Sticky Information Models in Dynare *

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Abstract

Macroeconomic models with sticky information include an infinite number of lagged expectations. Several authors have developed specialized solutions algorithms to solve these models under rational expectations. We demonstrate that it is also possible to implement this class of models in Dynare – a widely used software package for solving dynamic stochastic general equilibrium (DSGE) models. Using the Dynare macro language one can easily construct and change the required large number of lagged expectation terms. We assess the accuracy of simulations run with different truncation points for the lagged expectations terms and find that the solution is reasonably precise even for moderate truncation points.

Keywords: sticky information, Dynare, macro-processor, lagged expectations

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1 Introduction

This paper illustrates how Dynare can be used to solve and simulate rational expectations models with lagged expectations. In particular, this work might be of interest to economists interested in implementing sticky information models *à la* Mankiw and Reis (2002) in Dynare. Sticky information models have been developed as an alternative to the widely used Calvo sticky price framework. Agents update their information set infrequently and therefore adjust their decisions with a delay to the occurrence of shocks. These models have a number of interesting implications. First, they can generate hump-shaped and delayed inflation reactions in response to monetary policy shocks. Second, in contrast to the standard New Keynesian model announced and credible disinflations require a decrease in real economic activity. Finally, the change in inflation is positively correlated with the level of economic activity.

While these models are appealing from an economic point of view, they introduce a number of technical difficulties. Sticky information models include infinite sums of lagged expectations terms. Mankiw and Reis (2007) have developed an algorithm that uses a method of undetermined coefficients and exploits the recursiveness of the model's dynamics to efficiently solve this class of models. Wang and Wen (2006) transform variables with lagged expectations into their forecast errors and can thus keep the model's state space at its minimum. The most general algorithm has been developed in Meyer-Gohde (2010). His solution method combines a state-space and an infinite-MA representations with a simple system of linear equations. The method is more general and faster than the original algorithm by Mankiw and Reis (2007). Most closely related to our approach is the strategy pursued in Trabandt (2007). He approximates the infinite state space with a finite state space by truncating the number of lagged expectations. He starts with a minimal number of lagged expectations terms and adds sequentially more terms until the coefficients of the recursive equilibrium law of motion change by less than a prespecified tolerance.

We use Dynare, which is probably the most widely used software package for applied work with DSGE models, to solve sticky information models. We approximate the infinite state space with a finite version by truncating the lagged expectation terms. We show that the solution to the models by Mankiw and Reis (2002) and Reis (2009) is reasonably precise for a moderate number of lagged expectation terms. We demonstrate how the Dynare macro language can be used to quickly adjust the truncation point. Dynare requires more time to solve the model than the more specialized algorithms mentioned above. While for example the algorithm in Mankiw and Reis (2007) takes less than a second on a standard computer, the implementation in Dynare takes about 20 seconds due to the increased state space. However, 20 seconds is still a feasible amount of time for simulating models as well as for analysing different policy scenarios or computing optimal policy. Tools to conduct such analysis are already contained in the Dynare software package and can be used directly. Another advantage of using Dynare is that models can be simulated with higher order approximations, which is not possible with the specialized solution algorithms discussed above. Regarding the estimation of sticky information models, for maximum likelihood estimation and Bayesian estimation – where a model needs to be solved many times to simulate the posterior distribution – researchers will need to use a more specialized software package, such as the one developed by Meyer-Gohde (2010). For estimation, it is necessary to compute the ergodic variance to initialize the Kalman filter. This is actually one of the most time consuming parts using Dynare, and it makes estimation of sticky information models with Dynare unfeasible.

The remainder of the paper is organized as follows. Section 2 introduces the sticky information Phillips curve from the Reis (2009) sticky information general equilibrium model. Section 3 shows how to implement this equation in Dynare. In section 4 we analyse the accuracy and computational times of simulations computed with Dynare. Section 5 concludes. Appendix A provides a short description of the model equations of Reis (2009). Appendix B lists the Dynare and Matlab files that can be used to reproduce the results in this paper. These files are provided in the *SImodels.zip* file available on the authors' and Ricardo Reis' websites.

2 The sticky information Phillips curve

The general equilibrium model by Reis (2009) is an extension of the Mankiw and Reis (2002) partial equilibrium sticky information model. Here we briefly introduce the sticky information Phillips curve. A version of this equation is included in both models and features an infinite number of lagged expectation terms.[1]

The sticky information Phillips curve is given by:

$$p_t = \lambda \sum_{i=0}^{\infty} (1-\lambda)^i \, \mathbf{E_{t-i}} \left\{ p_t + \frac{\beta\,(w_t - p_t) + (1-\beta)\, y_t - a_t}{\beta + \nu\,(1-\beta)} - \frac{\beta}{(\nu - 1)\,[\beta + \nu\,(1-\beta)]} v_t \right\} \ . \tag{1}$$

The price level (p_t) depends on *past expectations* of its current value, real marginal costs and desired markups. Marginal costs increase in real wages paid to workers ($w_t - p_t$) and in the amount of goods produced (y_t) because of decreasing returns to scale ($\beta < 1$), while an increase in aggregate productivity (a_t) decreases marginal costs. The desired markups fall with the elasticity of substitution across goods varieties (v_t), which varies randomly over time (ν is the steady-state elasticity of substitution for goods). The key parameter in the sticky information Phillips curve is λ. While all firms can adjust prices in each period, not all firms have up-to-date information about the state of the economy. In particular, in each period only a fraction λ of firms update their information set and make new plans, while the remaining firms continue to set prices based on old plans and outdated information. This model thus predicts that information about economic conditions disseminates slowly through the economy.

The other key equations of Reis (2009) are an IS curve and a wage equation with similar lagged expectation terms, a standard production function and a Taylor rule. These equations link inflation, output, wages, the interest rate and hours worked to exogenous shocks to aggregate productivity growth, aggregate demand,

[1] While it is possible to implement models in Dynare in nonlinear form and let Dynare derive a first, second or higher order approximations to the solution, we stick here to the linearized sticky information Phillips curve as it is difficult in this particular model to eliminate firm-specific variables from the profit maximization first-order conditions without linearizing some terms beforehand.

goods markups, labor markups and monetary policy. Each of these shocks follows an $AR(1)$ process with independent and normally distributed innovations.

3 Sticky information in Dynare

In this section we show how to implement the sticky information Phillips curve in Dynare. The method also applies to the infinite number of lagged expectations terms in the IS curve (A.3) and the wage equation (A.4). To implement the sticky information Phillips curve in Dynare it is necessary to define additional state variables. It is not possible to replace the infinite sum in equation (1) by recursive equations as it is the case in the standard Calvo price and wage Phillips curves. Here, we need instead to take into account information sets, *i.e.* the economic state, at different points in time and create additional state variables – the lagged expectation terms – that are not predetermined, but must be solved for in equilibrium.

3.1 Lagged expectations

Consider a generic variable z_t, and let $\left\{z_{t|t-\tau} = E_{t-\tau}[z_t]\right\}_{\tau=1}^{T}$, $T \to +\infty$, denote the sequence of lagged expectations of z_t. Since Dynare version 4.1, the implementation of variables with lagged expectations can be easily done with an expectation operator using the following notation: EXPECTATION(period of the information set)(period that expectations are formed for). For example, if we want to implement $z_{t|t-3} = E_{t-3}[z_t]$, we just have to write EXPECTATION$(-3)(z)$.

Therefore, let z_t be the term in curly brackets in equation (1):

$$z_t = p_t + \frac{\beta(w_t - p_t) + (1-\beta) y_t - a_t}{\beta + \nu(1-\beta)} - \frac{\beta}{(\nu-1)[\beta + \nu(1-\beta)]} v_t \ . \tag{2}$$

Using lagged expectation terms, we can rewrite the sticky information Phillips curve (1) as:

$$p_t = \lambda\left[z_t + (1-\lambda) z_{t|t-1} + (1-\lambda)^2 z_{t|t-2} + (1-\lambda)^3 z_{t|t-3} + \cdots + (1-\lambda)^{\infty} z_{t|t-\infty}\right] \tag{3}$$

or, in Dynare syntax using the EXPECTATION operator, as:

$$\begin{aligned} p = \lambda\,[z &+ (1-\lambda)\,EXPECTATION\,(-1)\,z + \\ &+ (1-\lambda)^2\,EXPECTATION\,(-2)\,z + \cdots + (1-\lambda)^{\infty}\,EXPECTATION\,(-\infty)\,z\Big] \ . \end{aligned} \tag{4}$$

Note that equations (3) and (4) contain an infinite number of lagged expectations. Therefore, implementing these in Dynare entails a truncation of the number of lagged expectations included in the model, that is, $T < \infty$ so that $z_{t|t-\infty}$ will be replaced by $z_{t|t-T}$. As we will show in section 4, the choice of the truncation point T has noticeable effects on the the computational time required to solve the model.

The procedure outlined above can be used for other models with a small number of lagged expectation terms (*e.g.* the labor hoarding model of Burnside and Rebelo, 1993), or models that use lagged expectation to get the same timing as in a recursively identified VAR to run a minimum distance estimation (*e.g.* Christiano et al., 2005 or Cwik et al., 2011). As explained in the following section, for models with a large number of lagged expectation terms, the Dynare macro language can be used to easily define the required additional expression.

3.2 Macro-processor

The truncation point T determines the number of variables and equations of the model. Whenever one changes the value of T, one needs to manually add or delete variables in the *variable declaration block* of the *.mod* file and also needs to modify the Phillips curve equation in the *model block* of the *.mod* file. Using instead the Dynare macro-processor allows to do these tasks automatically. The procedure is as follows.

First, at the beginning of the *.mod* file, we add the following line of code:

```
@#define lags = [ 1 : T ]
```

where $1 \leq T < \infty$ represents the value of the truncation point. This generates a vector lags $= [1, 2, ..., T]$ that is used afterwards as a loop-counter. The only part of the code that might need to be adjusted after the first implementation is the truncation point T.[2]

Second, in the *model block*, we explicitly write equation (2):

```
z = p + (beta*(w-p) + (1-beta)*y - a)/(beta+nu*(1-beta))
        - beta*nuu/((nu-1)*(beta+nu*(1-beta)));
```

Finally, in the *model block*, we write the Phillips curve as:

```
p = lambda*( z +
    @#for lag in lags
        +(1-lambda)^(@{lag})*EXPECTATION(@{-lag})z
    @#endfor );
```

This generates the Phillips curve (4).

[2] A few papers using sticky information models include Andres et al. (2005), Paustian and Pytlarczyk (2006), Wang and Wen (2006), Keen (2007), Trabandt (2007), Meyer-Gohde (2010) and Verona (2011). They consider a truncation point ranging from 3 (Andres et al., 2005) to 252 (Meyer-Gohde, 2010).

4 Results

This section compares the accuracy of simulations and computational times in Dynare with the original results of Mankiw and Reis (2002) and Reis (2009).[3]

Table 1 shows the computational time that Dynare needs to solve the models for three different truncation points ($T = 16$, 24 and 32). As shown in Panel A, solving the Mankiw and Reis (2002) partial equilibrium model takes only a few seconds . More interesting are the results, shown in Panel B, for the Reis (2009) general equilibrium model. While it takes less than 1 second to solve the general equilibrium model using the Mankiw and Reis algorithm, Dynare needs 14 seconds to run the code when 16 lagged expectations are considered. By defining additional lagged expectations terms many equations are added in comparison to the original code. For example, for the version with a truncation point of $T = 16$ the model implemented in Dynare consists of 571 equations. The total computation time increases a lot more when improving the accuracy by increasing T from 16 to 32 as the number of equations increases to 1795. Accordingly, it takes about 19 minutes to run a version of the model with a truncation point of $T = 32$.

However, these numbers are exaggerated because they measure the time for computing the solution as well as various additional statistics, rather then the solution only. In fact, Dynare spends most of the time in solving Lyapunov equations to compute the ergodic variances needed for the variance decomposition. In case of $T = 32$ the amount of time spent on the variance decomposition accounts for 91% of the total computation time. Leaving out the computation of the variance decomposition reduces the computation time from 19 minutes to 100 seconds for a truncation point of $T = 32$ as reported in the last column of table 1. The computation times using Dynare are much higher than using the original solution algorithm of Mankiw and Reis. However, they are still in a range that they are sufficiently short to conduct simulations or the computation of optimal policy. Only estimation of sticky information models is unfeasible with Dynare as the computation of the ergodic variance is needed to initialize the Kalman filter. Even a computation time of 14 seconds (when $T = 16$) will be too long as the model needs to be solved many times to compute the posterior distribution of parameters when using Bayesian estimation.

We then evaluate the accuracy of simulations conducted with sticky information models by reporting differences of impulse responses between the solution method proposed here and the original solution method by Mankiw and Reis (2002). Before turning to an exact quantification of the accuracy, we start with a visual assessment. Figure 1 shows the impulse responses (Reis's codes: crossed lines; Dynare: circled lines) of four variables (inflation, nominal interest rate, hours worked and output gap) to one-standard-deviation impulses to the five shocks (productivity, demand, goods markups, labor markups and monetary policy) in the Reis (2009) general equilibrium model.[4] The impulse responses are reported for two different truncation values, $T = 16$ (top panel) and 24 (bottom panel) quarters. With only two exceptions, when $T = 16$ the impulse

[3] The original codes of Mankiw and Reis (2002) and Reis (2009) are publicly available from Reis' website: http://www.columbia.edu/~rr2572/

[4] The parameters are set at the maximum-likelihood estimates in Reis (2009, table 2).

responses are mostly overlapped. The exceptions are the impulse responses of inflation and the nominal interest rate to a productivity shock. However, extending the truncation point T from 16 to 24 quarters results in a better fit and differences between impulse responses computed with Dynare and the Mankiw and Reis algorithm cannot visually be detected anymore.

To give an exact quantification of the accuracy of simulations, we follow the approach proposed by Golub and van Loan (1989) and applied by Meyer-Gohde (2010) to sticky information models. We compute the Euclidian norm of differences in impulse response functions computed with Dynare and the Mankiw and Reis algorithm. Using the Euclidian norm one can quantify small differences in impulse response functions that are difficult to visualize in the previous graphs. Figure 2 shows the relative error of the Dynare solution for different truncation points. The Euclidian norm is computed for the impulse responses for a horizon of up to 32 periods. We report Euclidian norms jointly for inflation, the output gap, hours worked and the short term interest rate. Euclidian norms of impulse response functions for single shocks and for all shocks together (labelled 'total') are reported. The vertical axis shows the Euclidian norm on a log scale, while the horizontal axis indicates the three different truncation points ($T = 16$, 24 and 32).

The results show strong differences in the accuracy of simulating responses to different shocks. For the monetary and the goods markups shocks, a truncation of $T = 16$ is sufficient and a larger number of lagged expectation terms does not reduce the approximation error much further. The relative error for the labor markups is larger for $T = 16$ and can be reduced significantly when increasing the number of lags to $T = 32$. Interestingly, the approximation errors for the demand and especially the productivity shock are much larger. This is because these shocks are very persistent (the autocorrelation parameters of the shock processes are close to one), so it takes many periods to return to the steady state and the approximation error accumulate accordingly. Increasing the number of lagged expectation terms leads to a significant reduction of the relative error. The approximation with $T = 32$ is 20 times more accurate than for $T = 16$ for the productivity shock and still about 5 times more accurate for the demand shock.[5]

To judge whether the approximation error is statistically and economically significant, we exploit that the general equilibrium model by Reis (2009) has been empirically estimated using Bayesian estimation, so that there is uncertainty regarding the parameter values. We focus on the impulse responses of inflation to a productivity and demand shock as these are the ones where the Dynare implementation produces the largest deviations from the original impulse responses in Reis (2009). Using the original code by Ricardo Reis, we take 10000 independent draws from the posterior distribution of the model parameters, simulate the model and compute the posterior distribution of the impulse response functions. By comparing these statistics to the impulse response simulated using Dynare we can judge whether the approximation error of the solution algorithm is of less, similar or more importance for simulations and policy analysis than the empirical uncertainty about parameter estimates.[6]

[5] We have to point out that Meyer-Gohde (2010)'s method is much more accurate than the method described in this paper.

[6] Another measure of the accuracy of numerical solutions of rational expectation models is the Euler equation error as proposed by Judd (1992). Using this approach one can measure the size of the approximation errors in terms of consumption.

Figures 3 and 4 show the mean, median and 90% confidence band of the posterior distribution of impulse responses. The red and blue line show the impulse responses computed with Dynare using truncation points of $T = 24$ and $T = 32$. One can see that the Dynare impulse responses are close to the mean and median estimates of the Mankiw and Reis algorithm for both truncation points, and lie clearly within the 90% confidence band. Therefore, parameter uncertainty plays a much larger role for the accuracy of simulations than whether one uses the solution algorithm by Mankiw and Reis or the Dynare solution algorithm. In fact, the point estimates of the impulse responses for both solution algorithms are very close together and are far away from the boundaries of the confidence band. Thus, for the accuracy and economic interpretation of policy simulations, it hardly matters whether Dynare or the original codes are used.

5 Concluding remarks

In this paper we have illustrated how Dynare can be used to solve and simulate rational expectations models with a large number of lagged expectations terms. The results suggest that moderate truncation points of the lagged expectations are sufficient to obtain an accurate solution for sticky information models and a clear picture of these models' dynamics. The deviations of simulated paths of variables using Dynare compared to the usage of the original codes is negligible in comparison to uncertainty about simulation results stemming from parameter uncertainty. The size of the approximation error depends on both the truncation point and the shock that hits the economy. Solving the model with Dynare takes much longer than with the original code – the definition of lagged expectations increases the number of state variables considerably – but 20 seconds is a sufficiently low time amount to run simulations with Dynare.

In spite of requiring longer computational times, we think it is interesting to implement sticky information models in Dynare since it will only take a few moments to adapt the *.mod* code and use it for various further analysis. For instance, running policy simulations and computing optimal policy are tasks that can be easily done by using Dynare. Furthermore, the implementation outlined in this paper is the only one that can be used for higher order approximations, while the more specialized solution algorithms discussed in the introduction can only handle linear models.

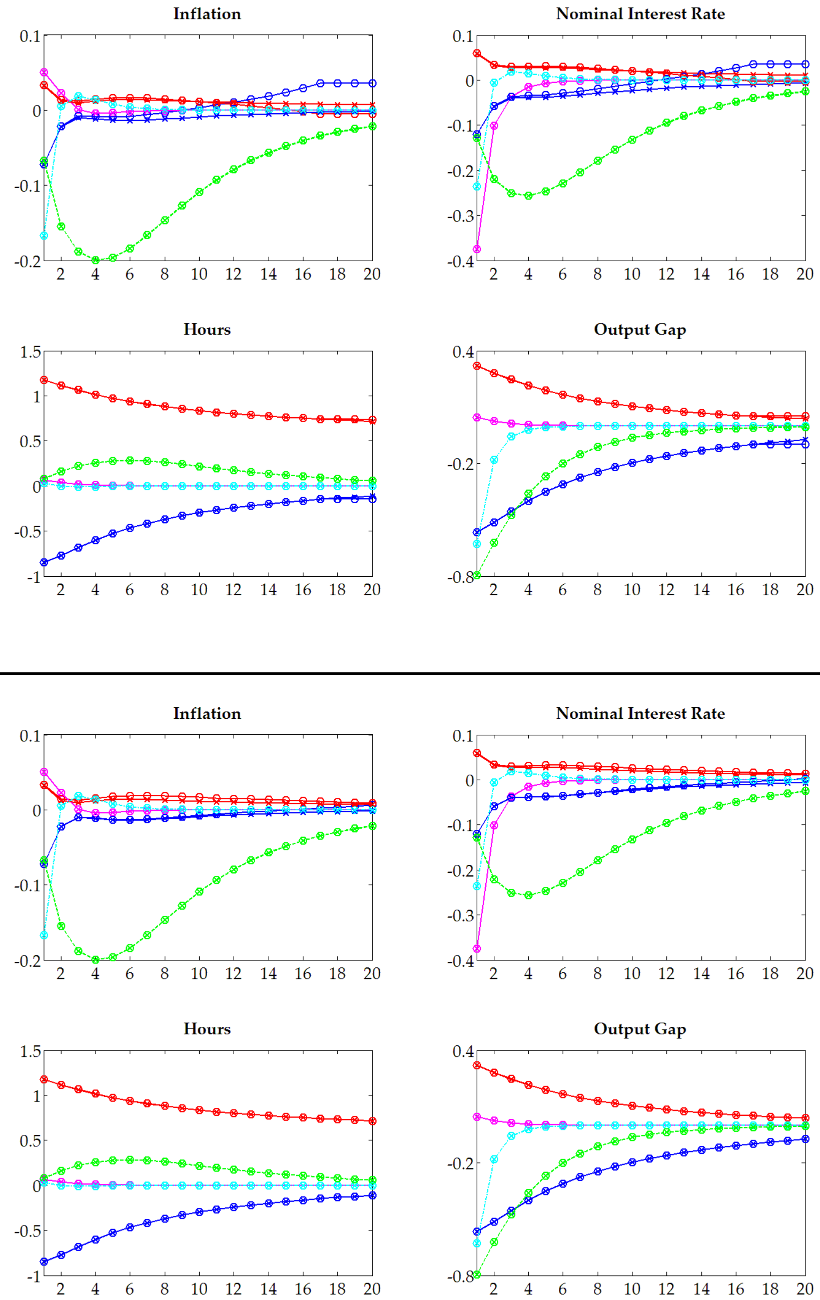
However, this methods requires an evaluation of the Euler equation using the policy functions from the model solution for a grid of the state variables. The approach outlined in the previous section leads to an extremely large number of additional state variables so that the computation of Euler equation errors would require the evaluation of policy functions over a high dimensional grid of state variables, which is not feasible.

Table 1: computational times

Model	**Lags**	**# equations**	**Dynare**	**Dynare (no var. dec.)**
	(T)		total computing time [a]	total computing time [a,b]
PANEL A				
Mankiw and Reis (2002)	16	157	2	1
	24	329	4	2
	32	565	19	5
PANEL B				
Reis (2009)	16	571	14	4
	24	1087	171	20
	32	1795	1140	100

Notes. The simulations have been conducted using Dynare version 4.3.2 and Matlab version 8.0.0.783 (R2012b) on a computer with an Intel(R) Core(TM) i7-2600 CPU working at 3.40 GHz and with 8GB of RAM. [a] Total computing time (seconds) as reported by Dynare. [b] These results have been obtained by using the option "*nomoments*" in *stoch_simul*.

Figure 1: Impulse response functions - Reis (2009) model



Note. Impulse response functions (Reis' codes: crossed lines; Dynare: circled lines) to a productivity shock (blue), demand shock (red), goods markups shock (cyan), labor markups shock (green) and monetary policy shock (magenta). Top panel: $T = 16$; bottom panel: $T = 24$. Horizontal axis: quarters. Vertical axis: percentage deviation from the steady state.

Figure 2: Simulation accuracy and truncation points

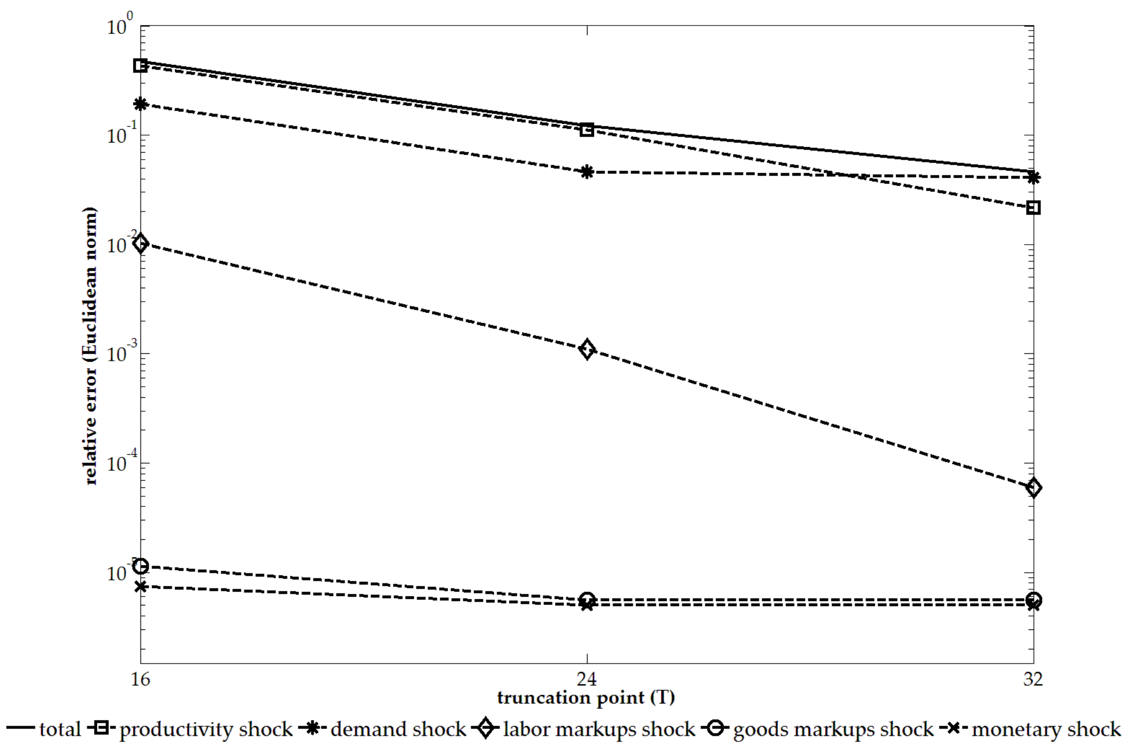


Figure 3: Impulse responses of inflation to a productivity shock

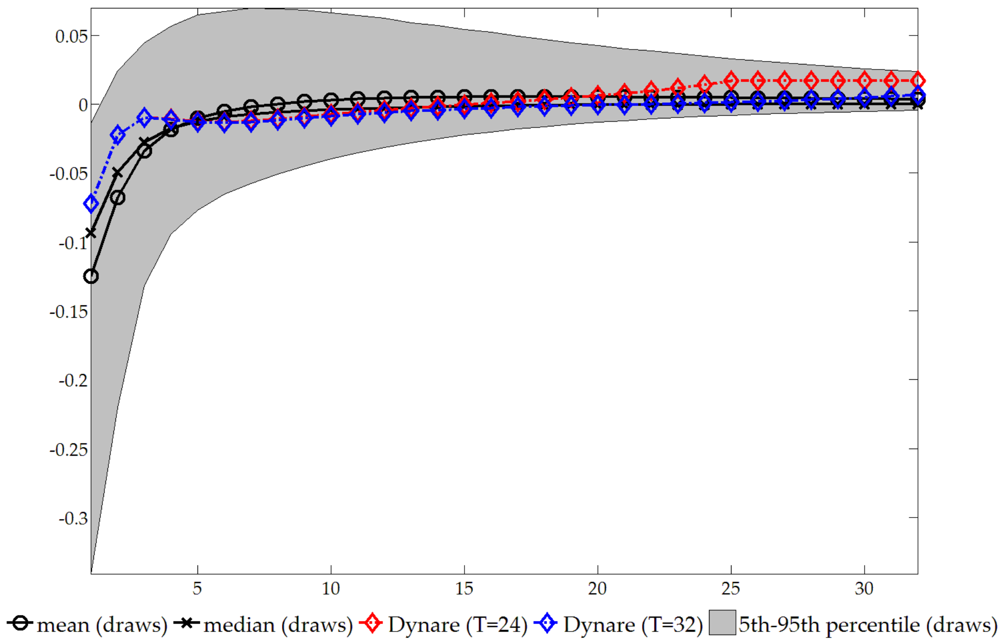
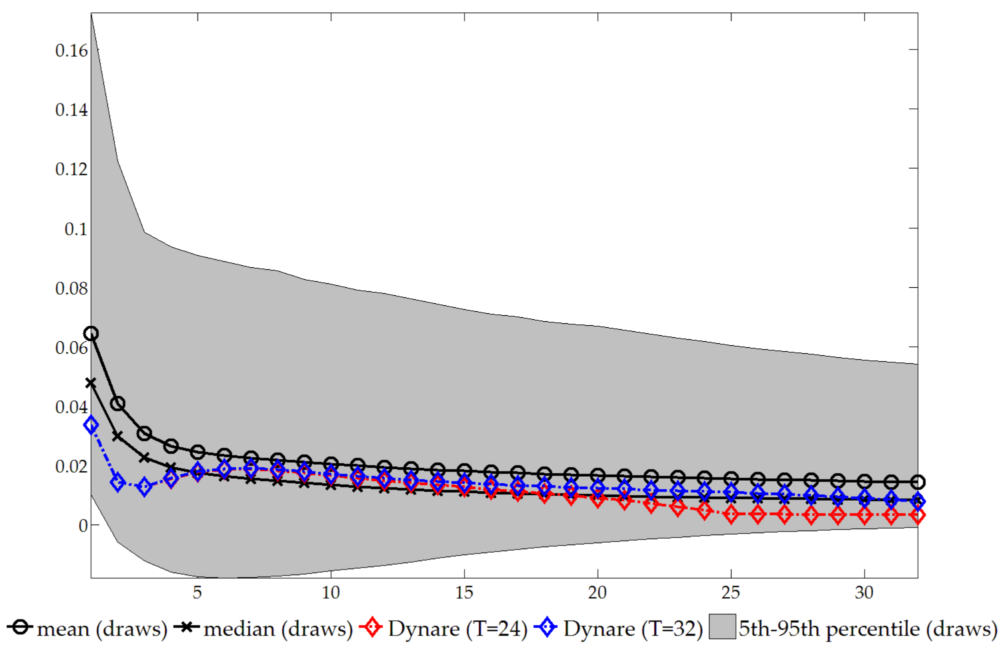


Figure 4: Impulse responses of inflation to a demand shock



Appendix A - Core equations of the general equilibrium sticky information model

The Reis (2009) model is an extension of the Mankiw and Reis (2002) partial equilibrium sticky information model to a general equilibrium framework. Here we briefly introduce the five key relations of this model.[7]

First, the production function relates total output (y_t) to a productivity shock (a_t) and hours worked (l_t):

$$y_t = a_t + \beta l_t \ , \tag{A.1}$$

where $\beta < 1$ measures the extent of decreasing returns to scale.

Second, the sticky information Phillips curve is given by:

$$p_t = \lambda \sum_{i=0}^{\infty} (1-\lambda)^i \, \mathbf{E_{t-i}} \left\{ p_t + \frac{\beta\,(w_t - p_t) + (1-\beta)\,y_t - a_t}{\beta + \nu\,(1-\beta)} - \frac{\beta}{(\nu - 1)\,[\beta + \nu\,(1-\beta)]} v_t \right\} \ . \tag{A.2}$$

The price level (p_t) depends on past expectations of its current value, real marginal costs and desired markups. Marginal costs increase in real wages paid to workers ($w_t - p_t$) and in the amount of goods produced because of decreasing returns to scale, while an increase in aggregate productivity decreases marginal costs. The desired markups fall with the elasticity of substitution across goods varieties (v_t), which varies randomly over time (ν is the steady-state elasticity of substitution for goods). A key parameter in the sticky information Phillips curve is λ. While all firms can adjust prices in each period, not all firms have up-to-date information about the state of the economy. In particular, in each period only a fraction λ of firms does update its information set and make new plans, while the remaining firms continue to set prices based on old plans and outdated information. This model thus predicts that information about economic conditions disseminates slowly through the economy.

The third equation is the sticky information IS curve:

$$y_t = \delta \sum_{j=0}^{\infty} (1-\delta)^j \, \mathbf{E_{t-j}} \left[y_\infty^c - \theta R_t \right] + g_t \ , \tag{A.3}$$

where $R_t = E_t \sum_{j=0}^{\infty} [i_{t+j} - \Delta p_{t+1+j}]$ is the long-term real interest rate (i_t denotes the nominal short-term interest rate), $y_\infty^c = \lim_{i\to\infty} E_t\,(y_{t+i})$ represents a measure of wealth and g_t is an aggregate demand shock. Higher expected future output raises wealth and increases spending, while higher expected interest rates encourage savings and lower spending. The impact of interest rates on spending depends on the intertemporal

[7] The description of the model closely follows Reis (2009, section 2), to which we refer the reader for further details.

elasticity of substitution θ. In each period, only a share δ of consumers updates information and plans, so the larger the value of δ, the larger is the share of informed consumers who respond to shocks immediately.

Fourth, the sticky information wage curve is:

$$w_t = \omega \sum_{k=0}^{\infty} (1-\omega)^k \mathbf{E_{t-k}} \left\{ p_t + \frac{\gamma (w_t - p_t)}{\gamma + \psi} + \frac{l_t}{\gamma + \psi} + \frac{\psi (y_\infty^c - \theta R_t)}{\theta (\gamma + \psi)} - \frac{\psi}{(\gamma + \psi)(\gamma - 1)} \gamma_t \right\} . \tag{A.4}$$

Nominal wages (w_t) increase one-to-one with the price level, since real rather than nominal wages determine real consumption. Higher real wages increase the demand for a worker's variety of labor and thus lead to rising nominal wages. An increase in employment rises nominal wages because the marginal disutility of working rises (ψ is the Frisch elasticity of labor supply). The model features a positive income effect on leisure, so that higher wealth leads to higher nominal wages. An increase in interest rates leads to higher returns on savings and therefore increases the incentives to work in order to save more, which in turn leads to lower nominal wages. Finally, nominal wages decrease with an increasing elasticity of substitution across labor varieties (γ_t), since an increase in the elasticity of substitution leads to lower markups of workers (γ is the steady-state value of γ_t). The higher the share of workers informed, *i.e.* the larger the value of ω, the more responsive wages are to changes in these determinants.

Finally, the Taylor rule is given by:

$$i_t = \phi_p \Delta p_t + \phi_y (y_t - y_t^c) - \varepsilon_t \ , \tag{A.5}$$

where ε_t is a monetary policy shock and

$$y_t^c = a_t + \frac{\beta \psi}{1 + \psi} \left(g_t + \frac{\gamma_t}{\gamma - 1} + \frac{v_t}{\nu - 1} \right)$$

denotes the classical equilibrium level of output if all agents were attentive (that is, if $\lambda = \omega = \delta = 1$), so that they update their information sets in each period.

Equations (A.1)-(A.5) give the equilibrium values for prices, nominal interest rates, output, hours worked and wages. The equations link these five variables to exogenous shocks to aggregate productivity growth (Δa_t), aggregate demand (g_t), goods markups (v_t), labor markups (γ_t) and monetary policy (ε_t). Each of these shocks follows an $AR(1)$ process with coefficients $\rho_{\Delta a}$, ρ_g, ρ_v, ρ_γ and ρ_ε, and is subject to innovations $e_t^{\Delta a}$, e_t^g, e_t^v, e_t^γ and e_t^ε, that are independent and normally distributed with standard deviations $\sigma_{\Delta a}$, σ_g, σ_v, σ_γ and σ_ε.

Appendix B - List of Dynare and Matlab Files

This appendix lists the Dynare and Matlab files used in this paper. All files are contained in the *SImodels.zip* file available on the website where this paper is posted.

Folder QJE:

- *MRQJE.mod* is the Dynare code for solving and simulating Mankiw and Reis (2002)
- *data_IRF_MR_QJE.m* has the impulse response functions computed by Mankiw and Reis (2002)
- *differenceMRQJEAR1.m* plots the impulse response functions to a negative shock to the $AR(1)$ aggregate demand (figure 4 in Mankiw and Reis, 2002 and those resulting from Dynare)
- *differenceMRQJEexp1.m* plots the impulse response functions to a permanent drop in the level of aggregate demand (figure 1 in Mankiw and Reis, 2002 and those resulting from Dynare)

Folder Chile:

- *RRChile.mod* is the Dynare code for solving and simulating Reis (2009)
- *data_IRF_Chile.m* has the impulse response functions computed by Reis (2009)
- *differenceChile.m* plots the impulse response functions to the five shocks (figure 1 in Reis, 2009 and those resulting from Dynare)

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