A DSGE MODEL FROM THE OLD KEYNESIAN ECONOMICS: AN EMPIRICAL INVESTIGATION

PAOLO GELAIN[‡]
Norges Bank
Monetary Policy

MARCO GUERRAZZI[§]
Department of Economics
University of Pisa

Version for the XXVI AIEL Conference
Milan, September 15-16, 2011

Abstract

In this paper we implement DSGE models' diagnostics to a framework built along the lines of Farmer's micro-foundation of the *General Theory*. Specifically, estimating a simple demand-driven competitive-search model, we test the ability of this theoretical proposal to match the behaviour of the US economy over the last 30 years. The main results achieved in this empirical investigation are the following. First, all over the period, the New 'Farmerian' model provides a good fit of actual data. Second, under the assumption that confidence shocks are serially correlated, the suggested framework reacts to demand shocks in the same way as more micro-founded DSGE models. Finally, the shock decomposition of the implied output gap reveals that the financial crisis of 2008 was driven by a strong negative demand shock probably triggered by a self-fulfilling drop of confidence.

JEL Classification: E24, E32, E52, J64.

Keywords: Old-Keynesian Economics, Competitive Search, DSGE Models, Bayesian Estimation.

Introduction

In a recent array of papers and a book, Farmer (2008a-b, 2010a-b-c, 2012) provides a new micro-foundation of the *General Theory* grounded on modern search and business cycle theories. The key ingredients of this theoretical proposal are the ideas that there is something distinctive about the

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[‡] Senior Economist, Norges Bank Monetary Policy, Bankplassen 2, 0151 Oslo, Norway, E-mail Paolo.Gelain@Norges-Bank.no. The views expressed in the paper are those of the author and they do not necessarily reflect Norges Bank's view.

[§] Research Fellow, Department of Economics, University of Pisa, via F. Serafini n. 3, 56124 Pisa (Italy), Phone +39 050 2212434, Fax +39 050 2212450, E-mail guerrazzi@ec.unipi.it labour market with respect to its Walrasian representation while beliefs and self-fulfilling expectations are the main drivers of the economic activity. The output of this ambitious research agenda is a competitive-search framework with multiple steady-states in which output and employment are demand driven, labour instead of output is used to post vacancies, the money wage is used as numeraire and prices are flexible. In the remainder of the paper, this set-up will be dubbed as ‘New Farmerian’ – or ‘Old-Keynesian’ – in order to distinguish the suggested proposal from the traditional New-Keynesian paradigm grounded on nominal and/or real rigidities.

Despite a strong theoretical emphasis, empirical contributions rooted in the New Farmerian economics are still in their infancy. On the one hand, Farmer (2010d) compares a three-equation monetary version of the Old-Keynesian framework with a companion New-Keynesian model showing that the former outperforms the latter in fitting US data. On the other hand, calibrating an Old-Keynesian model Guerrazzi (2011) shows that Farmer’s theoretical proposal can provide a rationale for the Shimer (2005) puzzle, i.e. the relative stability of labour productivity in spite of the large volatility of labour marker tightness indicators that standard search models à la Mortensen and Pissarides (1994) are unable to replicate unless augmented with nominal and/or real rigidities (e.g. Shimer 2005, Hall 2005a-b and Gertler et al. 2008).

Remaining on the empirical ground, in this paper we try to move one step forward by applying diagnostic tools typically implemented in DSGE models to a version of the New Farmerian framework developed by Guerrazzi (2011). Specifically, estimating a simple demand-driven competitive-search model by means of Bayesian techniques, we test the ability of this theoretical setting to match the dynamic behaviour of the US economy by focusing on the patterns of output, consumption, investments, real wages, job vacancies (or corporate recruiters) and unemployment.[1]

A distinguishing feature of our work is that we try to provide a quantitative assessment to a number of theoretical attributes of the New Farmerian economics. First, given that equilibrium unemployment is assumed to be a recurrent feature of real-world economies, unemployment rates are explicitly exploited in the estimation process (e.g. Galì et al. 2011). Second, since in Farmer’s (2008a-b, 2010a-b-c, 2012) proposal workers are allowed to recruit themselves, corporate recruiters are exploited as proxies of observed job vacancies (e.g. Guerrazzi 2011). Finally, retrieving a definition of potential output consistent with the postulates of the New Farmerian economics, we provide an estimation of such a critical indicator together with a shock decomposition aimed at discerning its stochastic determinants.

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[1] The monetary side of the economy is left to further research.

The main results achieved in this paper are the following. First, over the last 30 years, the New Farmerian framework provides a good fit of US data confirming at least in part its consistency with traditional real business cycle (RBC) matching models also on empirical grounds (e.g. Merz 1995 and Andolfatto 1996, den Haan et al. 2000). Specifically, the model is able to replicate the productivity slowdown of the 80s as well as the recent financial crisis. Second, under the assumption that confidence shocks are serially correlated, the suggested framework reacts to demand shocks in the same way as more micro-founded DSGE models in spite of its parsimonious specification. Finally, the shock decomposition of the estimated output gap reveals that the financial crisis of 2008 has been driven by a strong negative demand shock probably triggered by a self-fulfilling drop of confidence in the stock market (e.g. Farmer 2010b and Guerrazzi 2010).

The paper is arranged as follows. Section 2 provides the theoretical framework. Section 3 provides an overview of data and a description of the estimation methodology. Section 4 presents and comments the estimation results. Finally, section 5 concludes.

2. Theoretical Framework

The theoretical framework exploited for the empirical estimations draws on Guerrazzi (2011) who builds a competitive two-sided search model in discrete time in which, consistently with Farmer (2008a-b, 2010a-b-c, 2012), output and employment are driven by effective demand, labour instead of output is used to post vacancies, prices are flexible and the nominal wage rate is used as numeraire.

A distinctive feature of this New Farmerian proposal is that it also resumes some elements of the Cambridge theory of distribution. Specifically, Guerrazzi (2011) assumes that economic agents are divided in two broad categories, i.e. wage and profit earners, which also are assumed to differ in their propensities to consume and their tasks.[2] On the one hand, wage earners, i.e. the owner of a fixed amount of labour services, are assumed to dislike saving and consume the whole income earned by supplying their labour endowment. On the other hand, profit earners, i.e. the owners of the capital stock and/or overhead workers, are assumed to save the total income earned by employing a given amount of wage earners and arranging a stochastic production process aimed at financing capital accumulation.[3] Moreover, profit earners can employ wage earners alternatively in recruiting or production activities. Finally, consistently with Farmer (2008a), Guerrazzi (2011) formalizes profit earners' 'animal spirits' by assuming that their nominal investment expenditure

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[2] More detailed arguments on the Cambridge theory of distribution can be found in Kaldor (1955-1956) and Solow and Stiglitz (1968).

[3] A similar agents' structure can also be found in Woodford (1986).

measured in wage units follows an autonomous stochastic process such as those usually exploited for total factor productivity (TFP) in conventional real business cycle (RBC) models.

The model employed for the estimation can be summarized in four distinct blocks. First, the blocks from 1 to 3 provide the conditions for a symmetric demand constrained equilibrium (DCE), i.e. feasibility and market clearing in the market for goods, consistency with the optimal choices of wage and profit earners and search market equilibrium (e.g. Farmer 2008a-b, 2010a-b-c, 2012). Finally, block 4 provides the laws of motion of the model economy. In what follows, we provide a formal description for each of them.

2.1 *Feasibility and Market-Clearing in the Market for Goods*

A distinctive feature a DCE is that all the purchased goods are produced by profit earners while there is no certainty that all the wage earners are actually employed.

Consider a given time period, say t. Profit earners output (Y_t) is described by a constant-returns-to-scale Cobb-Douglas production function. Hence,

$$Y_t = A_t K_t^{\alpha} X_t^{1-\alpha} \qquad 0<\alpha<1 \tag{1}$$

where A_t is a common-knowledge stochastic productivity shock, K_t is the stock of capital, X_t is the fraction of wage earners employed in production activities while α $(1-\alpha)$ is the output elasticity with respect to capital (labour).

Wage earners can be alternatively allocated to production or recruiting activities. As a consequence, total employment (L_t) can be break down as

$$L_t = X_t + V_t \tag{2}$$

where V_t is the fraction of wage earners employed as corporate recruiters.

Labour service endowment of wage earners is normalized to 1. As a consequence, the unemployment rate is given by

$$U_t = 1 - L_t \tag{3}$$

Finally, the national account identity implies that

$$C_t + Q_t \tilde{I}_t = Y_t \tag{4}$$

where C_t is aggregate consumption in real terms, $\tilde{I}_t$ is the nominal investment expenditure measured in wage units while Q_t is the real wage rate, i.e. the ratio between the nominal wage rate w_t and the price level p_t.[4]

2.2 *Consistency with the Optimal Choices of Wage and Profit Earners*

As stated above, wage earners dislike saving and consume the whole income earned by offering their labour services in a competitive-search labour market. Therefore, aggregate consumption equals the aggregate wage bill all the times. Hence,

$$C_t = Q_t L_t \tag{5}$$

Plugging (5) into (4) allows to derive the value of aggregate demand measured in nominal wage units. Specifically,

$$\frac{AD_t}{w_t} = \tilde{I}_t + L_t \tag{6}$$

Profit earners employ a given fraction of wage earners by aiming at maximizing their net-of-wage payments. Obviously, this means that the marginal product of labour will equal the real wage all the times. As a consequence, taking into account the production function in (1), it will always hold

$$(1-\alpha)\frac{Y_t}{L_t} = Q_t \tag{7}$$

The expression in (7) is a conventional first-order condition for labour that allows to derive the value of aggregate supply measured in nominal wage units.[5] Specifically,

$$\frac{AS_t}{w_t} = \frac{1}{1-\alpha} L_t \tag{8}$$

Obviously, equalizing (6) and (8) provides the equilibrium nominal output in wage units and the equilibrium level of employment.[6]

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[4] As a consequence, $Q_t \tilde{I}_t$ provides real investments.

[5] Its counterpart for capital is missing because profit earners are assumed to invest the whole net-of-wage payments in productive investments. However, the real interest rate consistent with a zero-profit condition on profit earners' side would be equal to $Q_t \tilde{I}_t K_t^{-1}$.

[6] Respectively, $\alpha^{-1}\tilde{I}_t$ and $(1-\alpha)\alpha^{-1}\tilde{I}_t$.

2.3 *Search Market Equilibrium*

The two-sided search framework implies that in each period wage earners have a certain probability to find a job while profit earners have a certain probability of fill their vacant positions by allocating wage earners to recruiting activities.

On the one hand, the probability to find a job (H_t) equals aggregate employment.[7] Hence,

$$H_t = L_t \tag{9}$$

On the other hand, the recruiting effectiveness of a single wage earner employed as a recruiter is given by

$$R_t = \frac{L_t}{V_t} \tag{10}$$

The expression in (10) is aimed at providing a micro-foundation for applications processing and suggests that each profit earner knows that V_t corporate recruiters can hire $R_t V_t$ wage earners X_t of whom will be employed in production activities.

Finally, once (un)employment is determined by the level of aggregate demand in the market for goods, the fraction of wage earners allocated to recruiting activities is determined by a deterministic version of the Beveridge curve:

$$V_t = (1 - U_t)^{\frac{1}{1-\gamma}} \qquad 0 < \gamma < 1 \tag{11}$$

where γ is the matching elasticity.

The Beveridge curve in (11) summarizes the operation of search and production externalities in the whole economy and suggests that in Farmer’s (2008a-b, 2010a-b-c, 2012) framework labour instead of output is used to post vacancies. Moreover, (11) has the nice geometrical feature that the higher (lower) γ, the closer (more distant) the Beveridge curve from its axes. Since Solow (1998) provided a definition of labour market flexibility exactly in terms of such a distance, γ also provides a straightforward measure of the underlying degree of labour market rigidity. In addition, the ratio $V_t / U_t = V_t / (1 - R_t V_t)$ still provides a measure of labour market tightness (e.g. Pissarides 2000).

Finally, (11) can be combined with the results in (1), (2), (3) and (7) in order to derive the equilibrium wage function. Specifically,

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[7] Conversely, the probability to remain unemployment is $1 - L_t$.

$$Q_t = (1-\alpha)A_t K_t^{\alpha} \frac{\left(1 - L_t^{\frac{\gamma}{1-\gamma}}\right)^{1-\alpha}}{L_t^{\alpha}} \tag{12}$$

Guerrazzi (2011) shows that the expression in (12) has an inflection point for the level of employment the maximizes output per period, i.e. the allocation that fulfils the first-best level of (un)employment. Such an inflection is the endogenous source of real stickiness that in a reasonably calibrated model allows to resolve the Shimer (2005) puzzle.

2.4 *Laws of Motion*

Equations from (1) to (11) determine a real wage Q_t, a production plan $\{Y_t, V_t, X_t, L_t, U_t\}$, a consumption allocation C_t and a pair of search probability $\{H_t, R_t\}$ as function of the parameter set $\{\alpha, \gamma\}$ and the state variables $\tilde{I}_t$, A_t and K_t. As a consequence, the definition of the laws of motion of those three state variables closes the model.[8]

First, in the model economy under examination, investments are not derived from rational optimization. Following Farmer (2008a), Guerrazzi (2011) formalizes profit earners' animal spirits by assuming that their nominal investment expenditure measured in wage units is driven by an autonomous stochastic AR(1) process perturbed by white-noise disturbances that convey confidence shocks. In the remainder of this paper, we maintain the same autoregressive structure. However, we assume that such a structure also holds for confidence shocks.[9] Hence,

$$\tilde{I}_t = \kappa + \rho_i \tilde{I}_{t-1} + \varepsilon_t \tag{13}$$

where κ is a positive drift, ρ_i measures the persistence of the exogenous investment sequence while $\ln \varepsilon_t = \rho_\varepsilon \ln \varepsilon_{t-1} + u_t^{\varepsilon}$ with $u_t^{\varepsilon} \sim N(0, \sigma_\varepsilon^2)$ is the confidence shock.

The expression in (13) pins down the DCE of the model economy and formalizes in a very simple way a central issue of the *General Theory*, i.e. the idea that investment expenditure exogenously evolves with no regard for expected profits.[10] Moreover, as shown by Guerrazzi (2011), (13) allows to reconcile the traditional RBC dynamics of matching in which vacancies are

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[8] Obviously, the levels of state variables also provide the value of aggregate demand and supply in wage units.

[9] The underlying idea is that a period of bull (or bear) markets might induce agents to believe that such a situation will be long lasting.

[10] Along these lines, Kurz (2008) provides a piece of micro-foundation for (13) by deriving a similar first-order autoregressive process as a limit posterior of a Bayesian learning inference in non-stationary environments.

posted by means of output (e.g. Pissarides 1990 and Mortensen and Pissarides 1994) with the Farmerian approach in which vacancies are posted with labour so that workers are allowed to recruit themselves. Specifically, using (13) to derive the DCE level of (un)employment, it becomes possible to show that equilibrium employment evolves according to the following stochastic process:

$$L_t = B(\varepsilon_t)(1-L_{t-1})^{\gamma} V_{t-1}^{1-\gamma} + (1-\delta_L(\varepsilon_t))L_{t-1} \tag{14}$$

where $B(\varepsilon_t) \equiv (1-\rho_i)(\gamma\hat{L})^{-1}$, $\delta_L(\varepsilon_t) \equiv (1-\rho_i)(1-\hat{L})^{\gamma}(\gamma\hat{L})^{-1}$ while $\hat{L} \equiv (1-\alpha)(\kappa+\varepsilon_t)(\alpha(1-\rho_i))^{-1}$.

The expression in (14) suggests that a positive (negative) demand shock reduces (increases) the efficiency of matching $B(\varepsilon_t)$ as well as the job separation rate $\delta_L(\varepsilon_t)$. In this way, a positive (negative) demand shock increases (reduces) the steady-state level of employment.

Second, as in standard RBC models, the log of TFP is assumed to follow a stochastic AR(1) process. Thus,

$$\ln A_t = \ln\mu + \rho_a \ln A_{t-1} + u_t^a \tag{15}$$

where μ is a positive drift, ρ_a measures the persistence of productivity shocks and $u_t^a \sim N(0, \sigma_a^2)$ is a stochastic productivity disturbance.

The expression in (15) provides the stochastic trend that drives output, real investments, capital and real wages.

Finally, productive capital evolves according to the usual dynamic accumulation law. Hence,

$$K_t = Q_t\tilde{I}_t + (1-\delta_K)K_{t-1} \qquad 0 < \delta < 1 \tag{16}$$

where δ_K is the depreciation rate of capital.

An illustration of a DCE is given in the four panels of Figure 1.

In panel (*a*) of Figure 1 there is the equilibrium in the market for goods and services represented by the intersection of the value of aggregate demand (AD_t) with the value of aggregate supply (AS_t) both expressed in nominal wage units. In panel (*b*) there is the negative one-to-one relationship between employment and unemployment. In panel (*c*) there is a 45-degree line. Finally, in panel (*d*) there is the Beveridge curve and the (mirrored) equilibrium wage function.

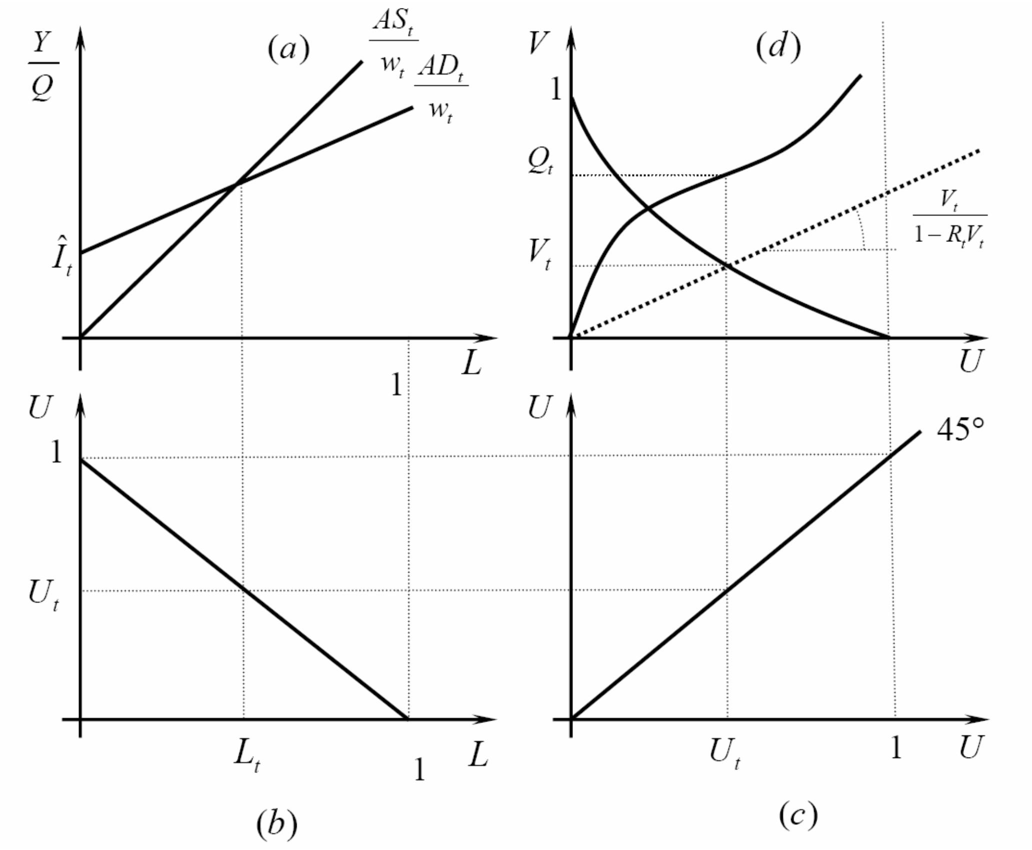

Figure 1: Demand constrained equilibrium.

3 Data and Estimation Methodology

In order to estimate the model developed in section 2 we use time series data for the following macroeconomic US aggregates: real GDP, real consumption, real investments, real wages, job vacancies and unemployment.[11]

US data are available from the Bureau of Economic Analysis with the exception of job vacancies that come from the Conference Board. Moreover, data on real wages are retrieved from the Bureau of Labor Statistics.[12] The estimation period is 1980q1 to 2008q4. Finally, all variables are per-capita and de-trended with their respective linear trend.[13]

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[11] By contrast, the labour share (α) and the capital depreciation rate (δ_K) are calibrated as in Kydland and Prescott (1982).

[12] Specifically, for the real wages we use the series of the quarterly average hourly earnings of production workers divided by GDP deflator.

[13] We checked the robustness of our results to the de-trending strategy. Specifically, we performed the estimation through the HP filter. Results are very robust to that alternative. Moreover, we also tried the estimation taking the observables in growth rates. Results seem less robust, but still acceptable. Finally, we discarded the growth rates

The choice of the priors has been done according to the following criteria. First, we choose an Inverse Gamma distribution for the standard deviation of shocks because it has a positive support. We allowed for an infinite variance to allow for the searching algorithm to explore a big portion of the support, although lower weights are given to higher values. Since they are bounded between 0 and 1, persistence parameters of demand and supply shocks are assumed to have a Beta distribution. Moreover, this allows to put higher prior weights on values close to unity, i.e. implying more persistence as we expect. The matching elasticity γ is assumed to be distributed as a Beta with a 0.5 mean. The most appropriate prior for that parameter would have been a uniform distribution because we do not have strong a priori beliefs about it. Nevertheless, this type of prior puts the same weights on all the possible values in the support. By definition, such a Beveridge curve parameter belongs to the interval $(0,1)$. Furthermore, if values too close to those bounds are selected, the steady state of the model may be strongly affected.[14] Hence, to reduce the number of draws to close to the bounds (or at least to give them less importance) we impose the Beta distribution.

4.1 *Methodology*

The aim of the estimation is to obtain posterior distributions of the model parameters and make inference out of them. Since the posterior distributions are unknown, we used a Markov Chain Monte Carlo (MCMC) simulation method, namely the so-called random walk Metropolis–Hasting algorithm, which uses an acceptance–rejection rule to converge towards the posterior distribution.[15] Before simulating, the maximization of the posterior kernel has been done in order to find the posterior modes and the variance-covariance matrix (evaluated at the modes) to be used in the initialization of the Metropolis-Hasting algorithm. The entire procedure is implemented in DYNARE for MATLAB^{TM} (e.g. Juillard 2004).[16] For a detailed description, see An and Schorfheide (2007) and Canova (2007).

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alternative because the poor performance of the model in terms of fit with the data with respect to the other two alternatives.

[14] For instance, if γ is close to 1, then corporate recruiters (or job vacancies) tend to explode.

[15] We run two chains of 500,000 draws each, and we discarded the first 50% as burn–in. The acceptance rate has been tuned to be around 30%, and the convergence of the chains has been evaluated with the checks proposed by Brooks and Gelman (1998). See Figure 2.

[16] DYNARE allows for different kinds of optimization procedure. In this paper, we used the option “modecompute= 6” which uses the Metropolis-Hasting to find the mode of the posterior distributions.

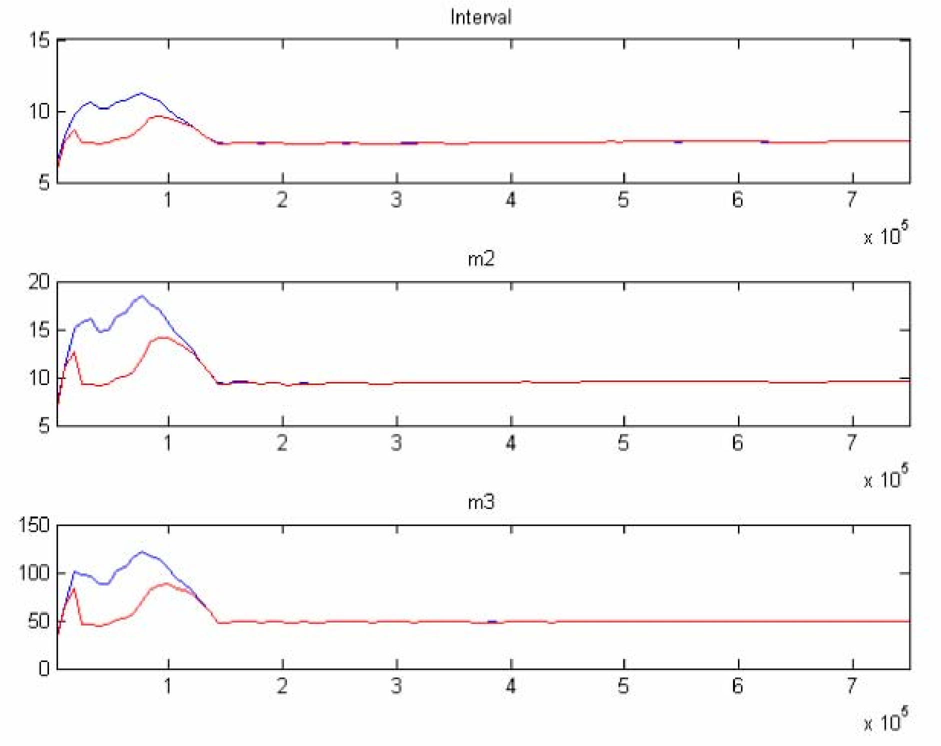

Figure 2: Convergence of the model.

4 Empirical Results

In this section we present and comment the estimation results. First, we focus on the fit of the theoretical framework developed in section 2 as well as on its estimated parameters. Thereafter, we use the impulse response analysis to evaluate the dynamics implied by demand and supply shocks. Finally, we provide an estimation of the output gap generate by the suggested model and its shock decomposition.

4.1 Fitting and Posterior Estimation

The overall fit of the model is evaluated through two different methods. The first is a comparison between the Kalman-filtered one-sided estimates of the observed variables and their estimated counterpart. The second is a moments comparison based on volatility and autocorrelation.

Figure 3 shows fitted values together with actual data. Straightforward observation reveals that they look pretty similar, indicating that for the last 30 years the theoretical model developed in section 2 provides a very good fit of US actual macroeconomic patterns. Interestingly, the model is able to match (inter alia) the productivity slowdown of the 80s as well as the recent financial crisis.

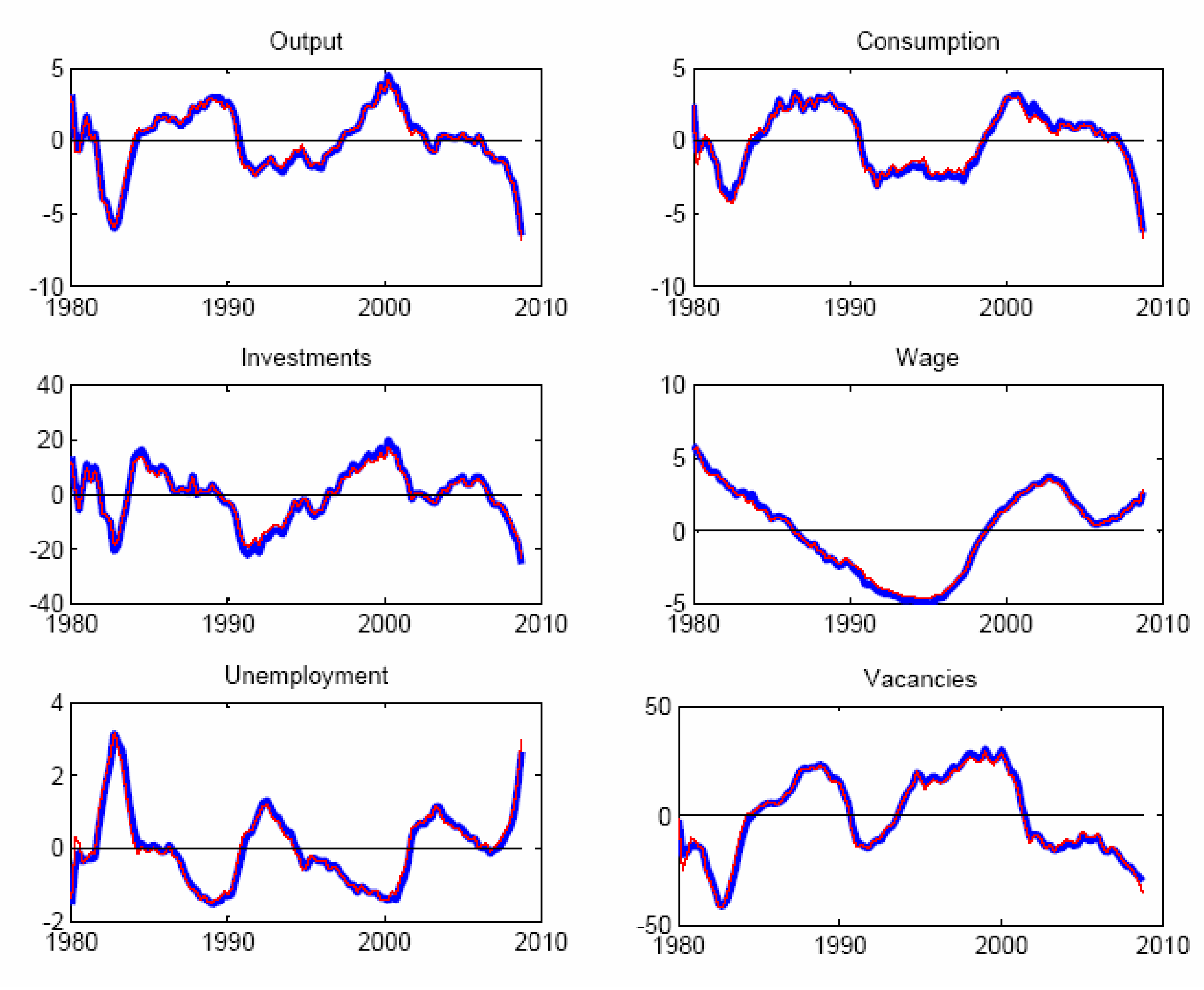

Figure 3: Actual data (--) and fitted (filtered) values (--).
(% deviation from steady state)

	STANDARD DEVIATION	
	Data	**Model**
Output	2.16	2.63
Consumption	2.16	2.68
Investments	10.12	8.39
Wages	2.96	1.56
Unemployment	1.02	1.63
Vacancies	18.43	18.09

Table 1: Observed and estimated volatilities.

Switching to moments comparison, Table 1 shows the standard deviations implied by the model and the data ones.[17] The figures suggest that the model matches quite closely the pattern of observed data, although it vaguely tends to understate the volatility of investments and wages.

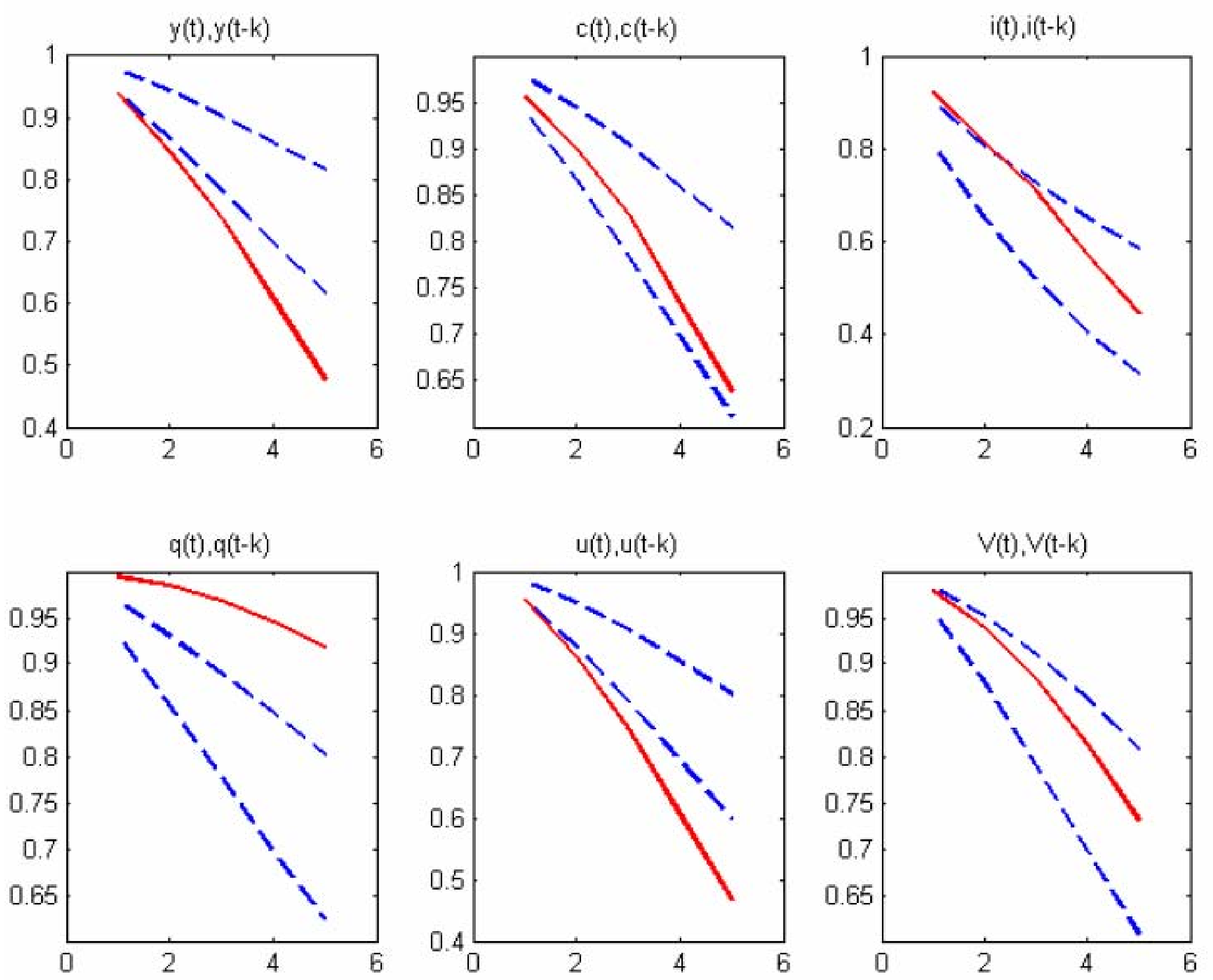

Figure 4: Observed and estimated autocorrelations.
(-- 90% confidence bars; -- data)

Figure 4 shows a comparison between observed and estimated values based on autocorrelations. Apart from output, wages and unemployment for which the model seems unable to reproduce the autocorrelation paths, encouraging results are obtained for consumption, investments and job vacancies (or corporate recruiters).

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[17] Model standard deviations are computed on simulated data generated from 147 draws from the posterior parameter distribution and 100 simulated samples of 1,000 observations for each draw.

Overall, considering the parsimoniousness of its specification, we judge the fit of the model quite satisfactory. Obviously, additional work is required to smooth the wage rigidity and low persistence of output and unemployment delivered by the suggested theoretical framework.

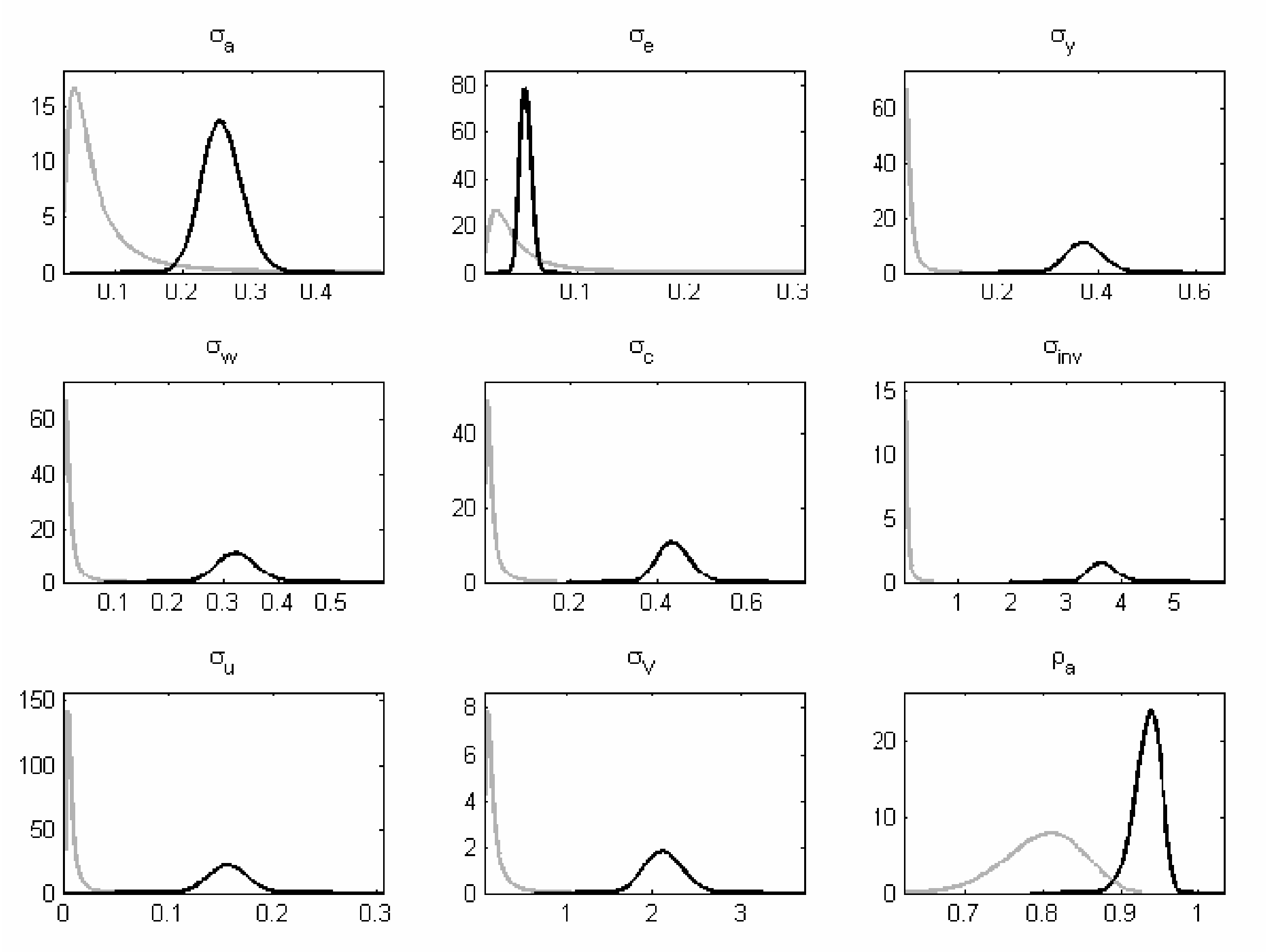

Figure 5: Prior and posterior modes.

Prior and posterior distributions are illustrated in the panels of figures 5 and 6. From visual inspection it is clear that data contain information about many of estimated parameters; indeed, all of them have posterior mean values consistent with their theoretical counterpart. Moreover, one of the most important, i.e. the matching elasticity (γ), is clearly data–determined.[18] Obviously, this confirms our theoretical guess that equilibrium unemployment brings relevant information in the estimation (e.g. Galì et al. 2011).

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[18] Estimating a companion model for the Euro area, Gelain and Guerrazzi (2010) find that the corresponding point value of the matching elasticity is slightly lower although the difference between the two is not statistically significant.

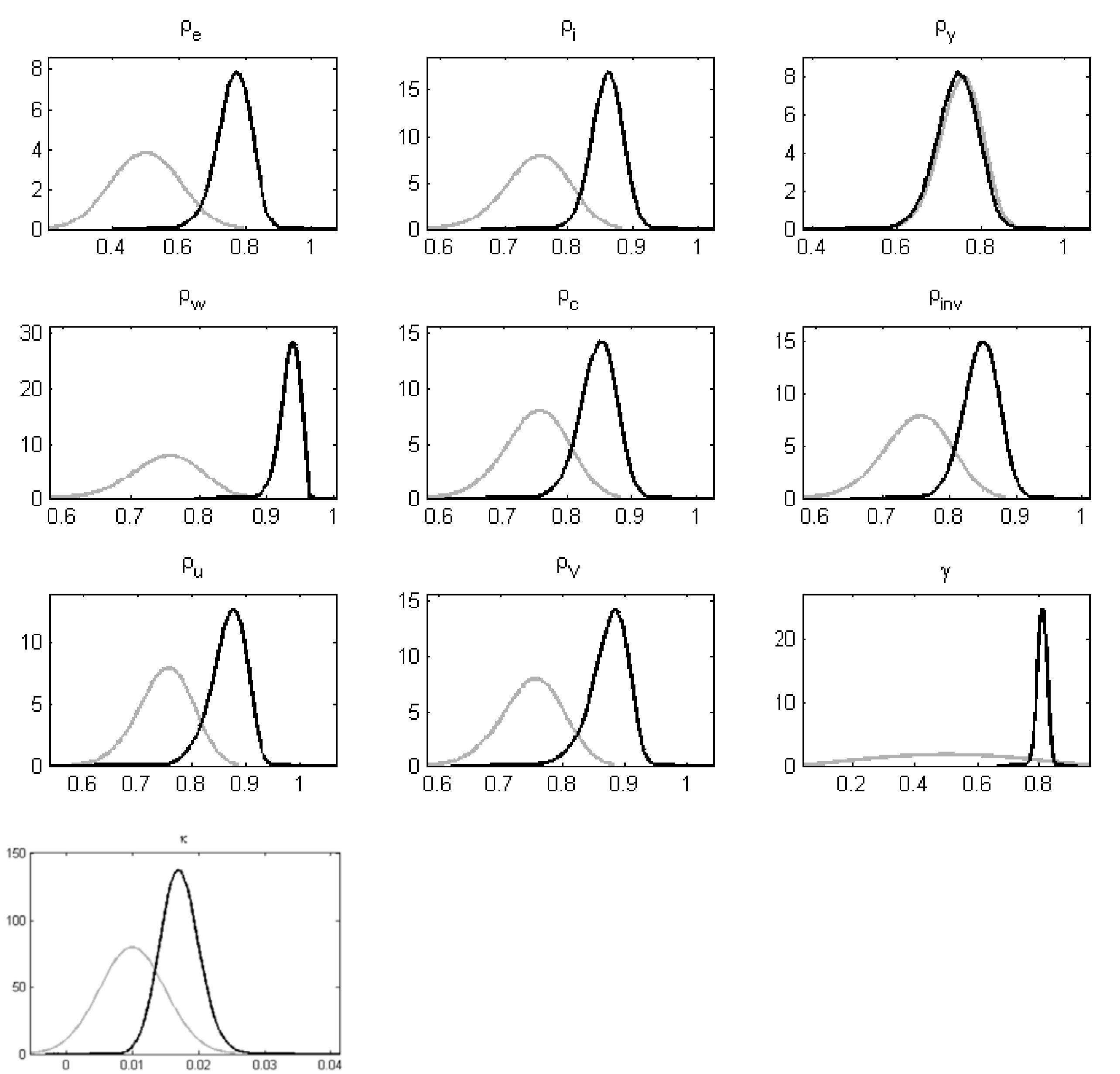

Figure 6: Prior and posterior modes.

In Table 2 we summarize the priors chosen for the parameters and their moments, and the posterior means with their 90% probability intervals. Some results are remarkable. For instance, the posterior mean of the matching elasticity is 0.8114. There are two references values for that parameter. First, Farmer (2008a) uses a value of 0.5 in his seminal ‘Old Keynesian’ simulations. This partially justifies our prior mean. Moreover, in the attempt to find a rationale for the Shimer (2005) puzzle, Guerrazzi (2011) calibrates it at 0.9868. Given those computational references, our point estimate looks quite reasonable.

PARAMETERS	PRIOR			POSTERIOR MEAN	PROBABILITY INTERVAL	
	Distribution	Mean	Std. dev.			
σ_a	Inv. Gamma	0.087	Inf.	0.2560	0.2066	0.3035
σ_ε	Inv. Gamma	0.055	Inf.	0.0522	0.0440	0.0606
σ_y	Inv. Gamma	0.022	Inf.	0.3720	0.3115	0.4325
σ_q	Inv. Gamma	0.022	Inf.	0.3235	0.2644	0.3817
σ_c	Inv. Gamma	0.030	Inf.	0.4350	0.3745	0.4943
σ_{inv}	Inv. Gamma	0.101	Inf.	3.6601	3.2479	4.0588
σ_u	Inv. Gamma	0.010	Inf.	0.1556	0.1242	0.1859
σ_v	Inv. Gamma	0.184	Inf.	2.1186	1.7615	2.4763
ρ_a	Beta	0.800	0.050	0.9327	0.9052	0.9610
ρ_ε	Beta	0.500	0.100	0.7641	0.6823	0.8489
ρ_i	Beta	0.750	0.050	0.8593	0.8204	0.8988
ρ_y	Beta	0.750	0.050	0.7412	0.6637	0.8223
ρ_q	Beta	0.750	0.050	0.9349	0.9136	0.9587
ρ_c	Beta	0.750	0.050	0.8467	0.8017	0.8929
ρ_{inv}	Beta	0.750	0.050	0.8465	0.8037	0.8904
ρ_u	Beta	0.750	0.050	0.8657	0.8133	0.9175
ρ_v	Beta	0.750	0.050	0.8744	0.8276	0.9230
γ	Beta	0.500	0.200	0.8114	0.7853	0.8380
κ	Normal	0.010	0.005	0.0172	0.0123	0.0219
B	--	--	--	0.6411	0.4384	0.8934
δ_L	--	--	--	0.6939	0.3264	0.7116

Table 2: Estimated parameters.
(Probability interval 90%)

In section 2 we have shown that the model economy is consistent with a stock-adjustment mechanism for employment equivalent to the one that holds in traditional matching models (e.g. Pissarides 1990 and Mortensen and Pissarides 1994). This particular specification allows to estimate two important parameters that do not directly contribute in determining a DCE, i.e. the job destruction rate (δ_L) and the coefficient conveying the efficiency of matching (B). Specifically, using our estimated parameters, we can calculate their implied posterior distributions.[19] The results are shown in the two panels of Figure 7.

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[19] Those two parameters depend on some estimated ones. For each posterior draws we can than compute them. But they also depend on the demand shock ε_t. Given that it is an autoregressive process we also know its distribution. It in

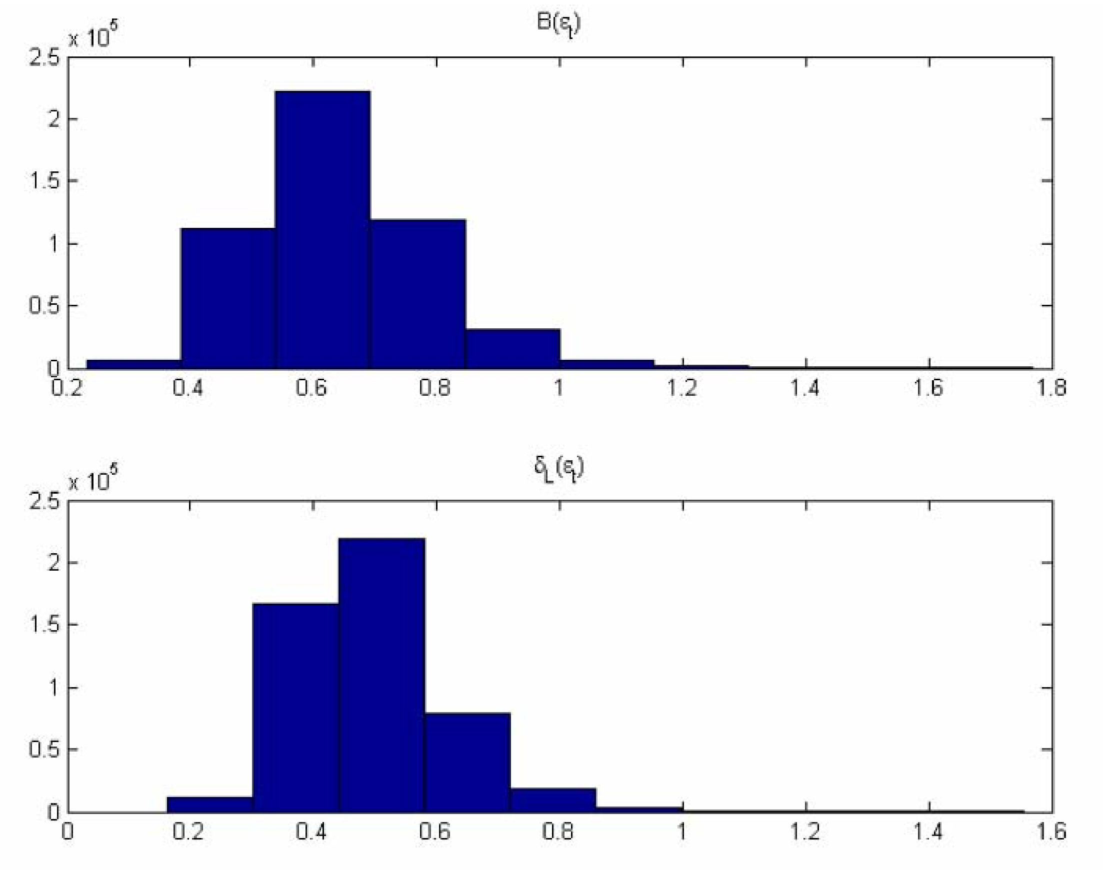

Figure 7: Efficiency of matching and job separation rate.

First, the posterior mean for B is 0.6411 with a 90% probability interval (0.4384,0.8934). The value of the posterior mean implies that in the steady-state allocation wage earners find jobs with a probability of 15.07% while the probability of filling a vacancies tends to explode. Those values are quite distant from the references used in similar contributions. For instance, den Haan et al. (2000) suggest a value of 45% for the former and a value of 70% for the latter. We suspect that those bad results rely on the relatively small values obtained for the posterior means of κ and γ.

Finally, the posterior mean for δ_L is 0.6939 with probability interval (0.3264,0.7116). Those figures are theoretically consistent but they fall well above the usual value of 10% exploited in conventional RBC matching models (e.g. Mertz 1995 and Andolfatto 1996). This means, that in the present version the estimated model predicts a too sustained labour market turnover.

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normally distributed with mean zero and variance $\sigma_\varepsilon^2/\left(1-\rho_\varepsilon^2\right)$. For each draw from the posterior parameter distribution we draw 7,000 values for ε_t and we use take the mean to have a point value.

4.2 *Impulse Response Functions*

Impulse response functions describe the way in which the endogenous variables of the model economy react to exogenous shocks. Specifically, the panels in Figure 8 suggest that positive (negative) demand shocks increase (decrease) consumption, employment, capital, real investments, vacancies and output while they decrease (increase) real wages, unemployment and the recruiting efficiency of corporate recruiters. Those movements are consistent with the thick (thin) market externalities induced by positive (negative) demand shocks within a demand-driven economy that fulfils the first postulate of the classical economy (e.g. Keynes 1936).

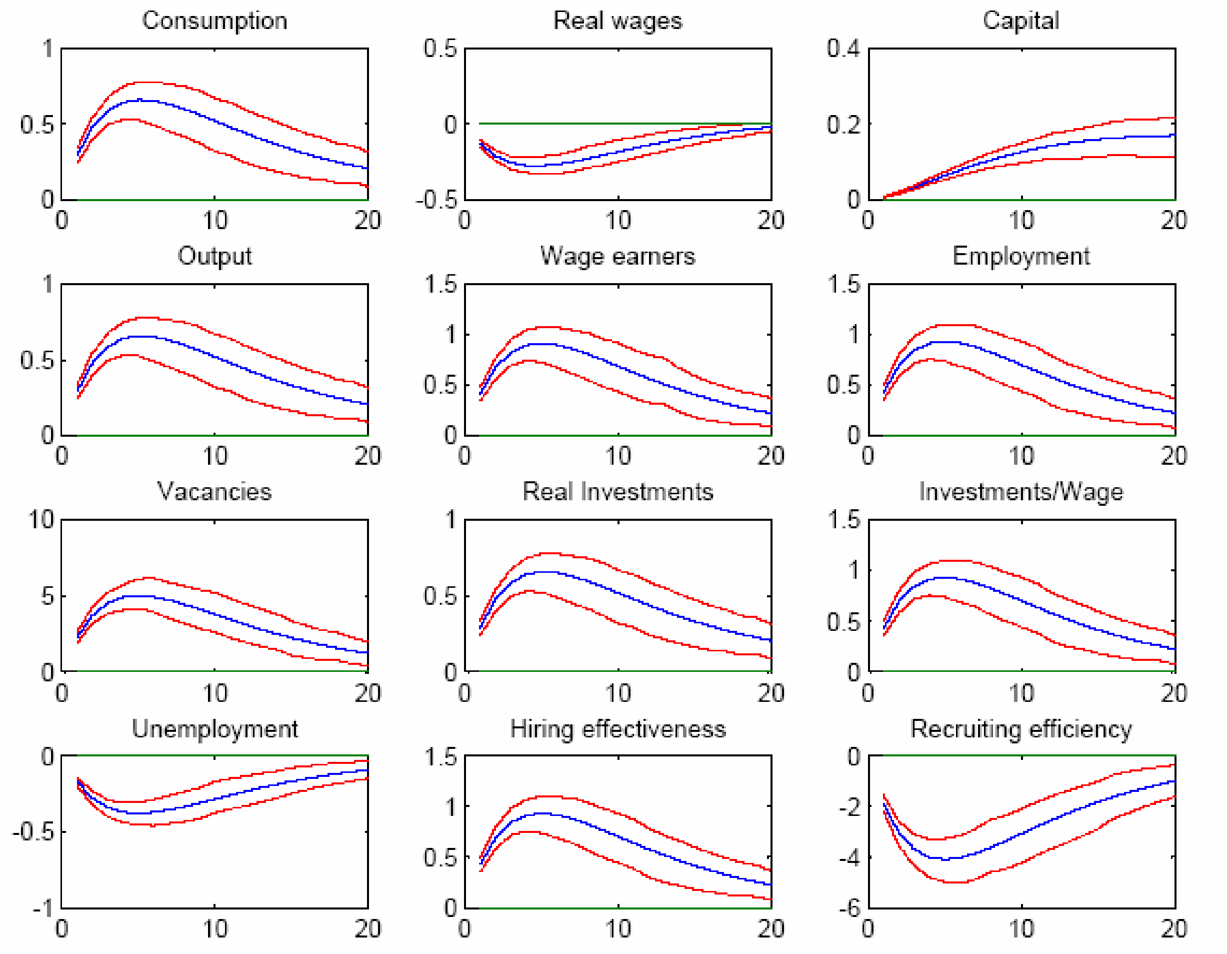

Figure 8: Orthogonalized impulse response functions to a one standard deviation demand shock. (% deviation from steady state)

The diagrams in Figure 8 allow to highlight another important result. Specifically, straightforward observation reveals that the model economy developed in section 2 model is able to generate hump–shaped responses to demand shocks for all the endogenous variables. In the DSGE literature, hump–shaped patterns are usually implied by the introduction of specific types of real rigidities. For instance, consumption can be hump–shaped combining habit formation and forward looking behaviour of households; indeed, the resulting dynamic Euler equation provides the desired response of consumption. Moreover, a hump–shaped response of investment can be obtained from the investments Euler equation, which in turns is the result of the combination of the investments adjustment costs assumption and of the forward looking nature of capital producers. On the contrary, price and wage rigidities only account for the persistence and impulse response shape of inflation and labour market variables; indeed, forward looking and indexation assumptions lead to one equation for inflation and one for wages which resemble very much Euler equations (e.g. Smets and Wouters 2003).

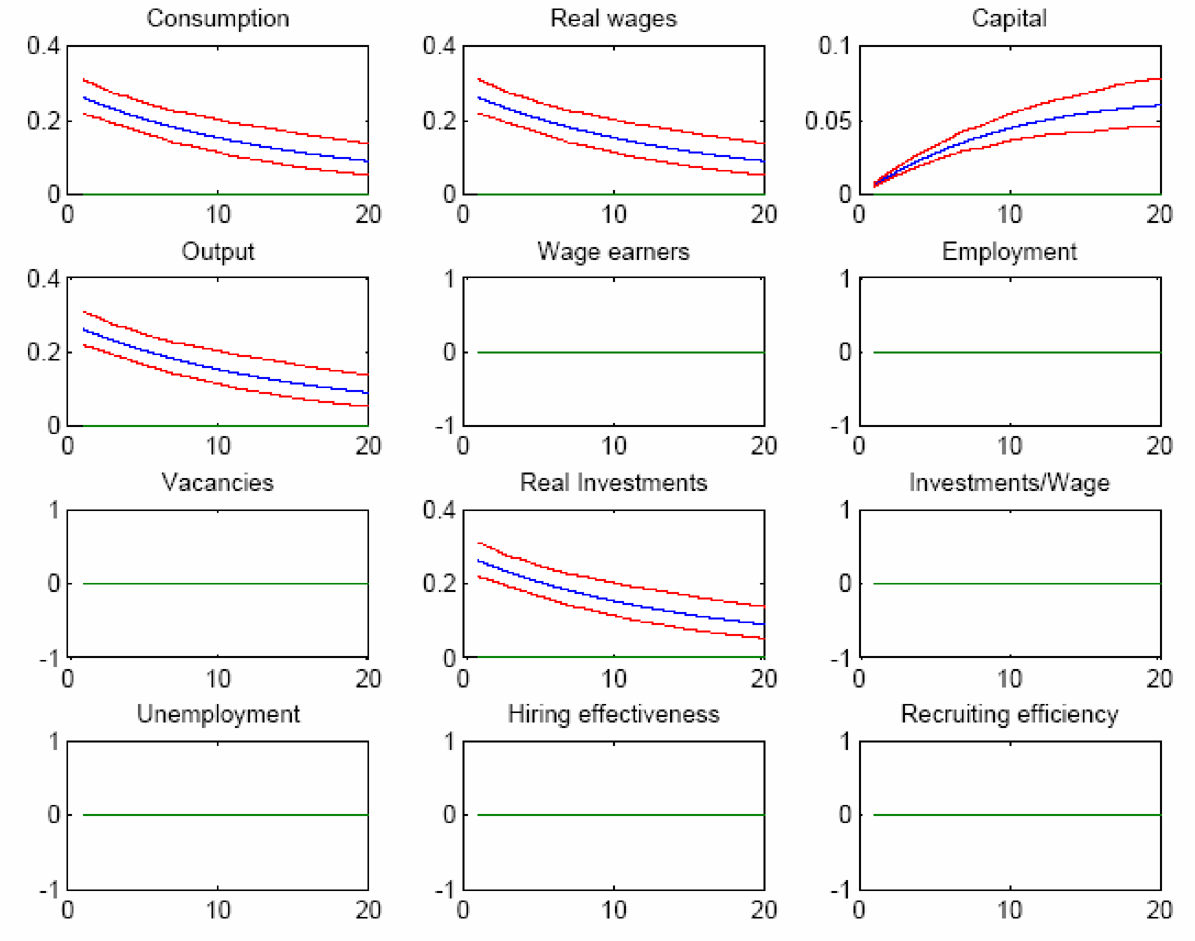

Figure 9: Orthogonalized impulse response functions to a one standard deviation technology shock. (% deviation from steady state)

In the set-up developed in section 2 things are different. There are no Euler equation; indeed, the responsible for the hump-shaped pattern of the diagrams in Figure 8 is the demand shock structure in (13). Specifically, as shown by Perron (1993) the hump-shaped behaviour of macroeconomic time series can be the upshot of a linear combination between stationary AR(1) processes.[20] Therefore, at least for demand shocks, the hypothesis that confidence shocks are serially correlated allows to derive hump–shaped impulse response functions similar to those generated by DSGE models with more well-structured micro-foundations.

Turning to technology shocks, given the demand-driven structure of the model economy it affects only consumption, output, real wages, real investments and the capital stock by leaving all the other variables unchanged. Specifically, the panels in figure 9 reveals that positive (negative) technology shocks increase (decrease) consumption, output, real wages, real investments and the capital stock. In this regard, it is worth noting that the positive (negative) effect on real investment works through the improvement (drop) of real wages.

In sharp contrast with the picture of Figure 8, the diagrams in Figure 9 do not lead to any hump-shaped impulse response function. Obviously, this raises the issue of improving the structure of the model disturbances in order to catch more carefully the effect of supply shocks. This extension is left to future works.[21]

4.4 *Output Gap and Shock Decomposition*

Now we present the path of output gap together with its shock decomposition. However, before entering the details of figures, it is necessary to provide a definition of potential output consistent with the postulates of the New Farmer economics and compare it with more traditional definitions exploited in the DSGE literature.

In general terms, the output gap is defined as the deviation of actual output from its potential value. In the context of the model developed in section 2, potential output is defined as the level of output that would prevail if an omniscient social planner could internalize search externalities by maximizing output per period. Such a level of production corresponds to the first-best allocation but it also entails a positive equilibrium unemployment which depends on the value of the matching elasticity only (e.g. Guerrazzi 2011).

This definition is somehow different from the one recurring in DSGE literature. For instance, in Smets and Wouters (2003) output gap is defined as the level of output that would prevail under flexible prices and wages in the absence of cost push shocks i.e. price and wage mark-ups disturbances.

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[20] Obviously, in the model economy under examination such a smooth dynamic behaviour is strengthened by the endogenous source of real wage stickiness delivered by the inflection point in the equilibrium wage function.

[21] A promising option could be the adherence to the ‘news shocks’ hypothesis according to which supply disturbance and confidence shocks are closely correlated (e.g. Beaudry and Portier 2006). In this way, hamp-shaped impulse response function should also follow from supply shocks.

Given that the framework developed in section 2 is radically different from the theoretical settings usually exploited in the DSGE literature, we put point comparisons on hold. By contrast, we provide the path of the output gap together with its shock decomposition. First, Figure 10 shows the paths of actual and potential output.

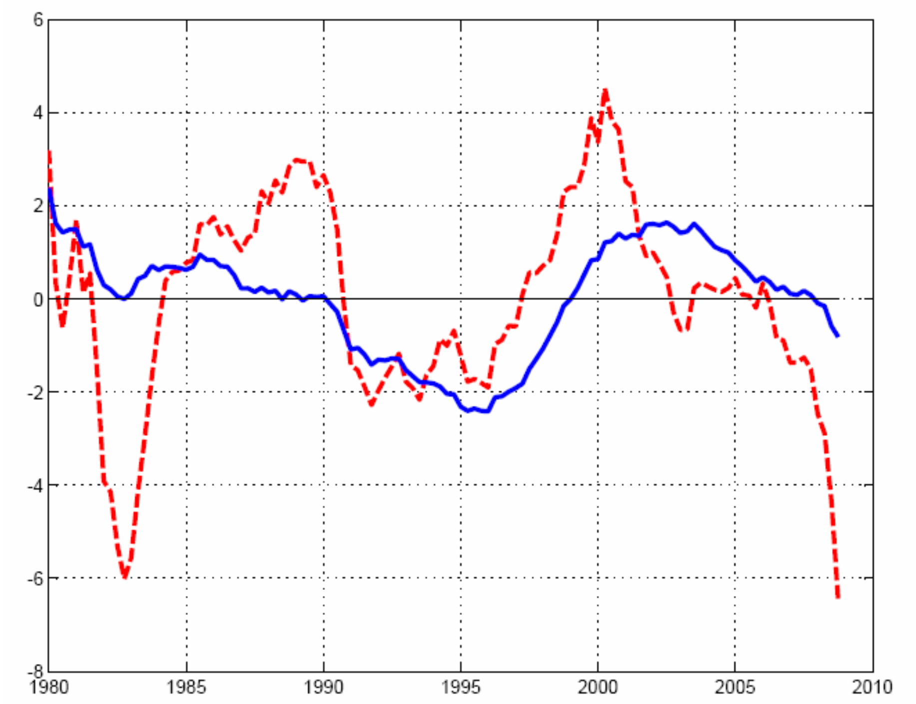

Figure 10: Observed (--) and potential output (--).

The diagram in Figure 10 shows that the model economy is able to replicate a number of NBER recessions. Specifically, the model replicates the recessions occurred in the US at beginning of the 80s, the 90s, just after 2000 and the recent financial crisis of 2008.

Finally, the output gap shock decomposition illustrated in Figure 11. The diagram allows to highlight an important aspect of the end–of–sample financial crisis; indeed, the severe decrease of the output gap is determined by the combined effect of a negative demand shock and a negative technology (supply) shock, the former being much more relevant than the latter. We would like to interpret this finding as a sign that the financial crisis of 2008 was driven by a strong negative demand shock triggered by a self-fulfilling drop of confidence in the stock market (e.g. Farmer 2010b, 2012 and Guerrazzi 2010).

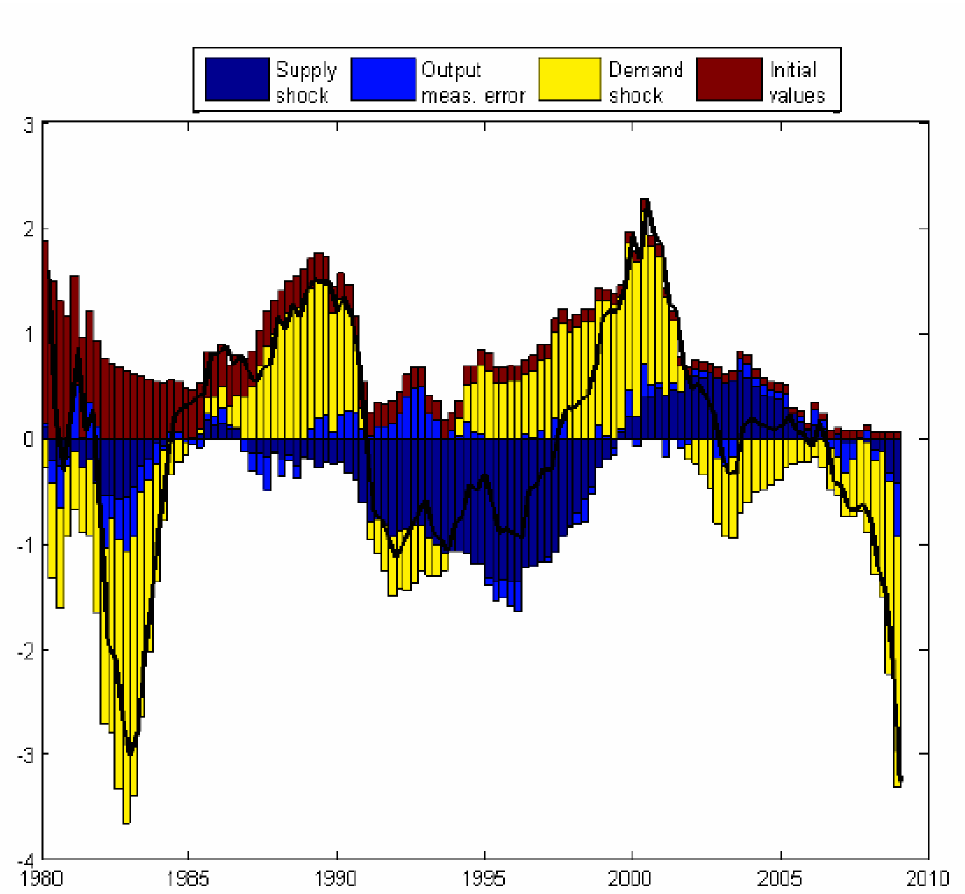

Figure 11: Output gap shock decomposition.[22]

5 Concluding Remarks

In this paper we apply the diagnostic tools of DSGE models to the New Farmerian framework developed by Guerrazzi (2011). Specifically, estimating a simple demand-driven competitive-search model, we test the ability of this new micro-foundation of the *General Theory* to match the dynamic behaviour of the US economy over the last 30 years by focusing on the patterns of output, consumption, investments, real wages, job vacancies (or corporate recruiters) and unemployment.

The main results achieved in this paper are the following. First, the New Farmerian model developed by Guerrazzi (2011) provides a good fit of US data by replicating (inter alia) the productivity slowdown of the 80s as well as the recent financial crisis. Second, under the hypothesis that confidence shocks are serially correlated, the suggested framework reacts to demand shocks in the same way as more micro-founded DSGE models. Finally, the shock decomposition of the output gap reveals that the financial crisis of 2008 was driven by a strong negative demand shock

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[22] The output gap is computed as the difference between actual and potential output showed in Figure 10.

probably triggered by a self-fulfilling drop of confidence in the stock market (e.g. Farmer 2010b, 2012 and Guerrazzi 2010).

Acknowledgements

We would like to greatly thank Roger E.A. Farmer and Francesco Furlanetto for their comments and suggestions on earlier versions of this paper. We also acknowledge participants from the 4th Italian Congress of Econometrics and Empirical Economics (Pisa, January 2011) for their useful discussions. The usual disclaimer applies.

Appendixes

A. *Steady-State Values*

In this section we derive the steady-state values around which the model is log-linearized. We start from the steady-state equation for the investment expenditure measured in wage units. Specifically, (13) implies that

$$\tilde{I}^* = \frac{\kappa}{1-\rho_i} \tag{A1}$$

where $\tilde{I}^*$ is the steady-state investment expenditure.

Taking the results in (6), (8) and (A1) into account, it follows that steady-state employment is given by

$$L^* = \frac{1-\alpha}{\alpha}\tilde{I}^* \tag{A2}$$

Given (3), steady-state unemployment is equal to

$$U^* = 1 - L^* \tag{A3}$$

Taking the result in (A3) into account, it follows that the steady-state rate of corporate recruiters is given by

$$V^* = \left(1-U^*\right)^{\frac{1}{1-\gamma}} \tag{A4}$$

Finally, the steady-state rate of wage earners allocated to production activities is equal to

$$X^* = L^* - V^* \tag{A5}$$

All the remaining steady-state values follow straightforwardly.

B. *Log-Linearization*

In this Appendix we provide all the log-linearized equations that describe the model economy developed in section 2. Small-hatted-variables denote log-deviations from the corresponding steady-state. Production function

$$\hat{y}_t = \hat{a}_t + \alpha \hat{k}_t + (1-\alpha)\hat{x}_t \tag{B1}$$

Total employment

$$\hat{l}_t = \frac{X^*}{L^*}\hat{x}_t + \frac{V^*}{L^*}\hat{v}_t \tag{B2}$$

Unemployment rate

$$\hat{u}_t = -\frac{L^*}{U^*}\hat{l}_t \tag{B3}$$

National account identity

$$\frac{C^*}{Y^*}\hat{c}_t + \frac{I^*}{Y^*}\hat{i}_t = \hat{y}_t \tag{B4}$$

Real investments

$$\hat{i}_t = \hat{\tilde{i}}_t + \hat{q}_t \tag{B5}$$

Wage earners budget constraint

$$\hat{c}_t = \hat{q}_t + \hat{l}_t \tag{B6}$$

First-order condition for labour allocation

$$\hat{y}_t - \hat{l}_t = \hat{q}_t \tag{B7}$$

Probability to find a job

$$\hat{h}_t = \hat{l}_t \tag{B8}$$

Recruiting effectiveness of a single wage earner employed as a recruiter

$$\hat{r}_t = \hat{l}_t - \hat{v}_t \tag{B9}$$

Beveridge curve

$$V^*(1+\hat{v}_t) = \left(1-U^*(1+\hat{u}_t)\right)^{\frac{1}{1-\gamma}} \tag{B10}$$

Capital accumulation

$$\hat{k}_t = (1-\delta)\hat{k}_{t-1} - \delta\hat{i}_t \tag{B11}$$

Nominal investments expenditure measured in wage units

$$\hat{\tilde{i}}_t = \rho_i \hat{\tilde{i}}_{t-1} + \frac{\hat{\varepsilon}_t}{I^*} \tag{B12}$$

Shocks

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + u_t^a \tag{B13}$$

$$\hat{\varepsilon}_t = \rho_\varepsilon \hat{\varepsilon}_{t-1} + u_t^\varepsilon \tag{B14}$$

Measurement errors

$$\hat{\varepsilon}_t^y = \rho_y \hat{\varepsilon}_{t+1}^y + u_t^y \tag{B15}$$

$$\hat{\varepsilon}_t^c = \rho_c \hat{\varepsilon}_{t+1}^c + u_t^c \tag{B16}$$

$$\hat{\varepsilon}_t^{inv} = \rho_{inv} \hat{\varepsilon}_{t+1}^{inv} + u_t^{inv} \tag{B17}$$

$$\hat{\varepsilon}_t^q = \rho_q \hat{\varepsilon}_{t+1}^q + u_t^q \tag{B18}$$

$$\hat{\varepsilon}_t^u = \rho_u \hat{\varepsilon}_{t+1}^u + u_t^u \tag{B19}$$

$$\hat{\varepsilon}_t^v = \rho_v \hat{\varepsilon}_{t+1}^v + u_t^v \tag{B20}$$

where $u_t^y \sim N\left(0, \sigma_y^2\right)$, $u_t^c \sim N\left(0, \sigma_c^2\right)$, $u_t^{inv} \sim\ N\left(0, \sigma_{inv}^2\right)$, $u_t^q \sim N\left(0, \sigma_q^2\right)$, $u_t^u \sim N\left(0, \sigma_u^2\right)$ and $u_t^v \sim N\left(0, \sigma_v^2\right)$. To close the model, we provide the relations between observables and corresponding theoretical variables. Specifically,

$$\hat{y}_t^{obs} = \hat{y}_t + \hat{\varepsilon}_t^y \tag{B20}$$

$$\hat{c}_t^{obs} = \hat{c}_t + \hat{\varepsilon}_t^c \tag{B21}$$

$$\hat{i}_t^{obs} = \hat{i}_t + \hat{\varepsilon}_t^{inv} \tag{B22}$$

$$\hat{q}_t^{obs} = \hat{q}_t + \hat{\varepsilon}_t^q \tag{B23}$$

$$\hat{u}_t^{obs} = \hat{u}_t + \hat{\varepsilon}_t^u \tag{B24}$$

$$\hat{v}_t^{obs} = \hat{v}_t + \hat{\varepsilon}_t^v \tag{B25}$$

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