be modelled within our simple multi-sectoral framework. Specifically, “exclusion” core inflation indicators and the so-called Edgeworth measure can be easily simulated in our model, by imposing appropriate constraints on the specification of the extended Taylor-type rule. We then compute the optimal coefficients of the rule so constrained, and compare the performance with that of the (unconstrained) benchmark measure.

We also compare the various competing rules on the basis of statistical, rather than policy-effectiveness based, criteria; in particular, we compute measures of their ability to predict future inflation developments, and assess their performance over the most recent past.

[TBW: We then repeat the same experiment using a dynamic stochastic general equilibrium model, calibrated with US and euro area data, whose structure is basically the same as in the DSGE models by Christiano, Eichenbaum and Evans (2001) and Smets and Wouters (2003, 2004, 2007). However, in our model there exist four types of output (industrial goods; services; energy; food) and oil enters the production function of all sectors.]

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<sup>2</sup>Due to data availability, particularly for the euro area, we were not able to model sectoral outputs separately.

We find that the benchmark measure is basically no less volatile than overall inflation itself, for both the US and the euro area. In case the US monetary policymaker reacts to inflation net of the energy and food components (a popular, quick-and-dirty core inflation measure often mentioned in the economic debate and in external communication), her/his performance would be just slightly —and, for all practical purposes, irrelevantly— worse than it would be if monetary policy relied on the benchmark indicator. However, by responding optimally to the prevailing macroeconomic conditions following an optimized standard Taylor rule the monetary policymaker would not do much worse than the benchmark either; in this sense, the usefulness of core inflation —as measured by overall inflation purified of the energy and food components— as a guidance for policy is questionable. As to other core inflation indicators, our results suggest that their under-performance is not trifling.

By contrast, in the euro area there are signs that, by reacting to core inflation measures that remove all volatile components, monetary policy effectiveness may be more markedly impaired, particularly when keeping inflation under control is the policymaker’s overriding concern, even if one’s reaction is designed in such a way so as to be optimal on the basis of standard welfare criterion. In fact, the euro area monetary policymaker would be better off —or at least not appreciably worse off— by reacting to headline overall “untreated” inflation than to core inflation (inflation net of the energy and food components).

Therefore, what is possibly the most widely used core inflation indicator (i.e., overall inflation net of the energy and food components) seems to fare well in the US case, but does less so for Europe: Adopting the same definition of core inflation for both areas does not seem to be advisable.

Interestingly, the benchmark indicator turns out to stand its own also when all core inflation measures are ranked in terms of predictive performance (a model-free assessment) rather than policy effectiveness: While the predictive power of all indicators is not particularly high, the benchmark indicator seems to be better than most others, despite the fact that, in the process of building the former, predictive performance played no role whatsoever.

It should be emphasized that the results are still preliminary: first, the simple backward-looking model used here, while sharing the main features of the work-horse model of Rudebusch and Svensson (1999), is not immune from the Lucas critique; to overcome this drawback, and to appraise the robustness of our results, repeating the experiments with different models (notably, of the DSGE-type) is being planned. Secondly, the model used

here, because of data limitations, does not model sector-specific outputs, and hence the transmission mechanism of monetary policy is arguably measured only in a rough manner.

The paper is organised as follows: Section 2 presents a brief overview of the literature; Section 3 exposes our approach; Section 4 presents the estimated, backward-looking, econometric model of the US economy; Section 5 presents the empirical results based on that model: first, it discusses the properties of our measure; second, it appraises the performance of a few popular core inflation indicators, relative to our measure[; Sections 6 and 7 are similar to Sections 5, except that a calibrated DSGE is developed and used for the policy experiment]; finally, Section 8 concludes.

## 2 Core inflation in the literature

With the introduction of explicit inflation targets in many countries, the last decade has witnessed a sizeable growth in the number of core inflation indicators routinely monitored by central banks; at the same time, the degree of sophistication underlying their construction has increased. Nonetheless, the ultimate goal of these indicators has remained the same, namely, to extract a signal regarding the underlying inflation trend that embodies the most relevant information from the perspective of the monetary policy-maker, and which may be more informative than the change in the official consumer price index (CPI).

The approaches suggested in the literature to extract the core inflation measures differ mainly with respect to the information set deemed relevant for the extraction of the underlying signal. In the most straightforward approach, core inflation computation relies on excluding some classes of products; their exclusion is typically justified on the grounds that the signal to noise ratio in their price changes is just too small to convey useful information on the underlying inflation dynamics. The best known core inflation indicator is indeed the CPI Excluding Food and Energy indicator, originally used by Blinder (1982) to estimate underlying inflation in the US in the 1970s and 1980s.

In the same class we can place more sophisticated core inflation measures that rely on the so-called *limited influence estimators* first introduced by Bryan and Cecchetti (1994). Their computation requires a rather high level of disaggregation of the CPI, since the full cross-section of the distribution of price changes is used to remove the most extreme observations in every month.<sup>3</sup> These measures, unlike the more traditional CPI Excluding

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<sup>3</sup>These measures, like the median, the weighted median, or the trimmed mean, aim to capture the

Food and Energy, do not a priori exclude specific classes of products, as they do not make the assumption that certain items are guaranteed never to contain relevant information regarding trend inflation. In a similar vein, Diewert (1995) proposes instead to exploit the full distribution of price changes in every month weighting each price observation by its information content. In practice, rather than discarding the information contained in the tails of the distribution of price changes, Diewert (1995) proposes assigning to individual price changes weights that are inversely related to their historical variance.

Univariate time series models have also been used to remove high frequency noise from CPI-inflation series and the resulting smoothed series taken to provide an estimate of core inflation. The year-on-year rate of inflation, which constitutes the standard reference measure for the inflation outlook, may itself be viewed as a very crude measure of core inflation; the signal extraction achieved by adopting the year-on-year rate removes seasonal fluctuations, but suffers from two well-known drawbacks: it is still affected by a sizeable amount of short-run volatility and, furthermore, being a 12-month moving average of the month-on-month changes, it makes severely inefficient use of most recent (and arguably most valuable) information. Other forms of univariate filtering typically involve the use of the Kalman filter, which requires an assumption on the functional form of the underlying core inflation process. More recently, Cogley (2002) has obtained a univariate one-sided filter designed to estimate the persistent component of inflation resulting from monetary policy regime changes.

Bryan and Cecchetti (1993) were the first to apply the dynamic factor index model of Stock and Watson (1991) in the context of inflation analysis. Their approach exploits the cross-section and time-series information on a small set of price indices to extract the common component of price changes, which is interpreted as core inflation.

A more recent extension of the factor index approach may be found in Cristadoro *et al.* (2005), who construct a core inflation indicator for the euro area. Unlike Bryan and Cecchetti (1993), they use a large panel of euro-area time series containing national/sectoral price variables as well as monetary and real variables. Their core inflation measure is then constructed by projecting the medium- and long-run component of monthly inflation on a set of common shocks, estimated from the panel using a dynamic factor model.

In the SVAR-based approach to the estimation of core inflation, economic theory plays a more direct role. These multivariate time series models attempt to decompose observed central tendency of the distribution of price changes in a more efficient way than the mean does. For a detailed description and evaluation of these measures see Vega and Wynne (2001).

inflation into a core and a non-core component. The identification of these unobserved components relies on restrictions that are derived from economic theory. Among these, Quah and Vahey (1995) resort to a structural bivariate VAR, where core inflation is defined as that component of measured inflation that has no impact on output in the medium to long-run. In practice, they estimate it as the component of overall inflation driven by a nominal shock, which is identified using a restriction of long run neutrality on the activity variable. Blix (1995) and Bagliano *et al.* (2002) extend the Quah and Vahey (1995) methodology by modelling the long-run neutrality of money within a cointegrated VAR framework.<sup>4</sup>

To date, lacking a clear theoretical definition, existing core inflation measures are appraised empirically on the basis of three main criteria: their ability to track past movements in overall inflation, their degree of smoothness, and their ability to predict future headline inflation movements (Vega and Wynne, 2001, and Le Bihan and Sedillot, 2000). Only recently Cristadoro *et al.* (2005) have documented the empirical performance of their indicator by comparing actual policy interventions with its dynamics, and showing that the latter tracked well the first five years of interest rate decisions.

### 3 A policy-effectiveness-based approach

To describe our approach, it is first convenient to give our definition of core inflation: in our framework, core inflation is given by an appropriate combination of available information on disaggregate (sectoral) price developments, such that, by basing her policy decisions on that measure, the monetary policymaker maximises policy effectiveness (i.e., minimises a standard welfare loss). This definition explicitly recognises that, for any underlying inflation indicator to be of use in the decision-making process, it must be the case that that measure provides valuable information that facilitates the monetary policymaker's task of keeping overall inflation under control in the future. In other words, we take it for granted that enhancing policy-effectiveness is, in the end, the only motivation behind the construction of core inflation measures. Given these premises, it is natural to explicitly adopt policy effectiveness as the main guiding criterion in the search for such measures. Our indicator will thus by construction be immune from the main criticism often raised with regard with other popular indicators, to the effect that their performance as a tool

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<sup>4</sup>Blix (1995) assumes stationarity of the velocity of money, implying a cointegrating relationship between output, prices and money

to support policy decision-making is usually not demonstrated.

Since our focus is on the optimal way to combine available disaggregate information, we mostly restrict our attention to rather standard Taylor-type rules—in which only contemporaneous inflation and the output gap appear among the arguments, along with a lagged interest rate term—and ignore a number of suggestions that have been made in the literature (e.g., we are not interested in appraising the relative performance of forward-looking rules such as the ones proposed in Batini and Haldane (1999)). However, we depart from the standard framework in that we assume disaggregate information on consumer price inflation to be available, so that the policymaker is not necessarily constrained to react to overall inflation but may instead choose to react only to some components of it, or, more generally, to all components, but not in the way that would be dictated by the way sub-components are aggregated into the overall index of inflation.

We first need to define the policymaker’s preferences. We assume the monetary policymaker to have the following standard quadratic time-separable loss function:

$$L_t = (1 - \delta)E_t \sum_{\tau=0}^{\infty} \delta^\tau [(4\pi_{t+\tau})^2 + \lambda y_{t+\tau}^2 + \mu(\Delta i_{t+\tau})^2], \quad (1)$$

where  $\pi_t$  is quarter-on-quarter inflation (so that  $4\pi_t$  is annualised quarter-on-quarter inflation),  $y_t$  is the output gap,  $i_t$  is the policy interest rate controlled by the central bank,  $\delta$  is a discount factor,  $\lambda$  and  $\mu$  are parameters that reflect the weights attached by the policymaker to the variability of the output gap and of the policy interest rate changes relative to the variability of inflation around a target, assumed to be zero for simplicity. Note that the monetary policymaker is assumed to be interested solely in aggregate inflation; sectoral inflationary developments may be of interest if they improve monetary policy effectiveness, but they are of no interest *per se*.

For  $\delta \rightarrow 1$  the intertemporal loss function can be interpreted as the unconditional mean of the period loss functions, which in turn is given by the weighted sum of the unconditional variances of the target variables (see Rudebusch and Svensson (1999)):

$$L_t = 16\text{var}(\pi_t) + \lambda\text{var}(y_t) + \mu\text{var}(\Delta i_t). \quad (2)$$

Let us now assume that monetary policy decision-making is supported by a model that provides relatively detailed information on the functioning of the economy, in that it includes not only aggregate inflation, but also models the evolution of a number of sub-components of the aggregate inflation index. Let us assume that information on  $n$  sub-components is available.

The policy-maker is thus faced with the task of combining the available disaggregate information into a measure of inflation that provides the best possible guidance when it comes to taking action now to keep price dynamics under control over the indefinite future.

The most natural way to combine available information optimally is to postulate a generic monetary policy reaction function in which all pieces of information enter separately and let the optimal combination be determined by the solution of the policymaker's loss minimisation problem. Accordingly, we posit the following extended Taylor-type monetary policy rule:<sup>5</sup>

$$i_t = \sum_{j=1}^n \gamma_{1,j} \pi_{j,t} + \gamma_2 y_t + \gamma_3 i_{t-1}. \quad (3)$$

where  $\gamma_{1,1}, \dots, \gamma_{1,n}, \gamma_2$  and  $\gamma_3$  are  $n + 2$  coefficients to be determined by minimising eq. (1) subject to the constraints given by the available empirical model and to eq. (3). In the empirical applications below,  $n = 4$ ; in principle, however, a larger number of sectors may be included in the model.

Let the optimal values of the  $n$  parameters  $\gamma_{1,j}$  be  $\widehat{\gamma}_{1,j}$ . We define core inflation  $\pi_t^C$  to be the following linear combination of sectoral inflation rates:

$$\pi_t^C = \sum_{j=1}^n \frac{\widehat{\gamma}_{1,j}}{\widehat{\gamma}_1} \pi_{j,t} = \sum_{j=1}^n \omega_j \pi_{j,t} \quad (4)$$

where  $\widehat{\gamma}_1$  is the optimal policymaker's reaction to core inflation itself. Thus, the optimal simple monetary policy rule is similar to the dynamic version of the standard Taylor rule, except that overall inflation is replaced by core inflation:

$$i_t = \widehat{\gamma}_1 \pi_t^C + \widehat{\gamma}_2 y_t + \widehat{\gamma}_3 i_{t-1}. \quad (5)$$

While the definition of core inflation above is rather natural from a policy-effectiveness viewpoint, it is not operational yet, as a value has to be chosen for the free parameter  $\widehat{\gamma}_1$ :

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<sup>5</sup>Alternatively, one could compute the truly optimal rule, in which the instrument reacts to the whole set of state variables in the model. We chose to stick to simple rules following the recommendations that may be found in most of the literature on optimal monetary policy. Several authors have emphasised that the underperformance of the simple rules should be weighted against their simplicity, that can make them easier to use for the monetary authorities, and a more useful tool for communication with the public. Furthermore, simple rules are in general found to be more robust, as compared with more model-dependent optimal rules. Thus, there may be a trade-off between performance in the context of a specific model and robustness (see, for instance, the papers presented at the January 1998 NBER Conference on Monetary policy rules, published in Taylor (1999)).

only once the latter has been set, it becomes possible to compute core inflation as in eq. (4). One possibility is to choose  $\hat{\gamma}_1$  so that core inflation coincides with actual headline inflation on average over the whole available sample period. A second straightforward possibility is to impose  $\sum_{j=1}^n \omega_j = 1$  in eq. (4). In the empirical application below we adopt the first option.

There is *a priori* no guarantee that  $\bar{\pi}_t^C$  built as described above be a smooth series; this contrasts with most, if not all, other measures of underlying inflation, which usually are, and are in fact required to be, substantially smoother than headline inflation; it could well be the case that relevant information goes lost when filtering that could actually help to prevent future price accelerations.

We also build what we term a “long-run” core inflation indicator, by approximating the infinite moving average representation that can be computed on the basis of eq. (5):

$$\pi_t^{C,L} = \sum_{\tau=0}^{\infty} \gamma_3^\tau \left( \sum_{j=1}^n \omega_j \gamma_{1,j} \bar{\pi}_{j,t-\tau} \right). \quad (6)$$

Whether or not other popular core inflation indicators are appropriate and desirable may be assessed by measuring their relative performance with respect to the ideal measure built as described above. A number of those indicators may be easily appraised within our framework, by simply imposing the appropriate constraints on the coefficients of the optimal rule.

Consider first the case in which core inflation is given by current headline inflation, so that the policy interest rate is assumed to be determined by a standard (optimal simple) monetary policy rule. This case may be explored by imposing the following constraint:  $\gamma_{1j} = w_j \gamma_1$ , where  $w_j$  represents the weight of the  $j$ -th inflation component in the overall index (so that:  $\sum_j w_j = 1$  and  $\pi_t = \sum_j w_j \pi_{j,t}$ ). In this case, the optimal values of just three coefficients of the rule are to be selected. This is done by solving the same optimisation problem as above.

Widely-used measure of core inflation are given by headline inflation net of the latter’s most volatile components. Such measures are very easy to compute, which is the main reason for their popularity. To appraise the performance of the indicator given by inflation net of, say, the last  $m$  components, we solve the loss minimisation problem above subject to the constraint that the rule be given by:

$$i_t = \gamma_1 \pi_t^{-[n-m+1, n]} + \gamma_2 y_t + \gamma_3 i_{t-1} \quad (7)$$

where:

$$\pi_t^{-[n-m+1,n]} = \sum_{j=1}^{n-m} \frac{w_j}{\sum_{i=1}^{n-m} w_i} \pi_{j,t} \quad (8)$$

Other popular measures may also be mimicked in a similar fashion (see Section 5).

In all cases, we require that the reaction to the chosen core inflation indicator be the best possible one.

As a benchmark, in the empirical application below we also compute the fully optimal rule (which we label FOR), that depends on all state variables of the multi-sectoral models presented in the next section (see e.g. Chow (1975)).

## 4 The estimated, backward-looking models

### 4.1 The US model

The US economy is described by a simple 5-equation model, consisting of an aggregate demand equation (also referred to as IS curve), and four sectoral inflation equations (also referred to as supply or Phillips curves). The first equation relates the overall economy output gap to its own lags and the real interest rate. The sectoral inflation equations instead relate inflation in each sector to its own lags, and to those of inflation in other sectors, as well as to the overall output gap.<sup>6</sup>

Sectoral inflation is given by the seasonally adjusted quarter-on-quarter rate of change in the corresponding CPI series. Potential output is the one estimated from the Congressional Budget Office, as in Rudebusch and Svensson (1999).<sup>7</sup>

The model is thus specified as follows:

$$\begin{aligned} \pi_{j,t+1} &= \sum_{k=1}^p \alpha_{j,k} \pi_{j,t+1-k} + \sum_{i \neq j}^4 \sum_{k=0}^p \beta_{j,i,k} \pi_{i,t+1-k} + \sum_{k=0}^p \eta_{j,k} y_{t+1-k} + u_{t+1}^j \\ y_{t+1} &= \sum_{k=1}^p \theta_{j,k} y_{t+1-k} + \sum_{k=1}^p \psi_k (i_{t+1-k} - 4 \cdot \pi_{t+1-k}) + v_{t+1} \end{aligned}$$

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<sup>6</sup>While it might be appropriate to assume that price dynamics in each sector depend on the output gap for that particular sectors, the available data prevented us from building reliable measures of sectoral output gap.

<sup>7</sup>Source: Thomson Financial, February 2007.

The specification search entailed a general to specific approach: in the starting specification, the first 4 lags of all relevant variables were included on the right hand side of each equation. After all insignificant lags were dropped, the parsimonious specification shown in Table 2 was achieved (the estimation sample spans from 1971Q1 to 2005Q4). The restriction that the sum of the coefficients on lagged inflation in each sectoral equation be equal to one could not be rejected. This implies that the overall Phillips curve is of the accelerationist type.

Some insights into the main properties of the model can be obtained by looking at its impulse responses (Figures 1-7; the shocks are imparted in period 5). The model is closed using the same monetary policy rule as that underlying Figure 4 in Rudebusch and Svensson (1999), so that it is sensible to compare the two sets of impulse responses (it should however be brought in mind that our model is estimated with CPI inflation rates, whereas Rudebusch and Svensson (1999) use the rate of change of the GDP deflator).

A 1 percent output shock results in a 1.2 percent GDP rise after 2 periods; subsequently, output fall below the baseline value, reaching about -0.3 percent about 10 periods after the shock and converges back to zero after about 40 periods. Overall inflation rises about 0.7 percent above the baseline in about two-year time after the shock, and the interest rate reacts very aggressively, rising over 200 bps above its baseline value. This pattern of responses is virtually the same as in Rudebusch and Svensson (1999), except that the reaction of inflation is more pronounced here (this may partly depend on our using a different inflation indicator).

If all inflation rates are shocked by 1 percent, overall inflation initially jumps by the same amount as the shock, and then falls back to around 0.5 percent; after a short-lived, small rebound, it starts converging back to zero, virtually completing the process after 40-50 periods. This is almost exactly the same pattern as in Rudebusch and Svensson (1999). The largest fall in output, after about 10 periods, reaches roughly -0.3 percent; the interest rate is very quickly raised by about 200 bps. These responses compare once again rather favourably with Figure 4 in Rudebusch and Svensson (1999).

Following an interest rate shock, output reaches a trough after 2 periods, and then rebounds slightly above the baseline; by contrast, for monetary policy to fully exert its effects on inflation takes somewhat longer, the largest effect being recorded at the end of year 2 after the shock.

Thus, our simple 4-sector model shares much of the features of the work-horse model of Rudebusch and Svensson (1999), the only non negligible difference being the reaction

of inflation (CPI in our case, GDP inflation for Rudebusch and Svensson (1999)) to an output shock, and is consistent with the main stylised facts about the timing and size of the effects of monetary policy on the economy.

## 4.2 The euro area model

The euro area model has the same structure of the US model described in the previous section. Sectoral inflation is given by seasonally adjusted quarter-on-quarter rate of change in the corresponding HICP series.<sup>8</sup> The output gap is estimated as the cyclical component of (log) of euro area GDP, using the asymmetric band-pass filter proposed by Christiano and Fitzgerald (2003). After all insignificant lags were dropped, the parsimonious specification shown in Table 5 was achieved. The restriction that the sum of the coefficients on lagged inflation be equal to one could not be rejected in all sectoral inflation equations, except the one describing food inflation. This implies that the overall Phillips curve is of the accelerationist type.

Some insights into the main properties of the model can be obtained by looking at its impulse responses (Figures 14-20); as above, the model is closed using a standard monetary policy reaction function. The results are in line with the well-established stylised facts regarding the monetary transmission mechanism in the euro area. In particular, as found in Angeloni *et al.* (2002): (i) a positive monetary policy shock results in a temporary contraction of output, reaching a maximum during the first year, while the largest reduction in inflation occurs after around 2 years; (ii) following a 1 percent output shock, overall inflation rises about 0.4 percent above the baseline in about two-year time after the shock, and the interest rate reacts quite aggressively, rising 150 bps above its baseline value; output, having jumped on impact, declines monotonically to the baseline in about three years; (iii) if all inflation rates are shocked by 1 percent, overall inflation initially jumps by the same amount as the shock, and then falls back to around 0.8 percent, declining very slowly to zero thereafter.

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<sup>8</sup>Seasonal adjustment was performed using Tramo-Seats. Inflation series prior to 1991 were backdated using national CPI data for the four largest countries.

## 5 Empirical results, 1 (Econometric-model-based)

In this section we first apply the approach presented in Section 3 to the simple estimated multi-sectoral US and euro area models illustrated in the previous section; we then appraise, using the benchmark core inflation measures thus obtained, a few of the most popular core inflation indicators; finally, we compare the forecast performance of the various indicators.

### 5.1 Results for the US

#### 5.1.1 Policy-effectiveness-based measures of core inflation

Our approach relies, as mentioned above, on ascertaining the best way to combine information on sectoral inflation rates, where by “best” we mean that the particular combination chosen must result in optimising a given criterion function. Thus, as a preliminary step, we need to specify the policymaker’s preferences.

Given that our goal is that of building an inflation indicator that performs best when it comes to reigning in future inflationary pressures, it is quite natural to assume the monetary policy maker to be a pure inflation targeter, i.e.,  $\lambda = \mu = 0$ . However, we chose to solve the policymaker’s loss minimisation problem for a range of values for both  $\lambda$  and  $\mu$ ; specifically, for both  $\lambda$  and  $\mu$  we selected equally spaced values between 0 and 1.

We then find optimal values of the coefficients in eq. (3) (with  $n = 4$  and  $j$  =services (S), goods (G), food (F) and energy (E) sectors) by minimising eq. (2) for a range of values of  $\lambda$  and  $\mu$ .

The results are summarised in Table 3 and Figure 8. For comparison, the optimal responses to the four sectoral inflation rates are reported together with those that are implicit if we solve the same loss minimisation problem but we constrain the rule to be of the standard Taylor-type (i.e., one that includes only three arguments: the aggregate inflation rate, the output gap and the lagged interest rate). [TBC: We also include, again for comparison, the fully optimal rule, i.e., the one that reacts to the whole state vector of our model.]

A couple of features of the results are worthwhile discussing.

Firstly, while it is obviously the case that the policy rule that is allowed to react to sectoral inflation rates must necessarily perform better than the policy rule that is constrained to react to aggregate inflation only (this must be so by construction, as the

latter is a constrained version of the former), the difference in performance between the two may or may not be sizeable. On the basis of our results, the underperformance of the standard Taylor-type rule appears to be rather modest (they range between 5 and 10 percent, the underperformance being largest for  $\lambda = \mu = 0$ ).

Secondly, the weights implied by applying the approach adopted here tend indeed to be comparatively small for both food and energy inflation. However, they are not nil. Specifically, in the case of energy inflation, the optimal reaction coefficients are actually not far from those implicit in the standard rule.

Having found the optimal parameters of the extended policy rule, we construct our measure of core inflation by imposing the constraint that the latter be the same as actual inflation, on average, over the whole available sample. The measure —built on the basis of the optimised policy coefficients for the case  $\lambda = \mu = 0$ — are shown in Figure 9, together with actual aggregate inflation and other core inflation indicators.

It is worthwhile remarking that Figure 9 questions the requirement that is often imposed on core inflation measures, namely that they be substantially smoother than overall inflation. The standard deviation of the benchmark indicator is actually about the same as that of overall inflation, and its range of variation is only slightly smaller.

### 5.1.2 Appraisal of popular core inflation indicators

In this section we appraise the performance of other popular core inflation measures relative to our indicator. Not all measures may be easily included in our framework. We chose to restrict our analysis to indicators whose inclusion in our framework is straightforward and does not require any additional *ad hoc* assumption, namely: (i) consumer price inflation net of energy goods; (ii) consumer price inflation net of energy goods and food; (iii) Edgeworth measure of core inflation (see Diewert, 1995). The latter measure gives proportionately less weight to the most volatile components of the index, as it is a weighed average of sectoral inflation rates, the weights being inversely proportional to the respective sample variances. The dynamics of indicators (ii) and (iii) are shown in Figure 9. For both of them, the reduction in volatility, compared with overall inflation, is immediately apparent.

The performance of those core inflation measures may be easily appraised within our framework, by imposing appropriate constraints to the monetary policy rule, as shown in Table 1 below.

For each measure, we compute optimal parameter values by minimising the loss func-

Table 1: Modelling alternative core inflation indicators in a policy optimisation framework

	Constraints to be imposed on the rule coefficients
Policy effectiveness based indicator	none
Headline inflation	$\gamma_{1j} = w_j \gamma_1$ for $j = G, S, F, E$ ( $w_j =$ CPI weight of $j^{th}$ component)
Inflation net of energy	$\gamma_{1E} = 0, \gamma_{1j} = \frac{w_j}{w_G + w_S + w_F} \gamma_1$ for $j = G, S, F$
Inflation net of energy & food	$\gamma_{1E} = \gamma_{1F} = 0, \gamma_{1j} = \frac{w_j}{w_G + w_S} \gamma_1$ for $j = G, S$
Edgeworth indicator	$\gamma_{1j} = w_j^e \gamma_1$ for all $j$ 's (where $w_j^e = \frac{\frac{1}{\sigma_j^2}}{\sum_i \frac{1}{\sigma_i^2}}$ )

tion in eq. (2), under the constraints indicated in Table 1. The results are presented in Table 4 and Figure 10.

Our policy optimisation framework suggests that, by reacting to the core-inflation indicator that does away with the most volatile components (i.e., inflation net of energy and food), the monetary policymaker's performance is not sensibly worse than the optimal one attainable by reacting to the benchmark indicator obtained above: for the combinations of  $\lambda$  and  $\mu$  reported in 4, the worsening in the performance is trifling, ranging between 2 and 5 percent. The near irrelevance of the differences between the benchmark indicator and inflation net of energy and food is confirmed by the results of fault tolerance check (Figure 11): for all parameters but the coefficient on goods inflation, there tends to be ample mutual tolerance between the two rules (Levin and Williams, 2003).

However, while policy effectiveness is not sensibly reduced by adopting the core inflation indicator net of energy and food, it is not sensibly improved either: compared with the case in which the policymaker reacts to overall inflation as in the standard Taylor-rule case, one observes either negligible improvements or negligible deteriorations in performance, depending on the preference weights. At any rate, there seems to be little justification for making the core inflation indicator net of energy and food the yardstick to guide one's monetary policy decisions, instead of overall inflation.

Things take a sharp turn for the worse if other measures of core inflation are considered. For instance, inflation net of energy may imply an increase in the policymaker loss of as much as [10] percent. Even worse, the Edgeworth-type measure leads to sensible increases

of the loss, exceeding [30] per cent when (almost) pure inflation targeting is considered.

All experiments have been repeated in a somewhat more realistic setting, assuming that the policymaker cannot react instantaneously to macroeconomic aggregates, the latter being observed only with a 1-period lag. The results are almost identical to the ones commented above. Specifically, both the near-optimality of inflation net of energy and food and its doubtful usefulness (as its performance virtually coincides with that of the standard Taylor rule) are confirmed.

Of course, in our set-up the benchmark measure of core inflation cannot be outperformed: it is, by definition, the best one can do (short of adopting to the fully optimal rule). A truly independent check would be to compare the various core inflation indicators on a different playing ground —one that played no role in the construction of the benchmark model-based indicator. In Figure 13 we compare the predictive ability of the policy-effectiveness-based indicator, of inflation net of energy and food and of the so-called Edgeworth indicator. Specifically, we followed Cogley (2002) and regressed the acceleration of prices between  $t$  and  $t+h$  over an indicator of “current inflationary pressure,” the latter being the difference between the three competing measures of core inflation in turn and inflation itself, both at time  $t$ .<sup>9</sup> For each measure, Figure 13 reports the  $R^2$  statistic, for values of  $h$  ranging between 1 and 12.

In the short-run, the indicator of current inflationary pressure based on the policy-based core inflation measure is more correlated with future inflation than its competitors. In the longer-run, inflation net of energy and food scores better, but its explanatory power is very small indeed. Interestingly, the Edgeworth indicator emerges as the best performer. Given its patent inferiority when it comes to policy usefulness, this result again suggests that predictive content and policy usefulness do not necessarily go hand in hand.

## 5.2 Results for the euro area

### 5.2.1 Policy-effectiveness-based measures of core inflation

As in the case of the US, the monetary policymaker’s optimization problem was solved for a range of values of  $\lambda$  and  $\mu$  (both parameters assuming equally spaced values between

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<sup>9</sup>The results of the regressions are just indicative, as the real-time version of the policy-effectiveness-based indicator would not be able to take on board information regarding the whole available sample (note that the same applies to the Edgeworth indicator). [Insert genuine real-time comparison results when ready]

0 and 1), delivering the results shown in Table 6 and Figure 21. The Table reports the model-based rule together with the standard Taylor-type[ and fully optimal ones].

The underperformance of the standard Taylor-type rule appears to be relatively small but non-negligible, particularly in comparison with the finding in the case of the US: the increase in the loss is around 10 percent for all combinations of preference parameters.

As in the case of the US, the approach adopted here results in very small weights for both energy and food inflation, but also for goods inflation.

Aggregate inflation and the benchmark core inflation indicators for the euro area are depicted, together with other indicators, in Figure 22. As in the case of the US, it would appear optimal to react to an inflation measure that is not dramatically smoother than headline inflation itself, contrary to the requirement often imposed on core inflation measures. The standard deviation of the benchmark indicator is about the same as that of overall inflation, and its range of variation is only slightly smaller.

On the whole, the differences between the model-based rule and its performance and the Taylor rule do not appear to be such as to clearly signal the sub-optimality of the latter.

### **5.2.2 Appraisal of popular core inflation indicators**

In this section we appraise the performance of other popular core inflation measures relative to our indicator for the euro area, focussing on: (i) consumer price inflation net of energy goods; (ii) consumer price inflation net of energy goods and food; (iii) Edgeworth measure of core inflation.

Proceeding as in the US case, the results shown in Table 7 and Figures 23 and 22 are found.

The main message is that, contrary to the US case, the additional losses incurred by departing from the benchmark indicator and reacting to, e.g., inflation net of energy and food are far from trifling, particularly when the weights attached to the output gap and the volatility of the interest rates in the policymaker's loss function are small. In other words, based on monetary policy effectiveness considerations (and given our estimated model), there appears to be little justification to use the most popular exclusion core inflation indicators in the context of the euro area. This is also apparent from the optimal frontiers: exclusion measures are considerably to the NE of the benchmark. Also, reacting to overall inflation, without relying on any intermediate indicator of underlying inflation, does not seem to hamper the effectiveness of monetary policy. Indeed, the frontier associated

with the standard Taylor rule can be to the SW of the frontiers associated with core inflation indicators, or just about the same as the latter. Finally, as in the US, the Edgeworth measure seems to score particularly poorly. Summing up, for the euro area the case for building traditional core inflation indicators seems to be very weak, or at least considerably weaker than for the US (this of course may not necessarily apply to other, more sophisticated core inflation indicators not considered here).

As in the case of the US, all experiments have been repeated in a somewhat more realistic setting, assuming that the policymaker cannot react instantaneously to macroeconomic aggregates, the latter being observed only with a 1-period lag. The main results are virtually unaffected.

Finally, in Figure 25 we compare the predictive ability of the policy-effectiveness-based indicator, of inflation net of energy and food and of the so-called Edgeworth indicator, using the approach suggested by Cogley (2002). For each measure, Figure 13 reports the  $R^2$  statistic, for  $h$  step ahead predictions, with  $h$  ranging between 1 and 12.

The predictive performance of all indicators is very limited to say the least. For no indicator and no horizon does the  $R^2$  reach 0.2. However, it is remarkable that the model-based indicator is not outperformed by the two competitors, albeit the latter are more or less explicitly aimed at predictive performance. If anything, the model-based indicator is actually the best predictor of future inflationary pressures.

## 6 The DSGE models

TBW

## 7 Empirical results, 2 (DSGE-model-based)

TBW

## 8 Conclusions

It is common practice to build core inflation indicators that rely on purely statistical criteria; most popular measures are based on simple manipulations of the data (such as: trimming of tails of distribution; exclusion of some components; simple re-weighting schemes). While the precise way in which the various indicators are built differ, they all

tend to share a few key features: notably, they all tend to be significantly smoother than headline inflation itself.

While those indicators provide information as to the impact of transient and volatile inflation components of inflation, their practical usefulness for the purpose of providing guidance to the policy decision-maker has often been questioned.

In this paper we proposed an approach aimed at building a benchmark core inflation measure explicitly based on policy effectiveness criteria, and applied the approach to US and euro area data. We then used our indicator as a yardstick to appraise the performance of other, popular and widely used indicators. The results suggest that popular core-inflation indicators that work well in one context may be quite unreliable in others: specifically, for the euro-area, selectively responding to sectoral inflation rates does not pay off as much as it does for the US. By contrast, previous research on euro area data suggests that, in the context of the euro area, an effective core inflation indicator may need to explicitly acknowledge the heterogeneity of euro-area economies (see Angelini *et al.* (2003)).

The starting point of our analysis is that resorting to a core inflation indicator should find its justification, if any, in its being useful when it comes to supporting monetary policymaking.

Our empirical results are, at this stage, very preliminary: as they are model-based (although not entirely, as predictive performance comparisons obviously do not depend on the models we use), robustness checks are needed. However, a few interesting prescriptions seem to emerge, specifically: (i) what is good in one context, may not necessarily be exportable to other contexts; specifically, inflation net of energy and food components is a good indicator for the US (= it does not sizeably underperform the benchmark in terms of policy usefulness), whereas the very same indicator appears to fare non negligibly worse than the benchmark indicator in the case of the euro area. Based on our results, using simple exclusion indicators for the euro area would appear to be strongly inadvisable; (ii) for both the euro area and the US, there seems after all to be little point in using any of the simple core inflation measures we considered: by reacting optimally to headline inflation, the policymaker reaches the same loss as he/she would by reacting optimally to the best of the exclusion core inflation indicators.

Table 2: The estimated US model <sup>(1)</sup>

US	AD	$AS_{services}$	$AS_{goods}$	$AS_{food}$	$AS_{energy}$
y	0.909 [1-2]	0.177 [1]	0.171[1]	0.377 [1]	0.902 [1]
r	-0.043 [2]				
$\pi_{services}$		0.956 [1-3]	0.087 [1]		0.588 [1]
$\pi_{goods}$			0.913 [1-3]	0.336 [1]	
$\pi_{food}$				0.664 [1-3]	
$\pi_{energy}$		0.044 [1-2]			0.412 [1-4]
$\bar{R}^2$	0.883	0.764	0.752	0.473	0.210
$\sigma$	0.744	1.583	1.590	2.957	12.041
DW	2.115	1.788	1.944	1.890	1.922

(1) If more lags of one variable enter one equation, only the sum of coefficients is reported. Selected lags are in square brackets.

Table 3: US: reaction function coefficients and loss for the optimal, the standard and the FOR rules

$\lambda$	$\mu$	Type of Rule	Coefficients on:				Standard deviation of:				Loss
			$\pi_{Services}$	$\pi_{Goods}$	$\pi_{Food}$	$\pi_{Energy}$	Inflation	Output gap	Interest rate change		
0	0	Standard	8.84	3.58	2.24	1.39	2.63	4.11	25.63	6.93	
		Model Based FOR	12.13	4.92	0.21	0.89	2.53	4.02	27.36	6.39	
	1	Standard	1.05	0.42	0.26	0.16	3.92	2.82	2.33	20.81	
		Model Based FOR	1.32	0.38	0.10	0.10	3.85	2.81	2.29	20.07	
	1	0	Standard	3.99	1.62	1.01	0.63	3.02	2.53	10.67	15.50
			Model Based FOR	5.29	1.70	0.00	0.39	2.91	2.49	11.34	14.69
1		Standard	1.12	0.45	0.28	0.18	4.00	2.55	2.33	27.94	
		Model Based FOR	1.37	0.37	0.11	0.11	3.93	2.54	2.29	27.14	

Table 4: US: relative performance of alternative core inflation indicators

Parameter values in the loss function		Type of Rule	Standard deviation of:			Loss
$\lambda$	$\mu$		Inflation	Output gap	Interest rate change	
0		Model based	2.53	4.02	27.36	6.39
	0	Excl. ene. and food	2.58	4.02	28.71	6.65
		Excl. energy	2.65	4.19	28.55	7.02
		Edgeworth	2.91	4.31	27.61	8.45
1		Model based	3.85	2.81	2.29	20.07
	1	Excl. ene and food	3.93	2.84	2.31	20.83
		Excl. energy	3.99	2.86	2.35	21.46
		Edgeworth	4.21	2.90	2.44	23.67
1		Model based	2.91	2.49	11.34	14.69
	0	Excl. ene. and food	2.96	2.51	11.80	15.06
		Excl. energy	3.05	2.55	11.53	15.81
		Edgeworth	3.30	2.60	11.32	17.66
1		Model based	3.93	2.54	2.29	27.14
	1	Excl. ene. and food	4.01	2.57	2.32	28.05
		Excl. energy	4.08	2.58	2.34	28.77
		Edgeworth	4.29	2.61	2.43	31.16

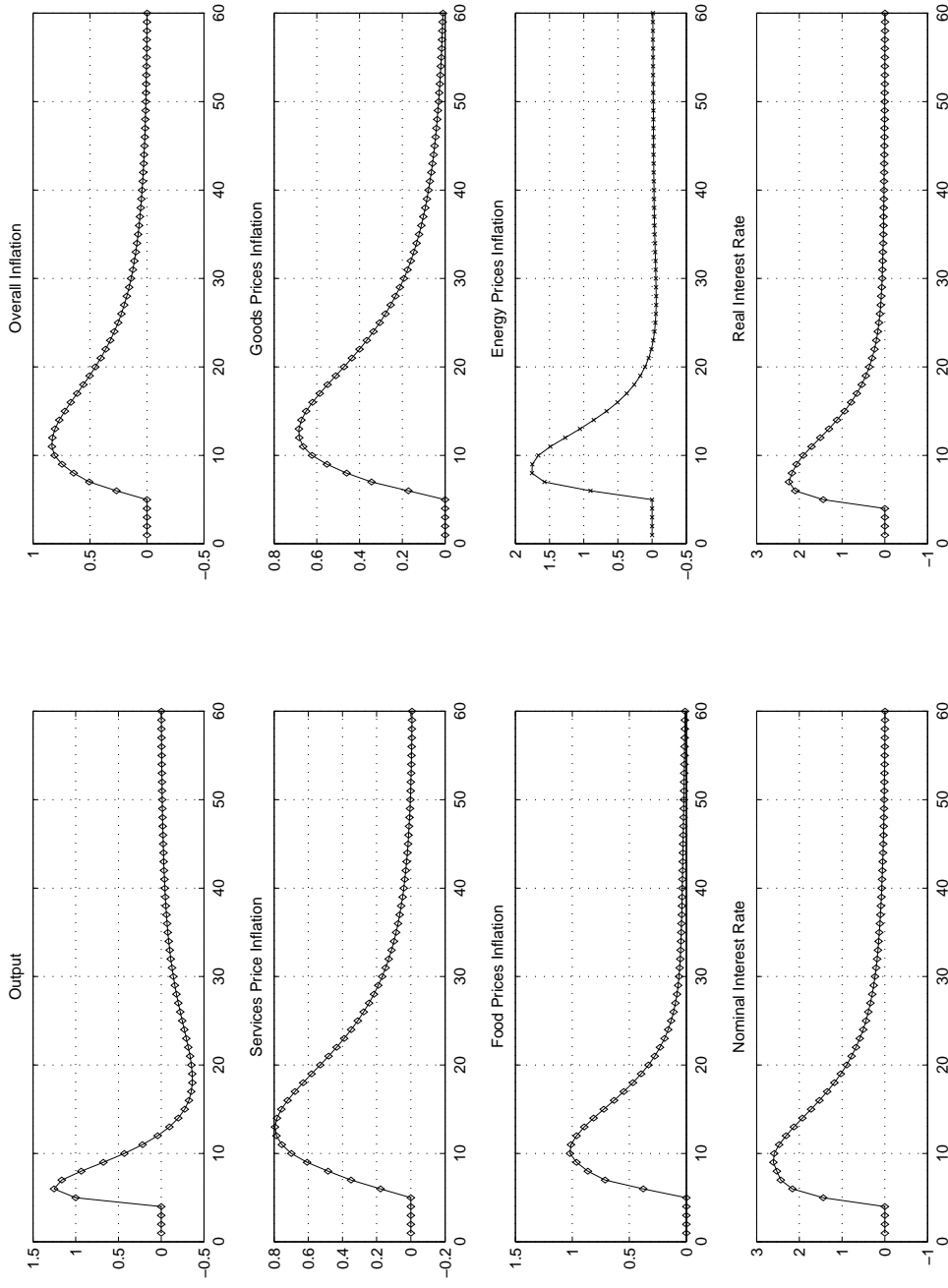


Figure 1: US: Output shock

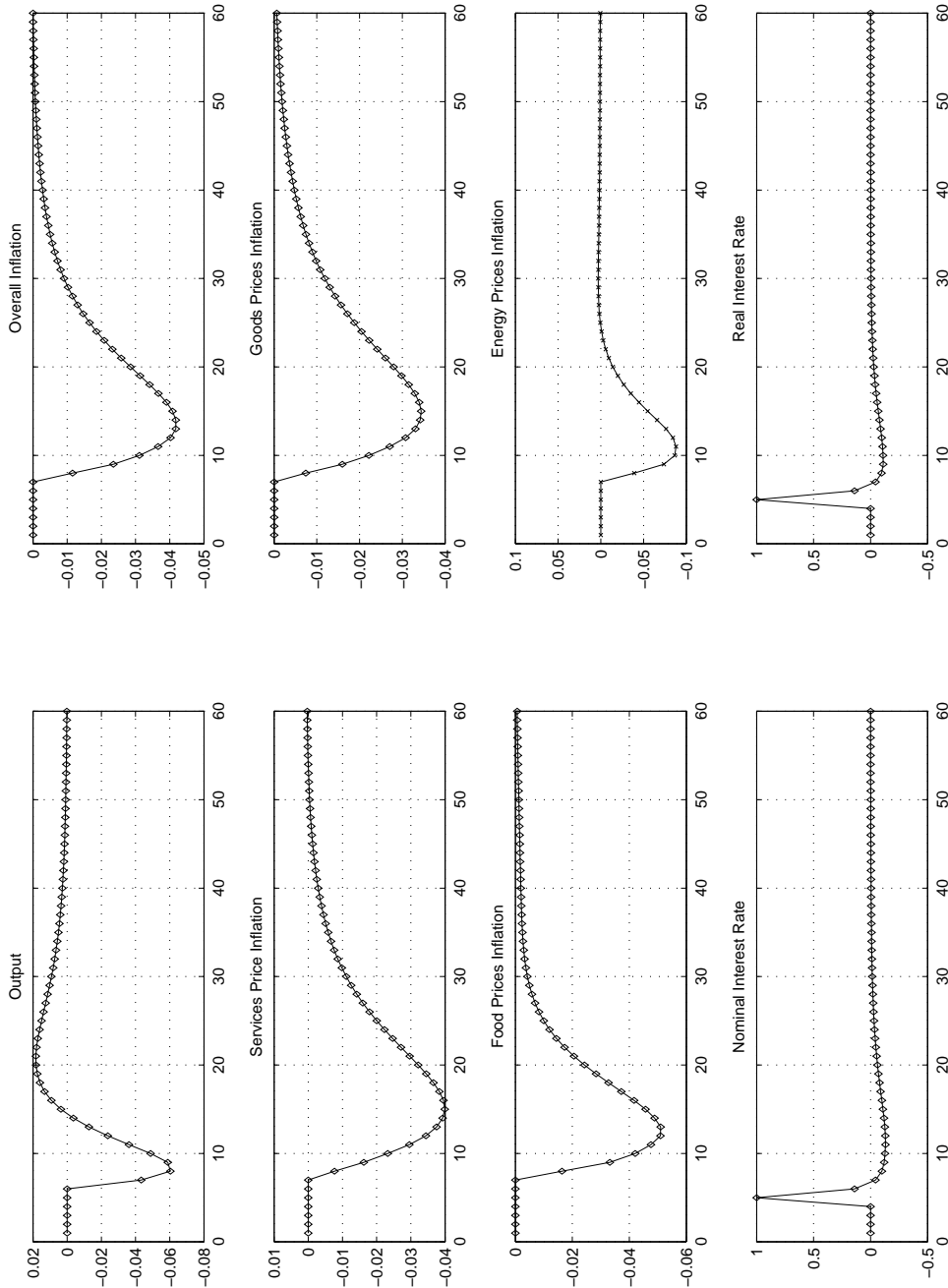


Figure 2: US: Interest rate shock

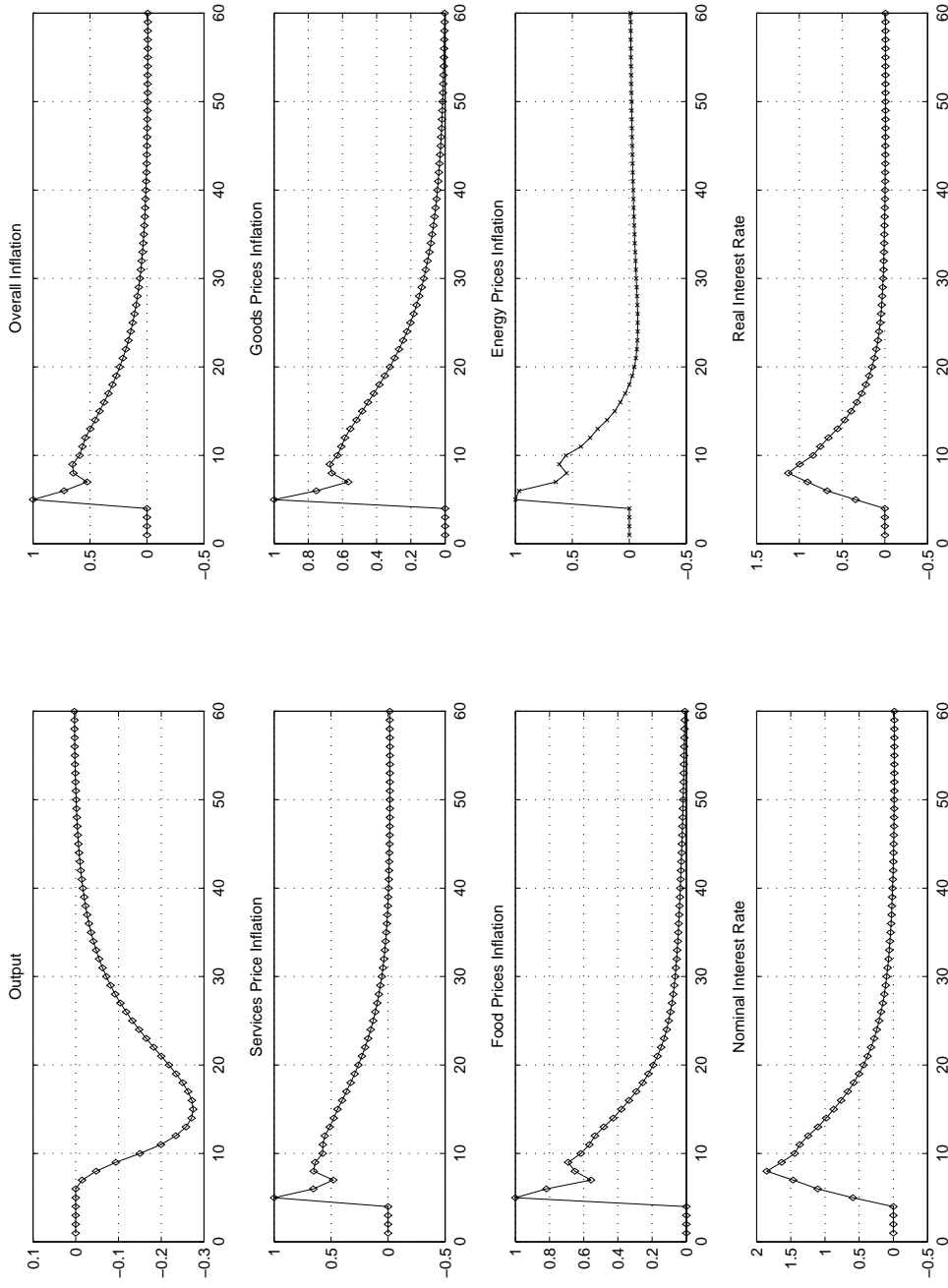


Figure 3: US: Overall Price shock

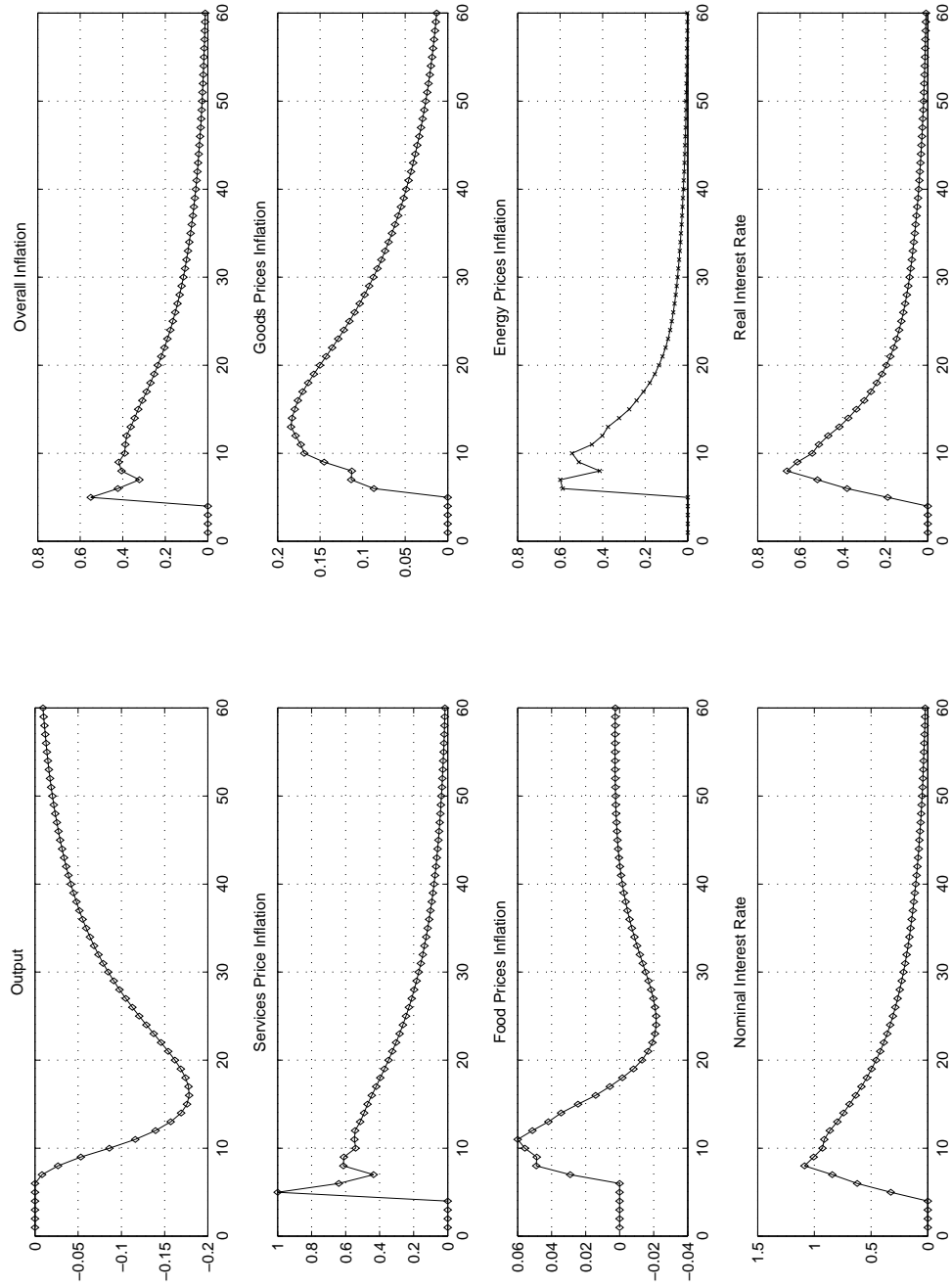


Figure 4: US: Services Price shock

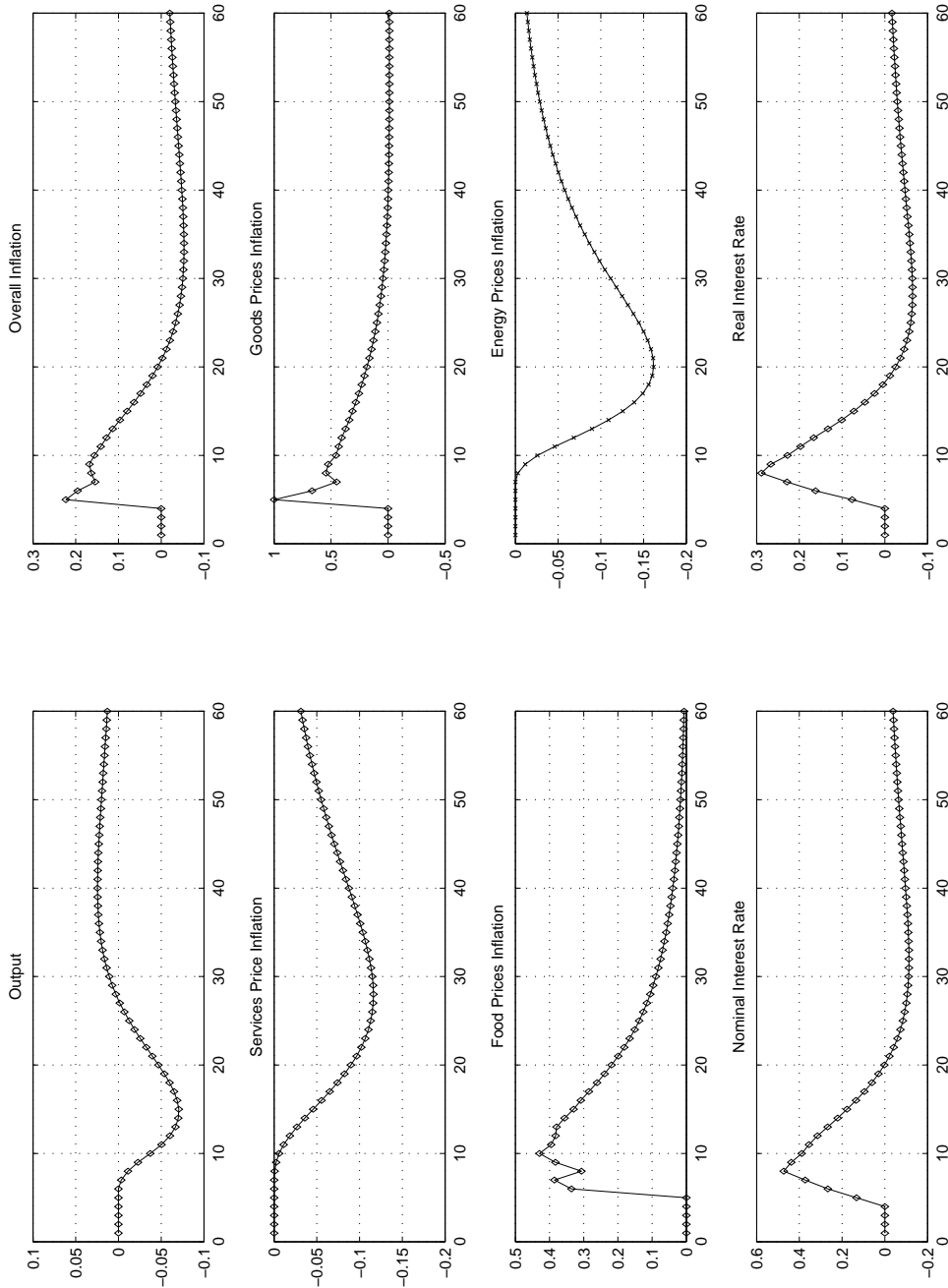


Figure 5: US: Goods Price shock

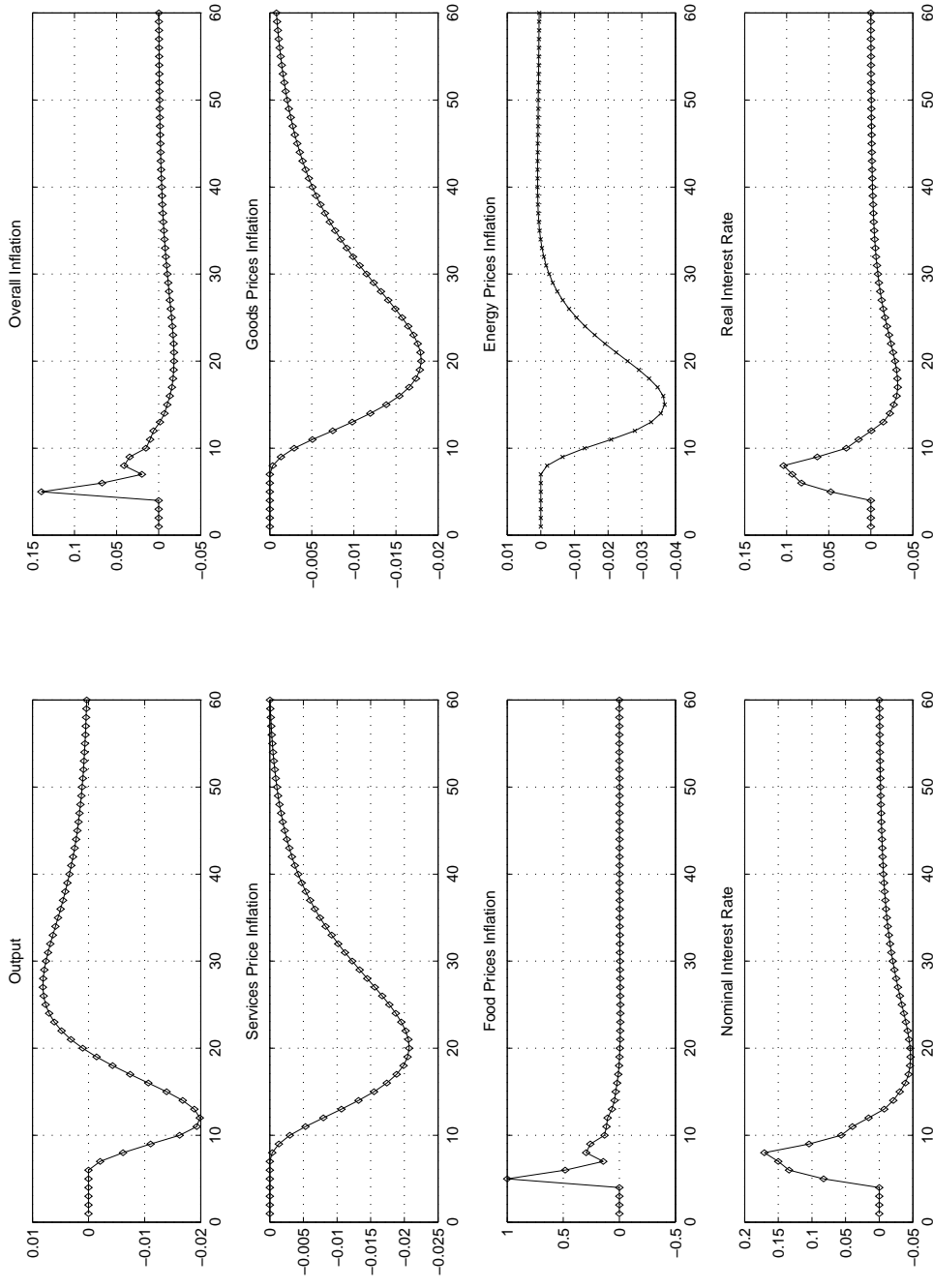


Figure 6: US: Foods Price shock

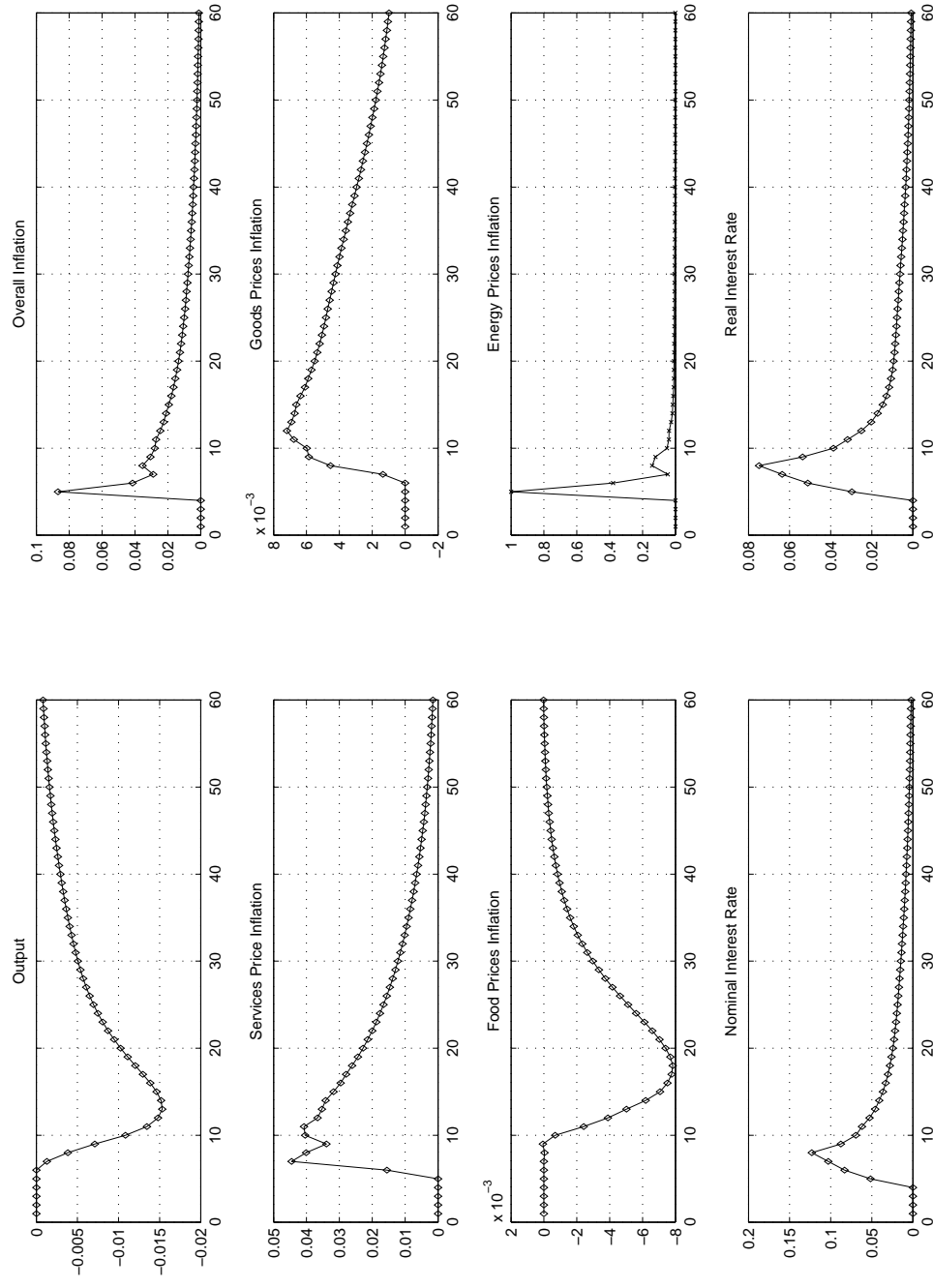


Figure 7: US: Energy Price shock

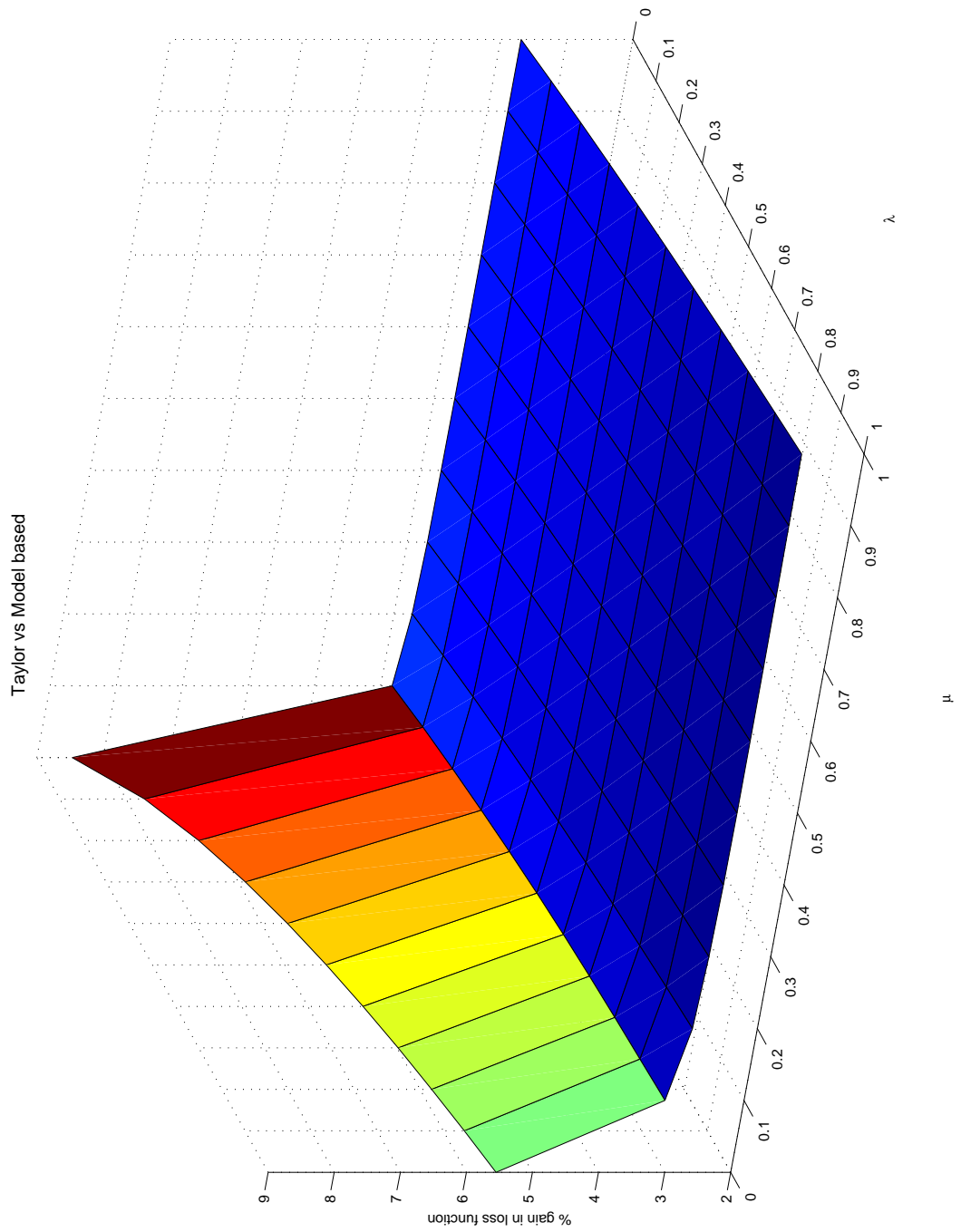


Figure 8: US: Relative Performance: Standard vs Model Based

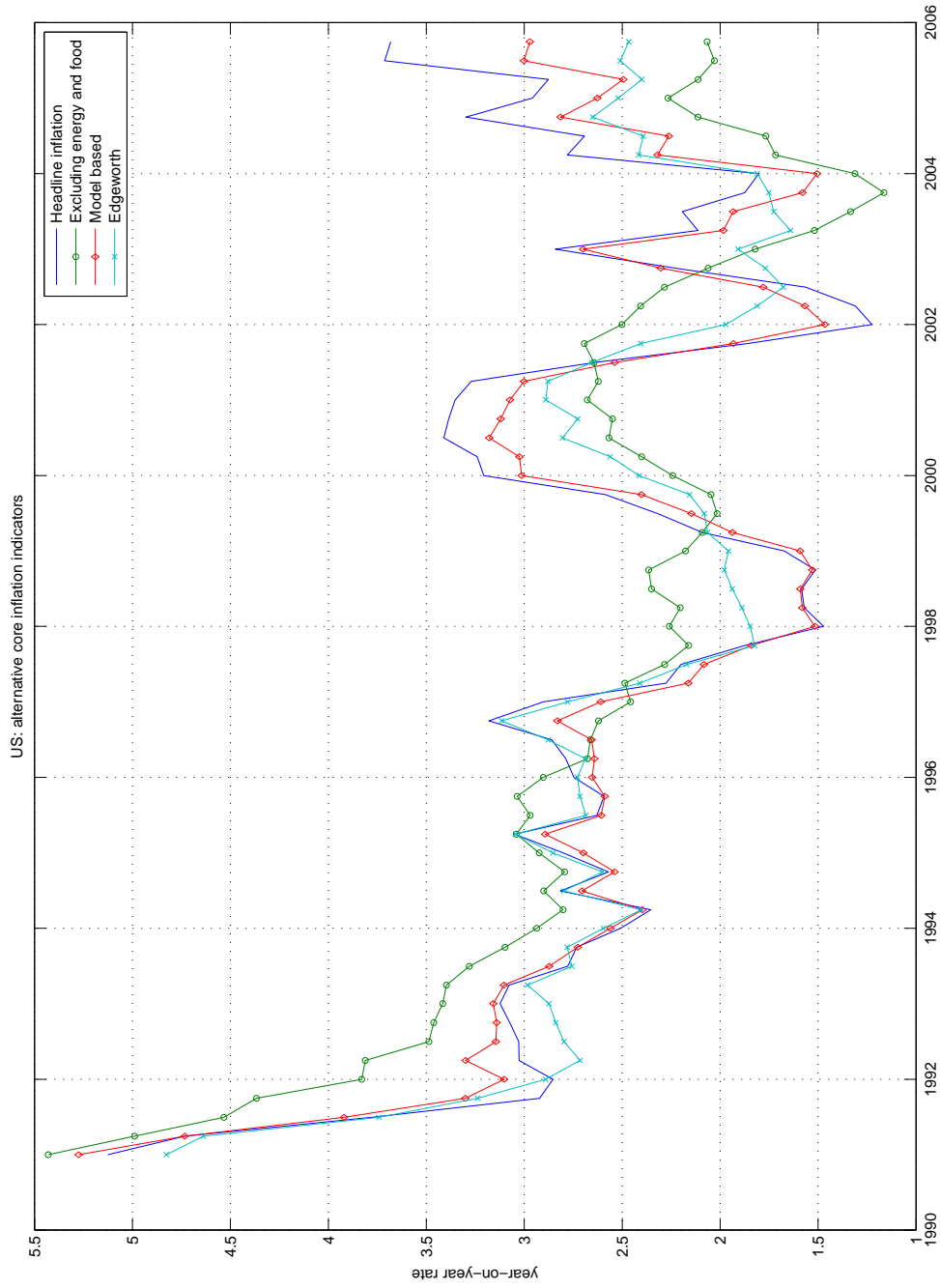


Figure 9: US: alternative core inflation indicators

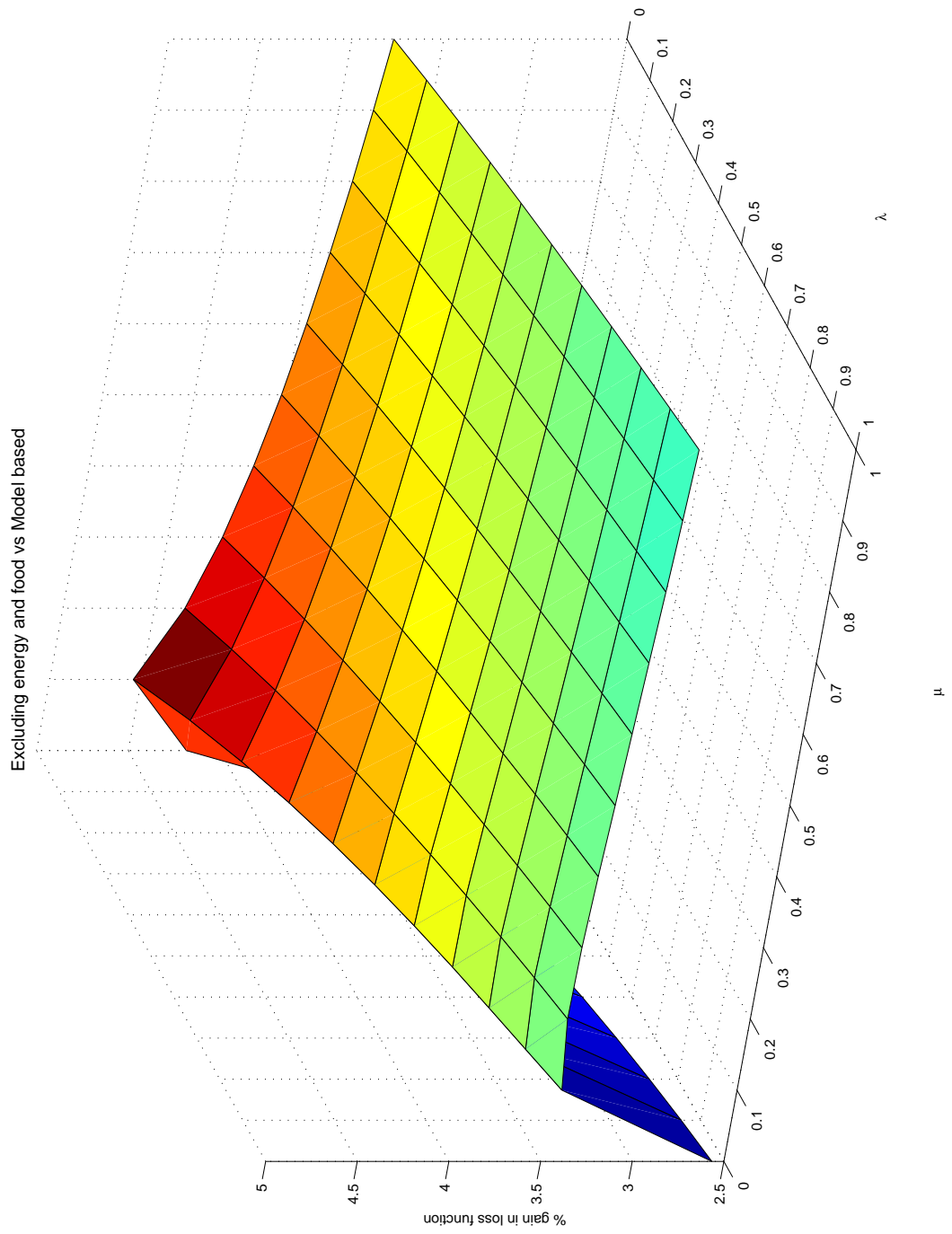


Figure 10: US: Relative Performance: Excluding Energy and Food vs Model Based

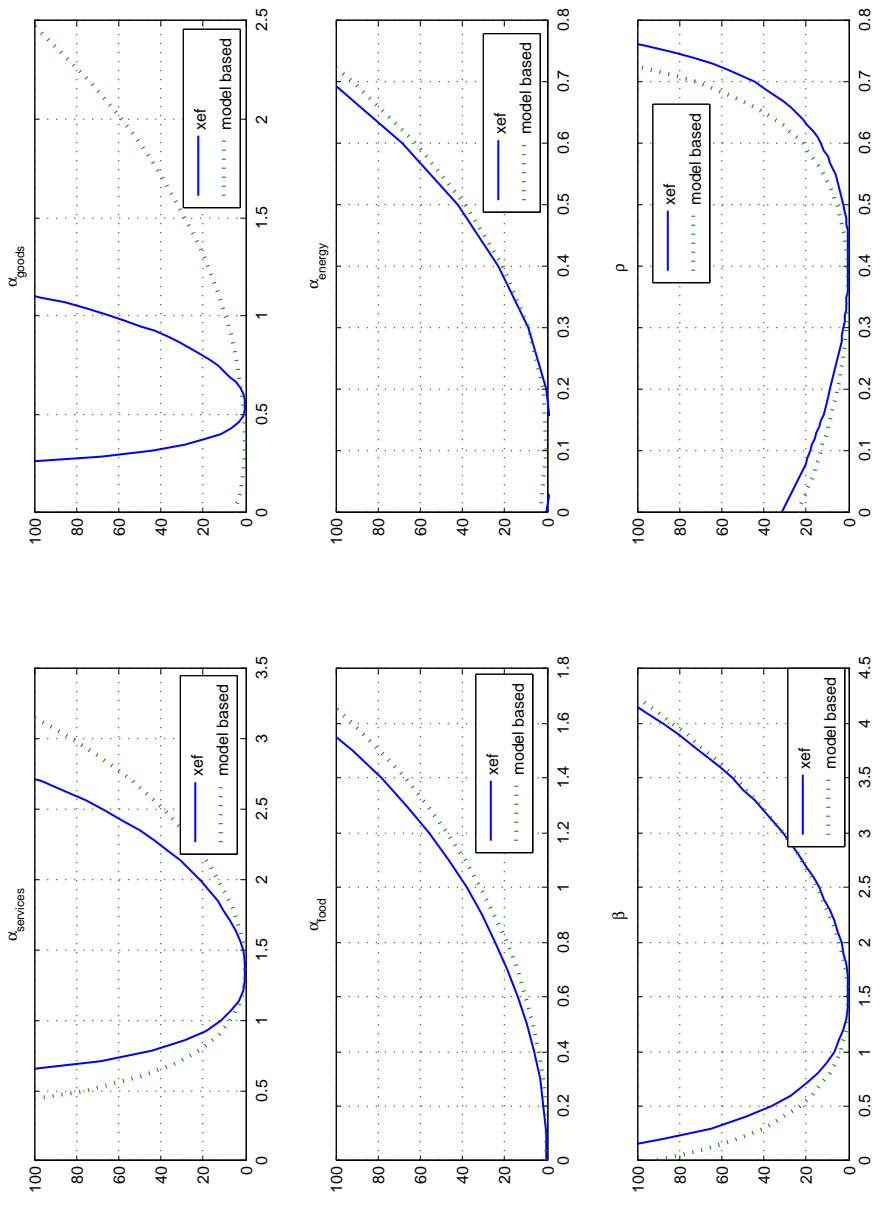


Figure 11: US: Fault Tolerance exercise

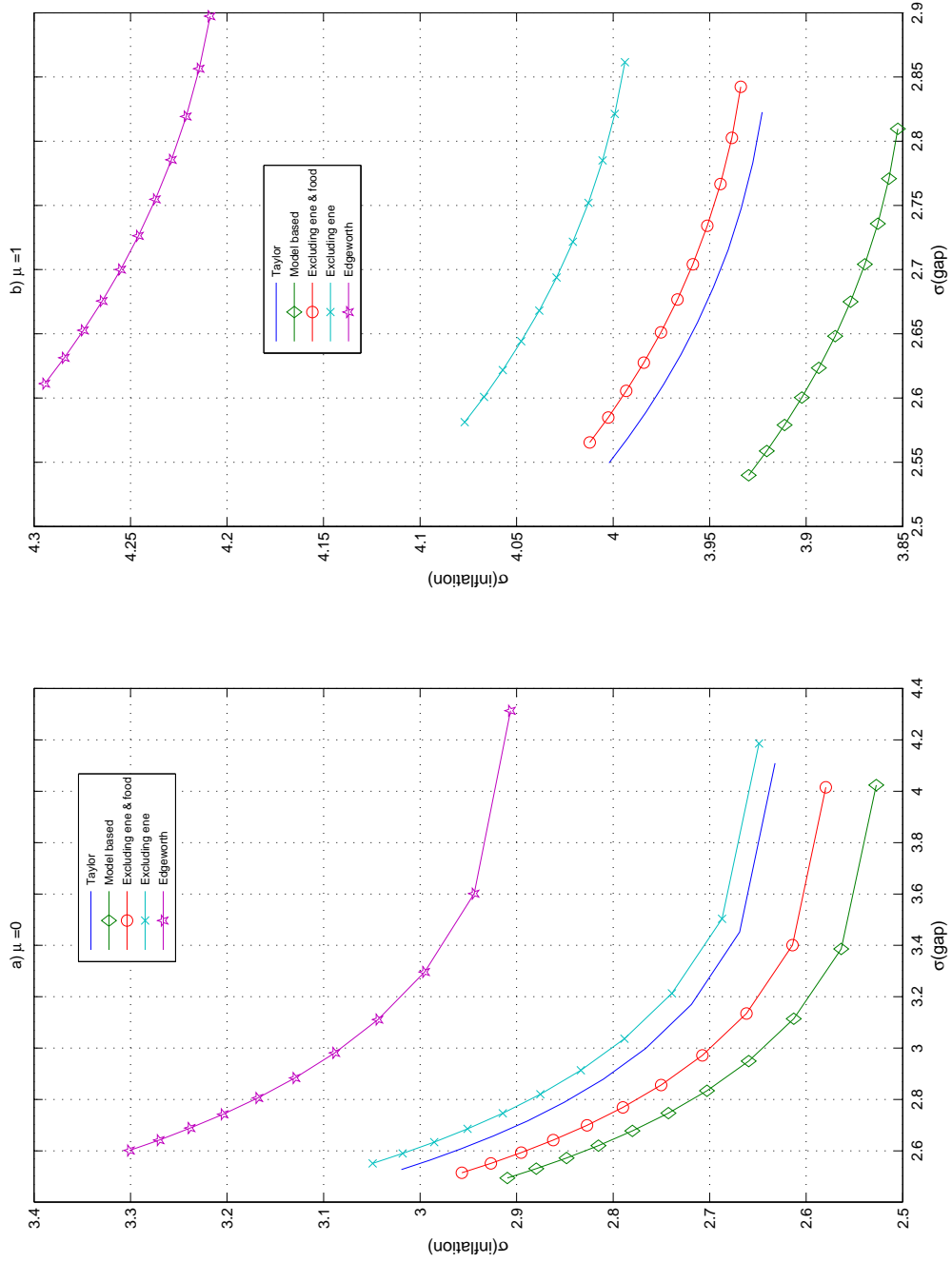


Figure 12: US: Inflation - Output Gap optimal frontiers

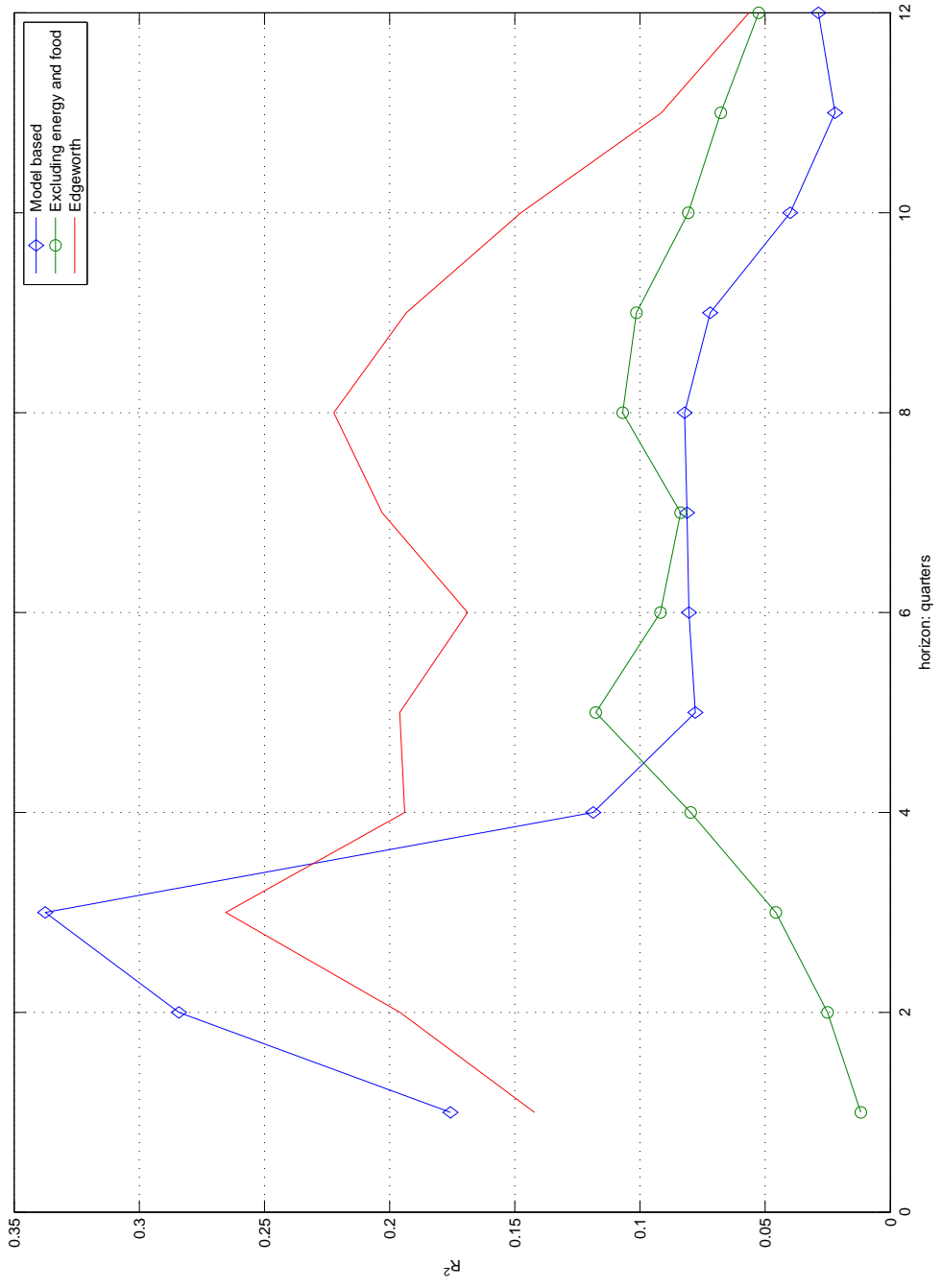


Figure 13: US: Forecast Performance of different core inflation measures

Table 5: The estimated euro area model <sup>(1)</sup>

Euro Area	AD	$AS_{services}$	$AS_{goods}$	$AS_{food}$	$AS_{energy}$
y	0.839 [1]	0.161 [1]	0.163[1]	0.185 [1]	
r	-0.042[2]				
$\pi_{services}$		0.989 [1-2]	0.338 [1]		0.390 [1]
$\pi_{goods}$			0.662 [1]		
$\pi_{food}$				0.822 [1-2]	
$\pi_{energy}$		0.011 [1]		0.035	0.602 [1-3]
$\bar{R}^2$	0.746	0.956	0.951	0.707	0.290
$\sigma$	0.458	0.619	0.745	1.612	8.292
DW	1.828	2.098	1.829	2.256	1.971

(1) If more lags of one variable enter one equation, only the sum of coefficients is reported. Selected lags are in square brackets.

Table 6: Euro Area Reaction function coefficients and loss for the optimal, the standard and the FOR rules

$\lambda$	$\mu$	Type of Rule	Coefficients on:				Standard deviation of:				Loss
			$\pi_{Services}$	$\pi_{Goods}$	$\pi_{Food}$	$\pi_{Energy}$	Inflation	Output gap	Interest rate change		
0	0	Standard	15.22	11.97	7.32	3.43	2.81	4.66	71.16	7.92	
		Model Based FOR	43.65	3.39	5.81	0.00	2.68	4.59	69.47	7.16	
	1	Standard	0.25	0.20	0.12	0.06	3.79	1.58	1.45	16.44	
		Model Based FOR	1.31	0.06	0.08	0.00	3.58	1.55	1.35	14.61	
	1	0	Standard	3.43	2.70	1.65	0.77	3.19	1.59	13.89	12.70
			Model Based FOR	11.29	0.28	0.92	0.00	3.06	1.53	13.32	11.67
1		Standard	0.27	0.22	0.13	0.06	3.82	1.44	1.42	18.70	
		Model Based FOR	1.28	0.07	0.08	0.00	3.61	1.41	1.32	16.76	

Table 7: EA: relative performance of alternative core inflation indicators

Parameter values in the loss function		Type of Rule	Standard deviation of:			Loss
$\lambda$	$\mu$		Inflation	Output gap	Interest rate change	
0	0	Model based	2.68	4.59	69.47	7.16
		Excl. ene. and food	3.05	3.72	58.23	9.29
		Excl. energy	2.85	4.70	72.02	8.11
		Edgeworth	3.37	3.60	61.94	11.36
	1	Model based	3.58	1.55	1.35	14.61
		Excl. ene and food	3.76	1.59	1.36	15.99
1	0	Excl. energy	3.83	1.60	1.46	16.83
		Edgeworth	4.27	1.80	1.52	20.51
		Model based	3.06	1.53	13.32	11.67
		Excl. ene. and food	3.28	1.48	13.60	12.98
	1	Excl. energy	3.22	1.61	14.06	12.95
		Edgeworth	3.59	1.71	17.19	15.86
1	0	Model based	3.61	1.41	1.32	16.76
		Excl. ene. and food	3.79	1.45	1.34	18.26
	1	Excl. energy	3.87	1.46	1.44	19.14
		Edgeworth	4.32	1.65	1.45	23.46

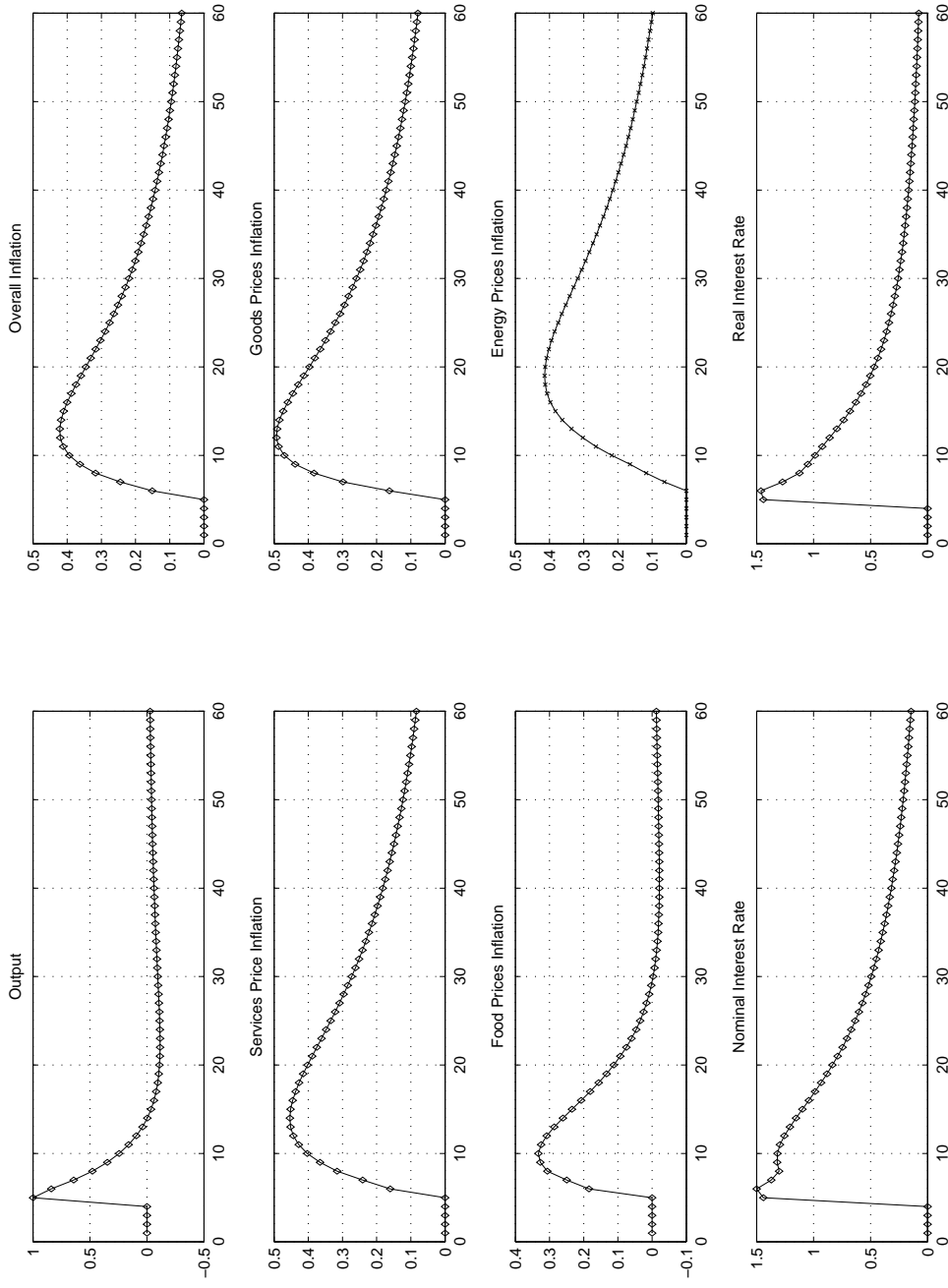


Figure 14: Euro Area, Output shock

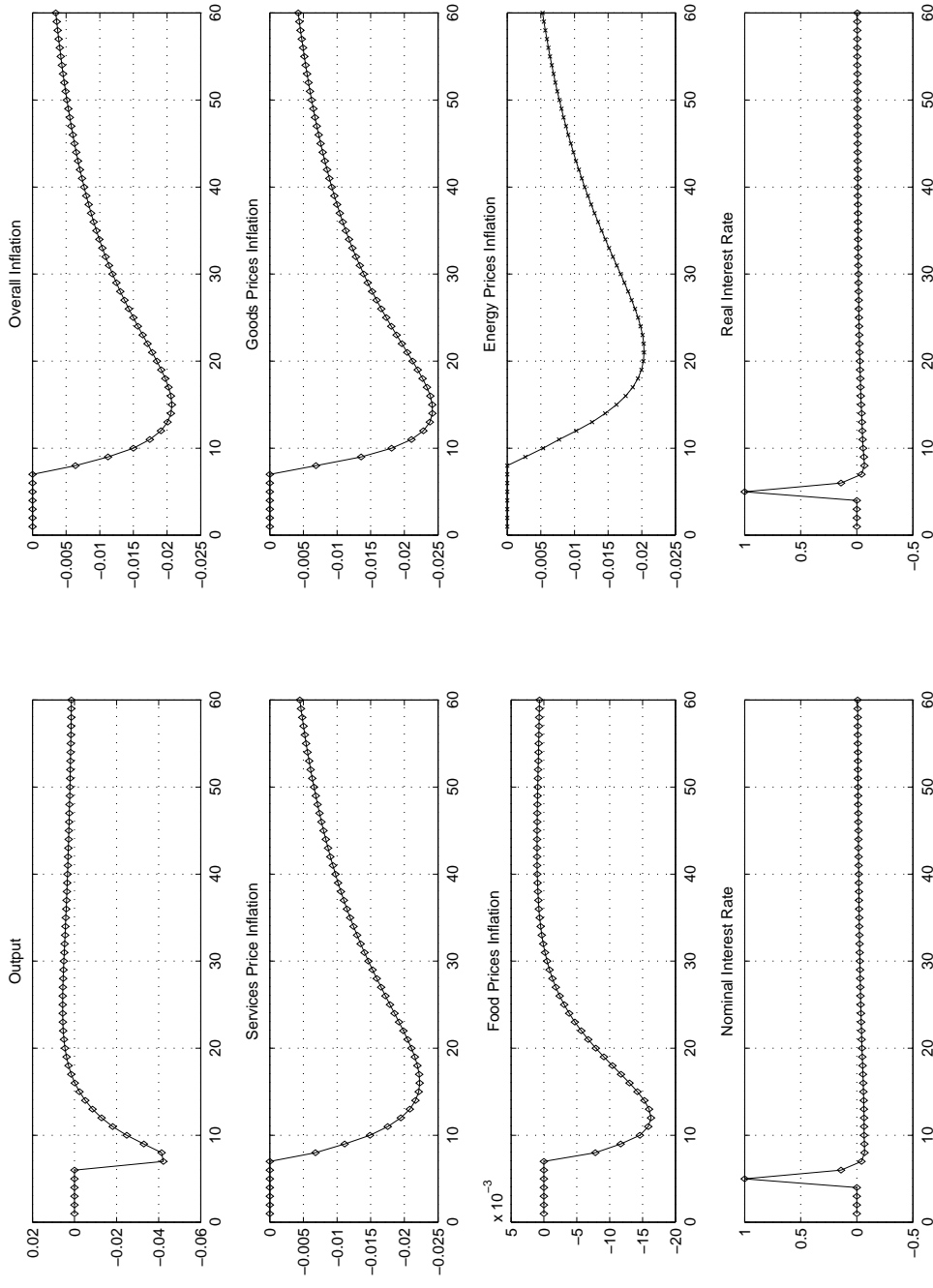


Figure 15: Euro Area, Interest rate shock

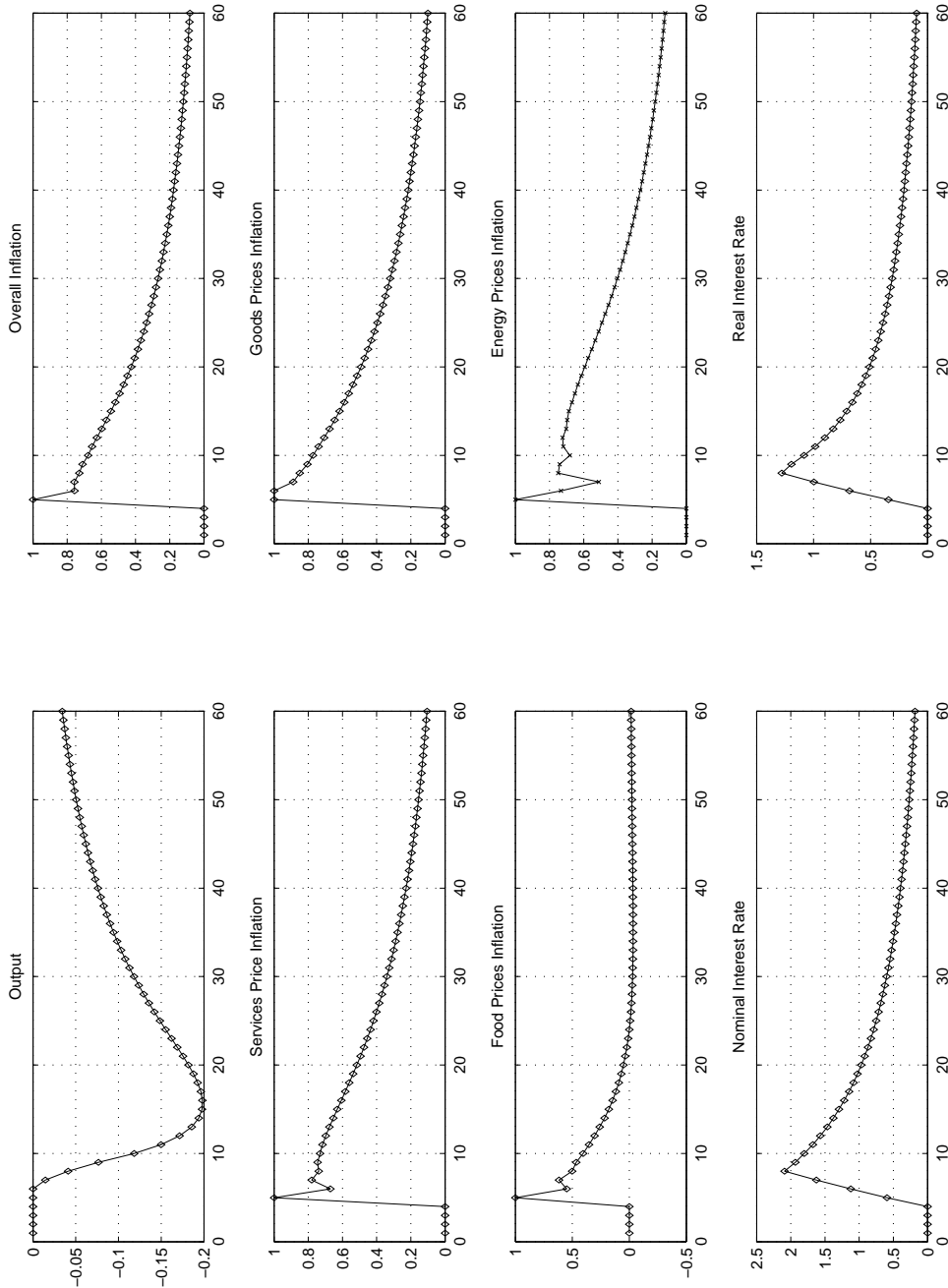


Figure 16: Euro Area, Overall Price shock

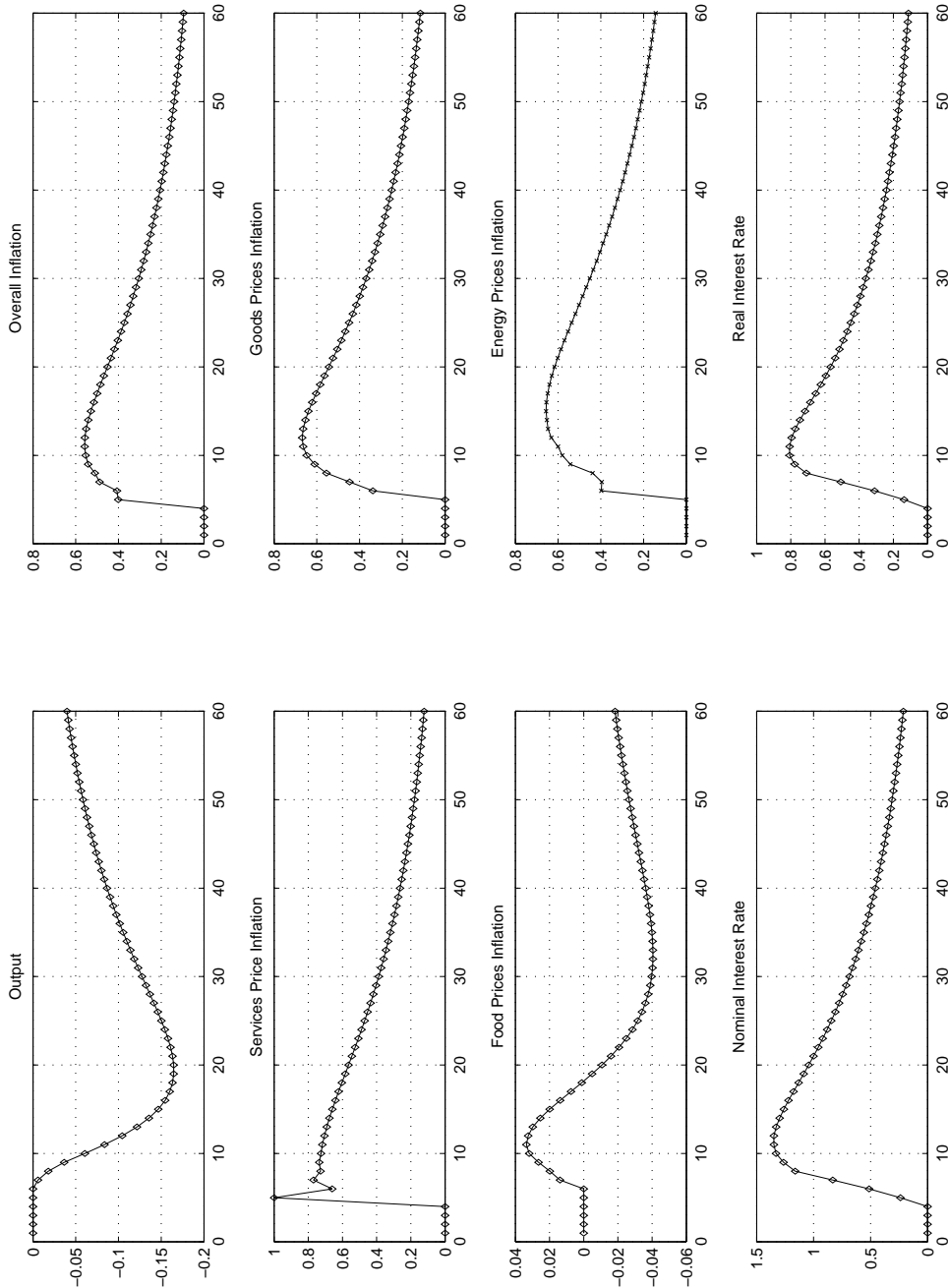


Figure 17: Euro Area, Services Price shock

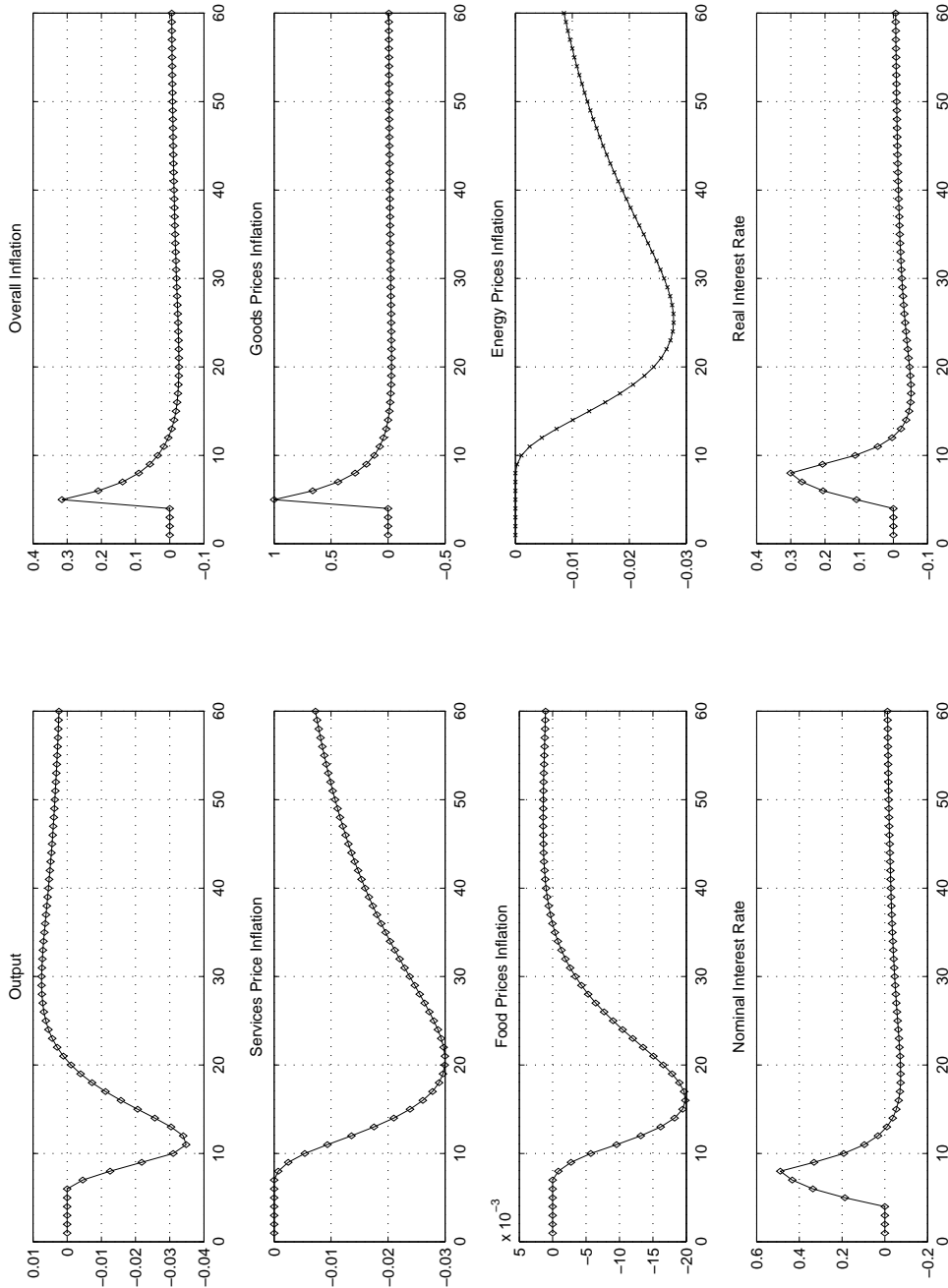


Figure 18: Euro Area, Goods Price shock

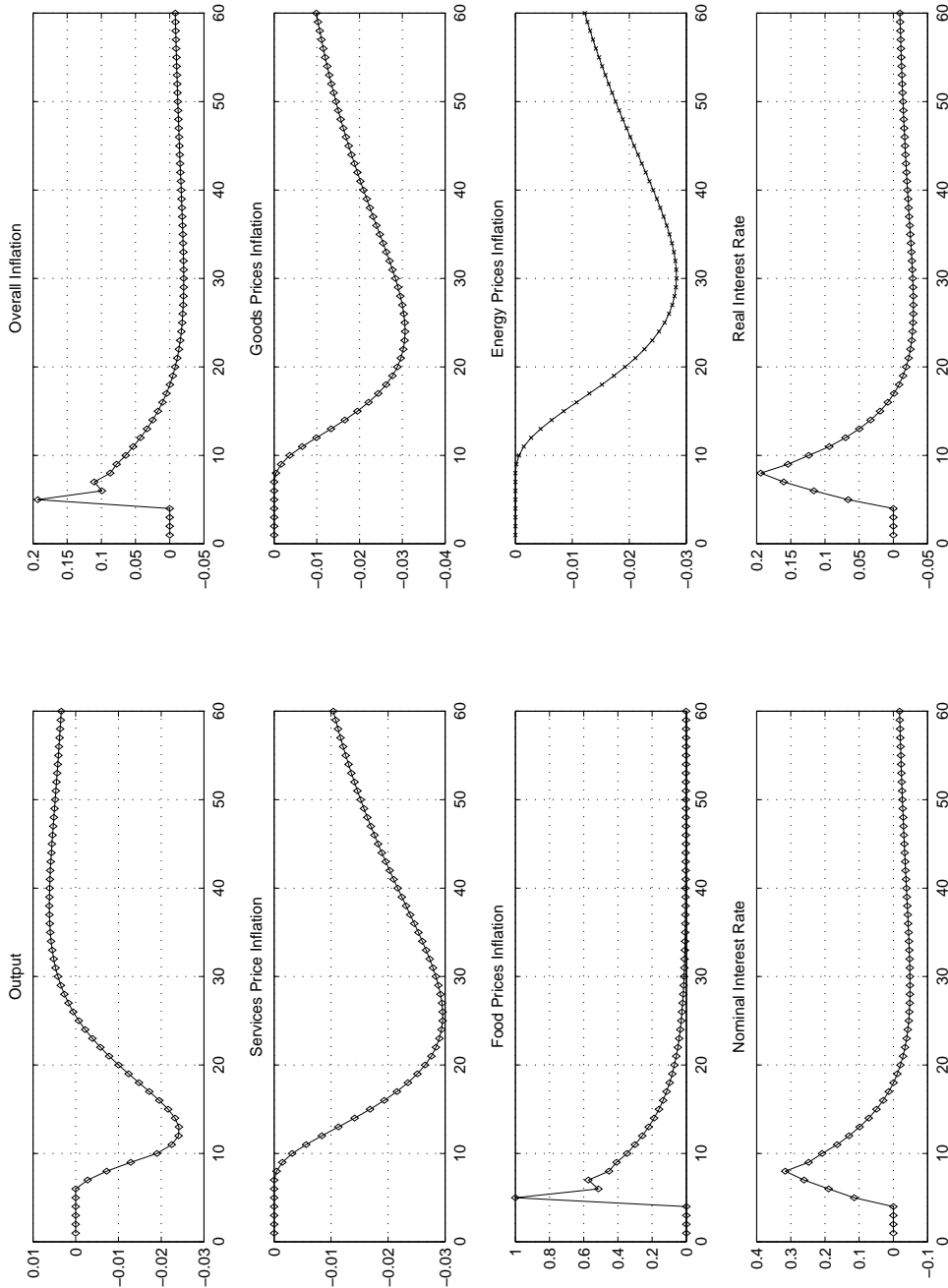


Figure 19: Euro Area, Foods Price shock

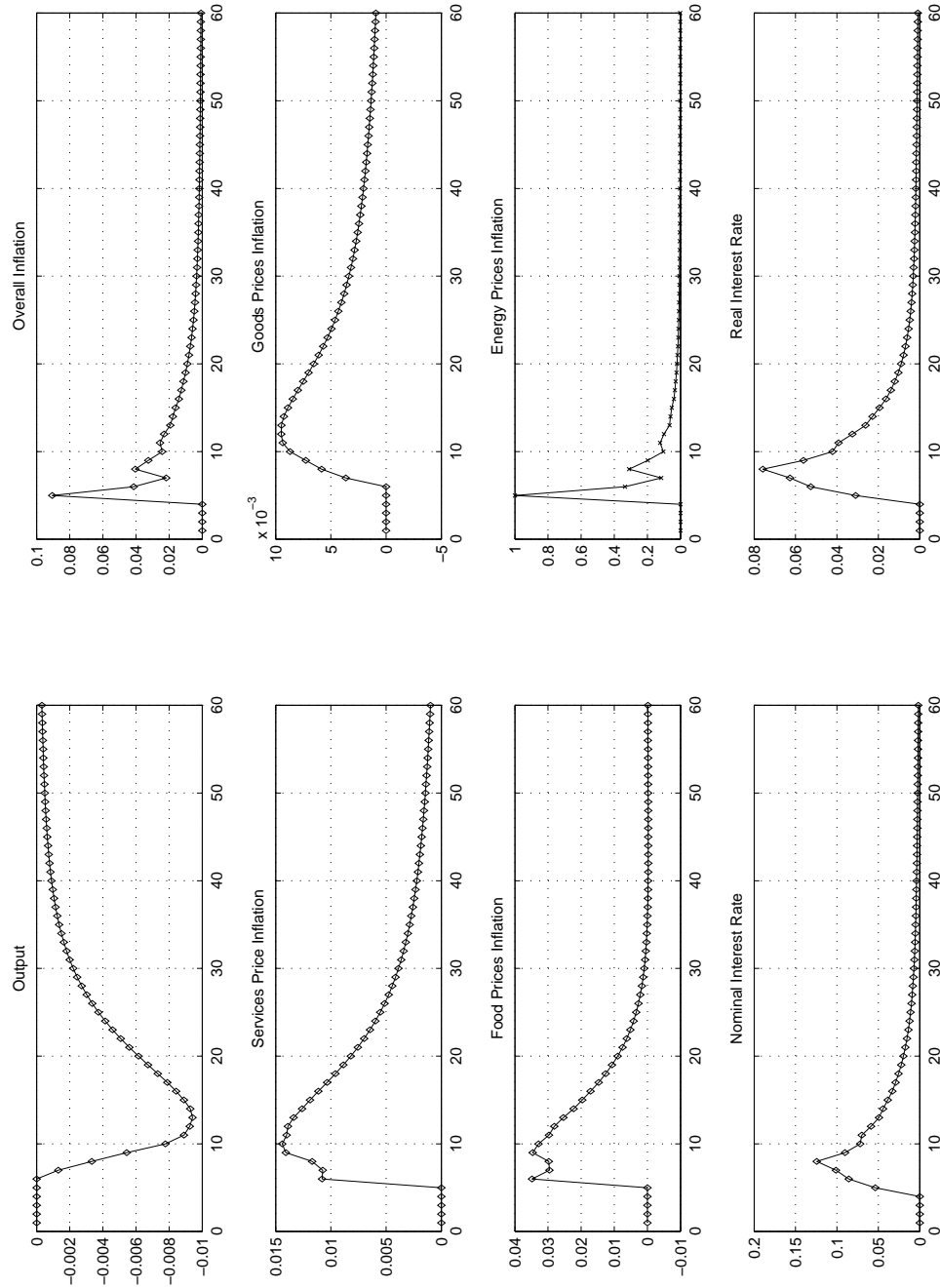


Figure 20: Euro Area, Energy Price shock

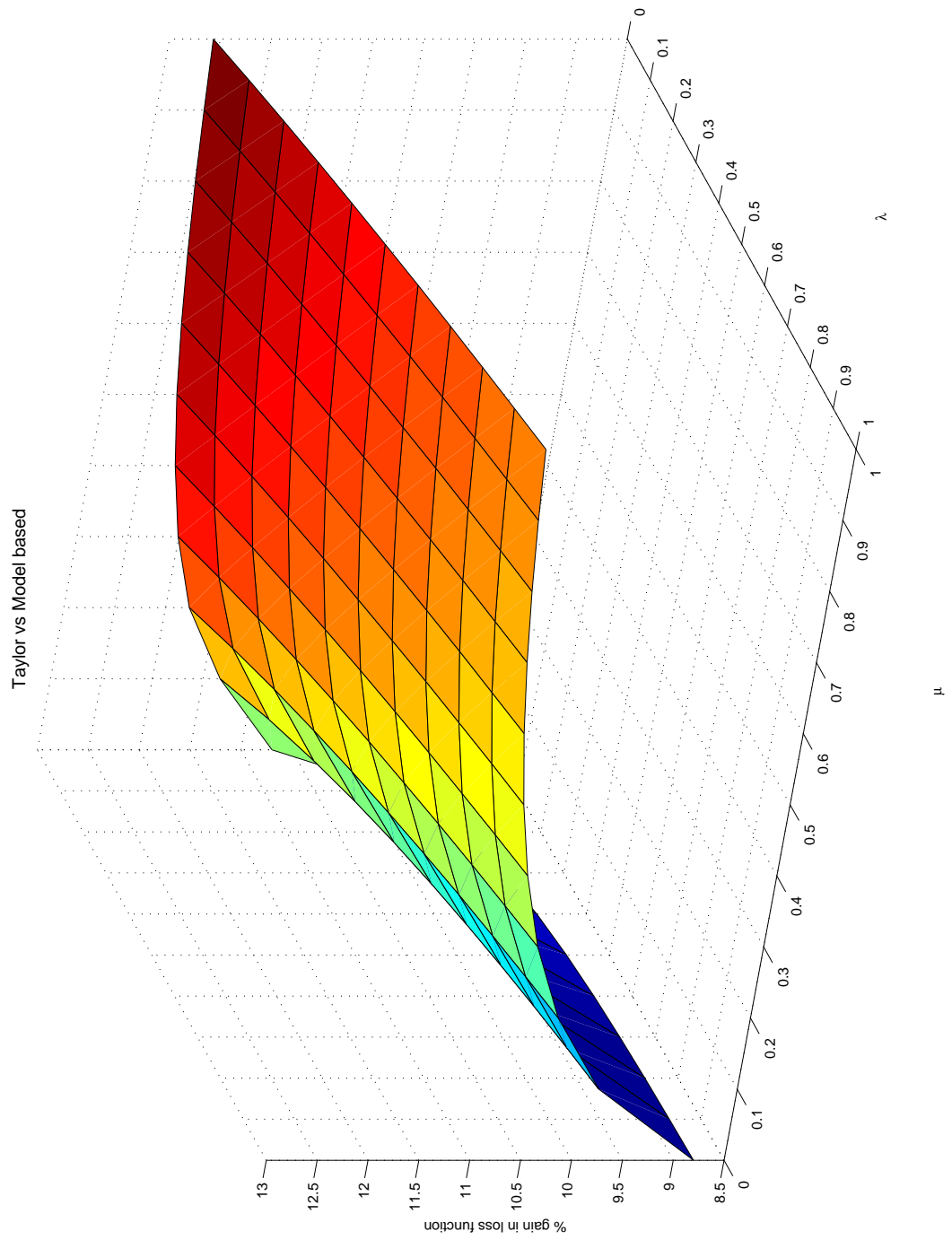


Figure 21: Euro Area, Relative Performance: Standard vs Model Based

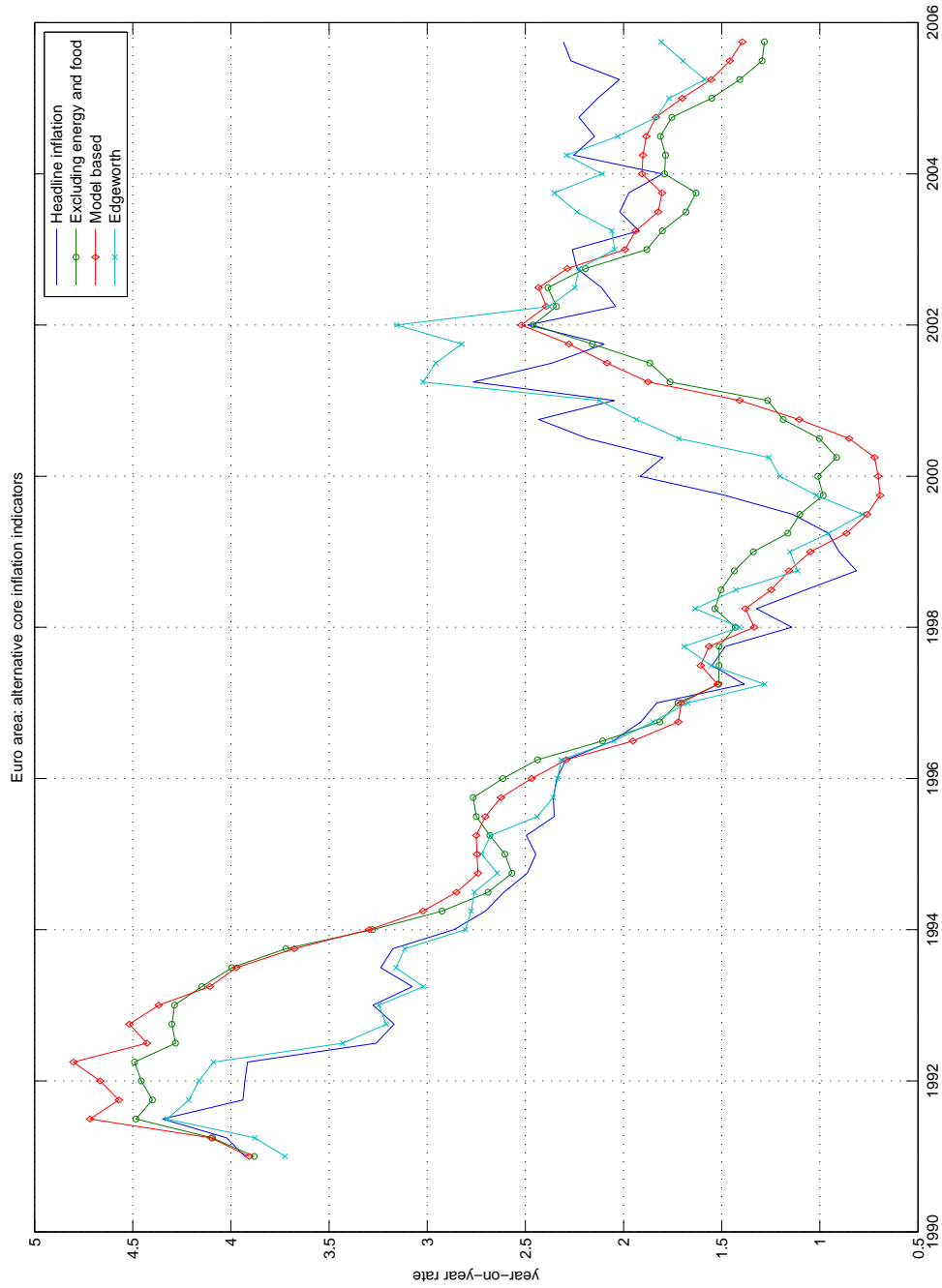


Figure 22: Euro Area: alternative core inflation indicators

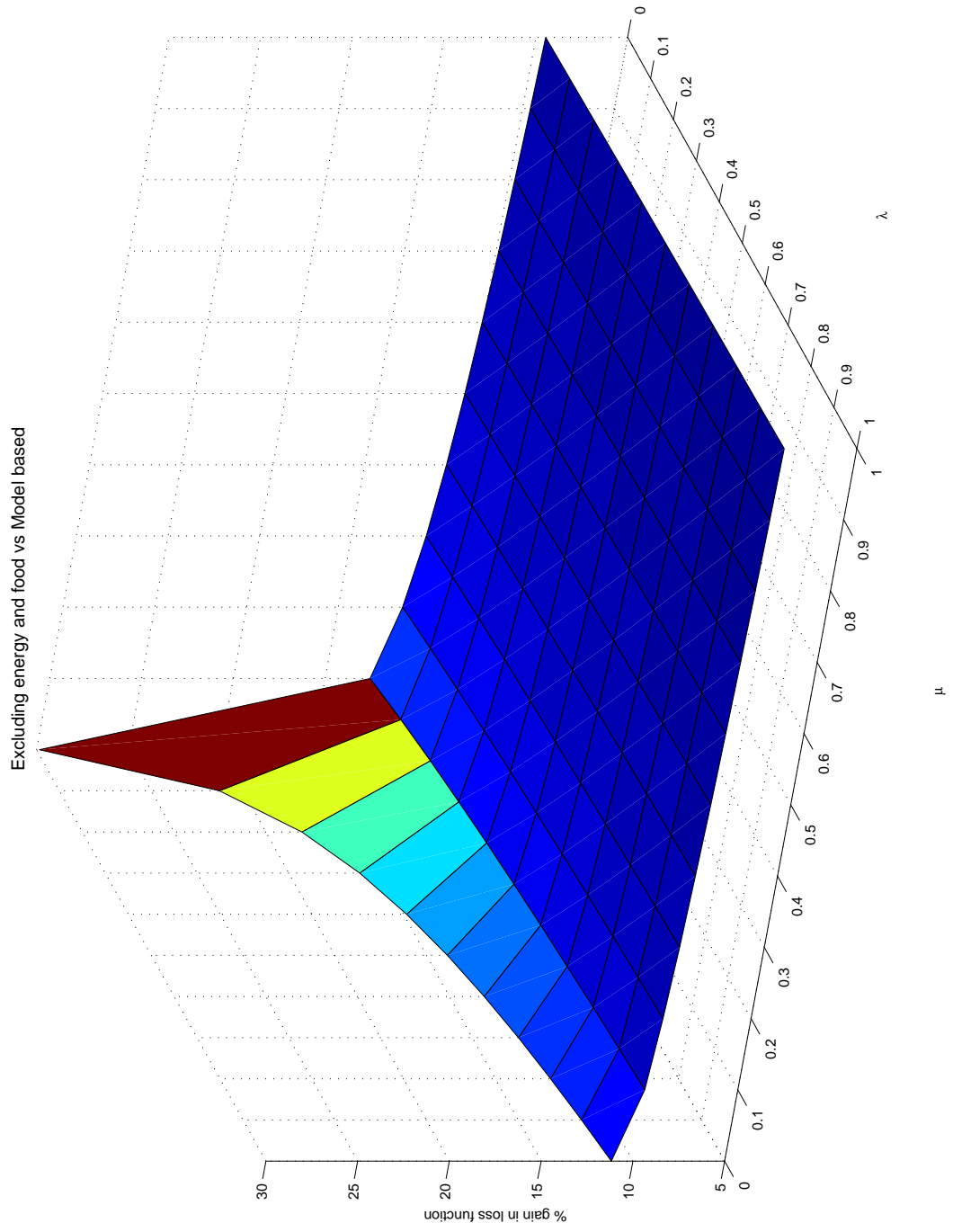


Figure 23: Euro Area, Relative Performance: Excluding Energy and Food vs Model Based

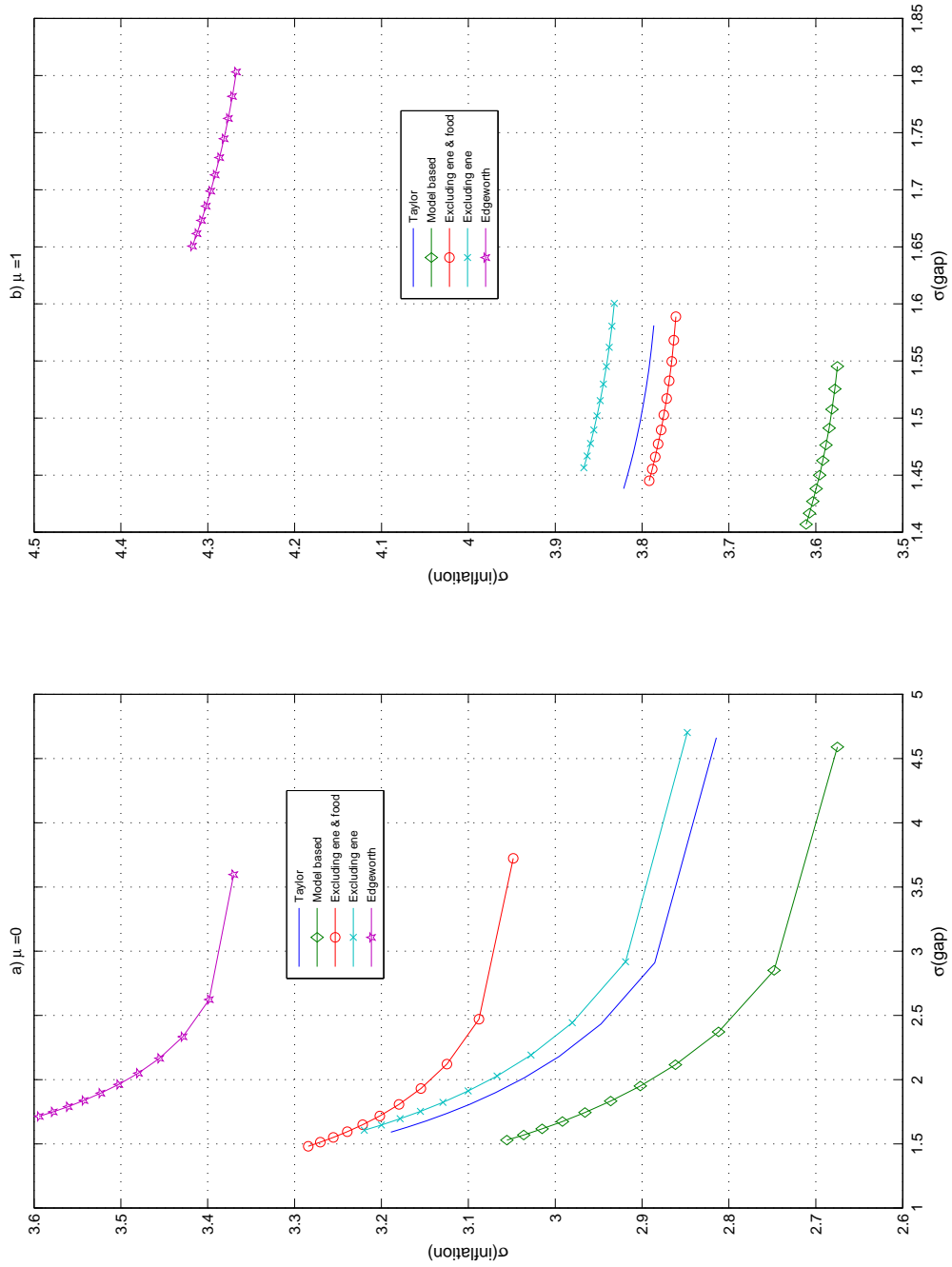


Figure 24: Euro area, Inflation - Output Gap optimal frontiers

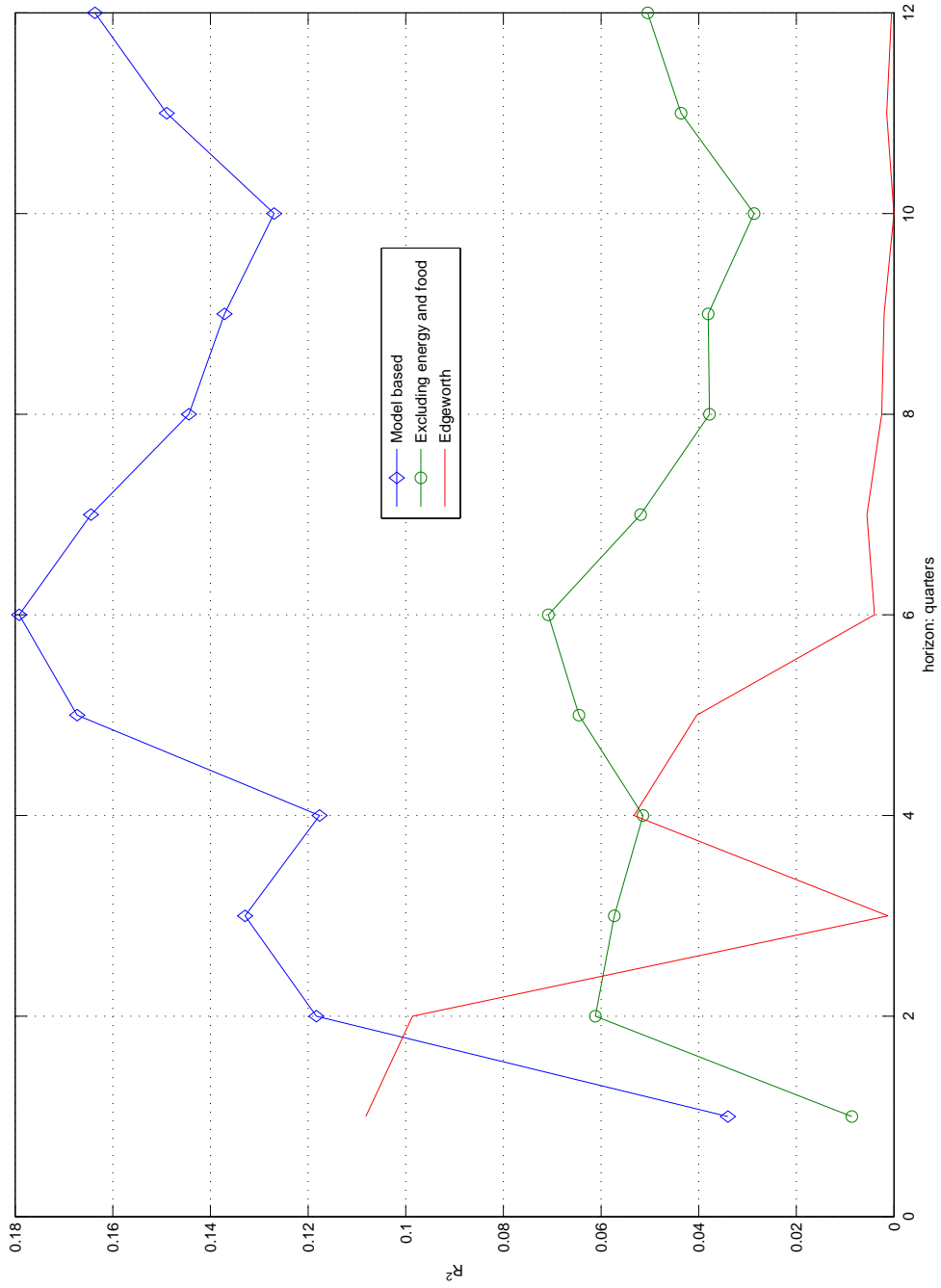


Figure 25: Euro area, Forecast Performance of different core inflation measures

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