ACCOUNTING FOR THE MULTIPLE SOURCES OF INFLATION: AN AGENT-BASED MODEL INVESTIGATION

Leonardo Ciambezi
Mattia Guerini
Mauro Napoletano
Andrea Roventini

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CONTACT US

OFCE
10 place de Catalogne | 75014 Paris | France
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ABOUT THE AUTHORS

Leonardo Ciambezi, Université Côte D'Azur, CNRS, GREDEG, France, Institute of Economics and l'Embeds, Scuola Superiore Sant'Anna, Pisa, Italy
Email Address: Leonardo.CIAMBEZI@univ-cotedazur.fr
Mattia Guerini, Department of Economics and Management, University of Brescia, Italy, Fondazione ENI Enrico Mattei, Milano, Italy, Université Côte D'Azur, CNRS, GREDEG, France, Institute of Economics and l'Embeds, Scuola Superiore Sant'Anna, Pisa, Italy
Email Address: mattia.guerini@sciencespo.fr
Mauro Napoletano, Université Côte D'Azur, CNRS, GREDEG, France, Institute of Economics and l'Embeds, Scuola Superiore Sant'Anna, Pisa, Italy, OFCE-SciencesPo, Paris, France
Email Address: mauro.napoletano@sciencespo.fr
Andrea Roventini, Institute of Economics and l'Embeds, Scuola Superiore Sant'Anna, Pisa, Italy, OFCE-SciencesPo, Paris, France
Email Address: andrea.roventini@sciencespo.fr

ABSTRACT

We develop a macroeconomic agent-based model to study the role of demand and supply factors in determining inflation dynamics. Local interactions of heterogeneous firms and households in the labor and goods markets characterize the model. Asymmetric information implies that firm selection is imperfect and depends both on firms' relative prices and on their size. We calibrate the model on EU data by using the method of simulated moments and show that it can generate realistic inflation dynamics and a non-linear Phillips curve in line with recent empirical evidence. We then find that the traditional demand-led explanation of inflation stemming from a tight labor market only holds when selection in the goods markets is mostly driven by relative prices in comparison to firm size. Finally, we study the response of inflation to shocks impacting consumption, labor productivity, or energy costs. The results indicate that only demand shocks lead to wage-led inflation surges. Productivity shocks are entirely passed through to prices without affecting the income distribution. Energy shocks, instead, induce sellers' inflation after changes in both firms' cost structure and profit margins. This is in line with the recent empirical evidence for the Euro Area.

KEYWORDS

Inflation, agent-based models, market structure, mark-up rates, sellers' inflation.

JEL

E31, E32, C63.

Accounting for the Multiple Sources of Inflation: an Agent-Based Model Investigation

Leonardo Ciambezi[1,2] Mattia Guerini[3,4,1,2] Mauro Napoletano[1,5,2] Andrea Roventini[2,5]

[1]*Université Côte D'Azur, CNRS, GREDEG, France*
[2]*Institute of Economics and l'Embeds, Scuola Superiore Sant'Anna, Pisa, Italy*
[3]*Department of Economics and Management, University of Brescia, Italy*
[4]*Fondazione ENI Enrico Mattei, Milano, Italy*
[5]*OFCE - SciencesPo, Paris, France*

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Abstract

We develop a macroeconomic agent-based model to study the role of demand and supply factors in determining inflation dynamics. Local interactions of heterogeneous firms and households in the labor and goods markets characterize the model. Asymmetric information implies that firm selection is imperfect and depends both on firms' relative prices and on their size. We calibrate the model on EU data by using the method of simulated moments and show that it can generate realistic inflation dynamics and a non-linear Phillips curve in line with recent empirical evidence. We then find that the traditional demand-led explanation of inflation stemming from a tight labor market only holds when selection in the goods markets is mostly driven by relative prices in comparison to firm size. Finally, we study the response of inflation to shocks impacting consumption, labor productivity, or energy costs. The results indicate that only demand shocks lead to wage-led inflation surges. Productivity shocks are entirely passed through to prices without affecting the income distribution. Energy shocks, instead, induce sellers' inflation after changes in both firms' cost structure and profit margins. This is in line with the recent empirical evidence for the Euro Area.

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1 Introduction

This paper investigates the multiple sources of inflation surges and the possible different roles of demand and supply factors. We employ an extended version of the agent-based model by Guerini et al. (2018), which is characterized by local search and matching of heterogeneous firms and workers in the labor and goods markets. In the model, asymmetric information implies that prices do not immediately clear the market, and firm selection depends both on firms' relative prices and on firm size so that larger companies can enjoy higher monopolistic power. Even in the presence of fully flexible prices and wages at the firm level, such a market mechanism induces a tighter association between supply side factors and the inflation rate, possibly leading to rich dynamics and the emergence of the so-called "seller's inflation" (see Weber and Wasner, 2023).

The inflation surge witnessed in Europe and the US since the first semester of 2021 has sparked a vivid debate among economists and policymakers. Some works interpreted the inflation surge as an excess-demand phenomenon due to a combination of lax fiscal and monetary policies (Summers, 2021; Bianchi et al., 2023; Cevik and Miryugin, 2024). This view originates from the inflation episodes experienced by developed economies since the Seventies and is theoretically grounded upon the standard New-Keynesian, Dynamic Stochastic General Equilibrium models. According to this view, inflation is the result of a negative discrepancy between the market interest rate and its natural level, which generates an excess demand that, in turn, accelerates wage growth and inflation (see Galı and Gertler, 1999; Woodford, 2003). Conversely, an opposing interpretations casts serious doubts on the demand-driven origins of the current inflation surge. Among the others, Stiglitz and Regmi (2023) argue that the main determinants of the current inflation ramp-up reside in "*industry-specific problems [...] possibly exacerbated by market power and market manipulation*", rather than in the labor markets tightness. Similarly, Weber and Wasner (2023) claim that the current inflation spike is likely to be the result of firms' pricing decisions: in their attempt to protect and expand their profit margins, firms propagate and amplify the supply shocks induced by Covid-19 and by the Russian-Ukraine conflict.

From an empirical viewpoint, there are some differences between the inflation of the 1970s and the one countries have witnessed in the 2020s. First, inflation emerged after the Covid-19 pandemic, a shock that originated outside the economic realm and led to rapid adjustments both in demand and supply (see Baqaee and Farhi, 2022). Second, the monetary policy stance was much more expansionary during the 2010s rather than the 1960s, with the federal funds effective rate over the two decades averaging respectively 0.61% and 4.18% in the US. Third, during the past three decades, a decoupling between productivity and wage growth has also taken place (see Stansbury and Summers, 2018; Baker, 2019; Greenspon et al., 2021). Fourth, the current surge in inflation follows two decades in which most advanced economies have witnessed a rise in both market concentration and average mark-up rates (e.g., De Loecker et al., 2020; Autor et al., 2020). In contrast, the post-WWII period was characterized by an increase in market competition.

In the past years, empirical works associating the surge of inflation to the rise of profit shares and mark-ups have blossomed. The evidence on profit shares is uncontroversial. An International Monetary Fund working paper (Hansen et al., 2023) shows a strong association between the 2022-2023 inflation growth and the rise of import prices and domestic profits. Similar results hold true also in Europe: Hahn (2023) find that corporations have more than compensated for the increases in non-labor costs, contributing to an acceleration in price growth. The OECD Economic Outlook (OECD, 2023) documented a similar trend for unit profits in several advanced economies (see also Glover et al., 2023).

The evidence about the increases in mark-ups is more controversial. Andler et al. (2022) and Konczal (2022) highlight that both corporate profits and mark-ups increased with prices, while wages stayed put in the same period. Gerinovics and Metelli (2023) and Arquié and Thie (2023) find a temporary increase in firm mark-ups in 2021-2022 in the US and France respectively. for the US in 2021-2022. In stark contrast, Manuel et al. (2024) document a decline in mark-ups for the UK after the energy shock episodes and Colonna et al. (2023) argue that while profit shares increased, the mark-ups remained constant in Germany and Italy in 2022. Nonetheless, the President and the Chief Economist of the European Central Bank, respectively Lagarde and Lane, released official declarations indicating that the current inflation surge is also a result of the increase in the profit margins (Lagarde, 2023; Lane, 2023).

To shed light on the possible multiple sources of inflation surges, we develop an Agent-Based Model

(ABM). Agent-based models represent the economy as a complex, evolving system populated by heterogeneous and interacting agents (see Dawid and Delli Gatti, 2018; Fagiolo and Roventini, 2017; Dosi and Roventini, 2019). The model extends the work by Guerini et al. (2018) and it is populated by heterogeneous firms and workers interacting locally in imperfectly competitive labor and goods markets. As the markets are characterized by deep uncertainty, firms set production, prices, and wages following heuristics (Dosi et al., 2010, 2020; Artinger and Gigerenzer, 2024). More specifically, firms set wages according to the previous period's gap between opened and filled vacancies (a measure of the perceived excess demand for labor). Prices are fixed according to a mark-up rule that is an increasing function of the market share growth (the individual firm's perceived market power). Production is set based on expected demand. Local search and matching protocols govern agents' interactions in the labor and goods markets. In the labor market, the probability of a worker matching a firm is an increasing function of the wage posted by the latter. In the goods market we assume that the probability of matching between a consumer and a firm is both a decreasing function of the price posted by a firm and an increasing function of its size.[1] The introduction of a size-effect in matching probability captures the imperfect selection in the market for goods in the spirit of customer market models (see Phelps and Winter, 1970; Greenwald and Stiglitz, 2005, among the others) and it mimics the search and matching algorithm introduced in Fontanelli et al. (2023). It also generates *ceteris paribus* an advantage for large firms as it implies that, given the prices, these firms will be able to attract more customers.

The introduction of imperfect selection in the model is important given the great amount of empirical evidence at odds with the efficient market selection hypothesis (Friedman, 1953). Large and persistent heterogeneity of firms concerning size (Bottazzi et al., 2007; Dosi et al., 2008), mark-up (De Loecker and Warzynski, 2012; Bellone et al., 2016), and productivity (Bartelsman and Dhrymes, 1998; Syverson, 2011) suggest that markets are generally unable to wipe out the least competitive firms and to induce convergence to some kind of "representative" firm. Although the strength of selection inefficiency varies across industries – according to whether competition is more or less price-based vs. differentiation-based (Almudi et al., 2013) – the empirical evidence indicates that various factors, such as brand credibility, advertising, or customer service can reduce price-elasticity of demand and increase customer loyalty (Kanetkar

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[1] Compared to Guerini et al. (2018) we also enrich the model by introducing a banking sector that provides credit to firms, and a central bank that fixes the reference interest rate according to a pure inflation-targeting Taylor rule.

et al., 1992; Lars Gronholdt and Kristensen, 2000; Erdem et al., 2002), possibly fueling a "success-breeds-success" dynamics like the one present in our model. This appears to be especially true for industries with more opportunities for product differentiation, such as retail and consumer goods (Clottey et al., 2008), automotive (Nasir et al., 2020), and technology (Said, 2014).

Our model provides a *Tobinesque* interpretation of inflation as a disequilibrium phenomenon emerging out of the interaction occurring among heterogeneous agents in different segmented markets (Tobin, 1972) [2]. It also adds up to the small but quickly expanding agent-based literature investigating inflation dynamics. A conspicuous number of ABM Macro models address price dynamics indirectly while investigating contiguous topics like monetary policy (Salle et al., 2013), business cycles (Riccetti et al., 2015), or financial instability (Assenza et al., 2015). Aside from Seppecher et al. (2018), relatively few contributions in the ABM literature focus directly on inflation and its determinants. Ashraf et al. (2016) focuses on decentralized interaction and customer markets, while Gualdi et al. (2017) and Knicker et al. (2024) draw policy implications from a stylized macroeconomic ABM with aggregate consumption. At the same time, some papers in the agent-based literature focus on inflation dynamics in open economies, addressing the impact of price shocks on expectations (Alvarez et al., 2020) and on income distribution (Rolim et al., 2022). Finally, the works of Poledna et al. (2023), Hommes et al. (2022), and Grazzini et al. (2023) develop a behavioral agent-based model with an emphasis on forecasting performance and use it to explain the macroeconomic impact of the COVID-19 pandemic for Austria and Canada. This latter strand of contributions is the most similar to ours. All these works employ a computational model in which agents employ adaptive heuristic rules to form expectations and make economic decisions, and they investigate post-pandemic inflation dynamics with a focus on forecasting performance. Our contribution, however, differs from theirs in that we focus mainly on the microeconomic drivers of inflation and, in particular, on the characteristics of the market selection process, leaving aside the problem of forecasting.

We calibrate our model using the Method of Simulated Moments (see Windrum et al., 2007; Chen et al., 2012; Fagiolo et al., 2019) and European Union data on key macroeconomic variables over the past 25 years. Extensive Monte Carlo simulations with the calibrated model show that it can generate realistic

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[2] Our interpretation of inflation outlined above is complementary, and not competing, with those views that trace back the roots of inflation to conflicting claims over real income by different groups of economic agents (see for example Lorenzoni and Werning, 2023; Hein, 2024; Lavoie, 2024). It is also akin to the concept of "granularity" of inflation recently proposed by Alvarez-Blaser et al. (2024).

inflation dynamics and a non-linear Phillips curve, agreeing with recent empirical works (Gagnon and Collins, 2019; Benigno and Eggertsson, 2023). We also show that the nature of inflation strongly depends on the characteristics of market selection in the market for goods. When selection in that market is close to perfect - and therefore competition is largely driven by price differences among firms - the market structure becomes less concentrated. In such a scenario, higher aggregate demand and widespread labor shortages push money wages upwards, increasing the pressure on prices. This is consistent with the traditional "demand-led" explanation of inflation. In contrast, as market selection becomes more and more imperfect, the allocation of market shares is increasingly affected by the size of the firms that gain monopolistic power. In such a scenario, the variability in mark-ups explains the rise of inflation with the emergence of a profit-price spiral (see also Tobin, 1972).

Finally, we analyze the impact of demand, productivity, and energy shocks on aggregate output, inflation, and market structure. A positive demand shock increases production and leads to a scarcity of labor, which in turn pushes up wages and prices. The result is a temporarily higher inflation rate accompanied by a moderate fall in mark-ups and profit shares. A negative supply shock to labor productivity increases inflation, as firms completely pass through the impact to consumers. Still, the shock does not significantly impact either mark-ups or the profit share. On the contrary, a shock increasing energy costs generates a profit-led inflation (Weber and Wasner, 2023), which stems from both changes in firms' relative cost structure and higher market concentration.[3] The former channel leads to an increase in the profit share, as nominal wages do not respond to the increased energy costs (in line with Manuel et al., 2024; Colonna et al., 2023). The second channel dampens market competition, thus spurring firms' profit margins (Konczal, 2022; Gerinovics and Metelli, 2023). Our results replicate the recent empirical evidence on the surge of profit-led inflation in the Euro Area (see e.g. the work of Hansen et al., 2023).

The rest of the paper is structured as follows: Section 2 introduces the model, while Section 3 presents the calibration procedure results of the first set of Monte-Carlo simulations, showing the explanatory capability of the model. Section 4 explores the impact of different demand and supply shocks on macroeconomic dynamics. Finally, Section 5 concludes.

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[3] see (Weber et al., 2024) for a representation of the cost-price relationships during the Ukraine war inflation in the US.

2 The Model

We consider a closed economy populated by F firms, H households, a bank, and a central bank. Time is discrete, indexed by "weeks" t = 1, …, T. There are 52 weeks per "year". Firms produce a homogeneous consumption good using a linear technology that employs only labor. Households supply labor inelastically and consume the final good using the income received by firms and their stock of liquid wealth. In the good and labor markets, firms and households locally interact via decentralized protocols. The commercial bank collects deposits from households, and it provides loans to firms. The central bank adopts a single-mandate Taylor Rule in to steer the economy towards an inflation target.

2.1 Timeline of events

In any given time period *(t)*, the following microeconomic decisions take place in sequential order:

1. Financial state variables are updated. Firms and bank update their balance sheets, and households update their wealth.
2. The central bank fixes the reference interest rate. Inflation expectations by households and firms are updated.
3. Bankrupted firms exit from the economy and are replaced by new ones on a one-to-one basis.
4. Firms set their mark-up rate, the offered wage and their production target; they compute their demand for labor and selling price accordingly.
5. Firms compute their loan demand and the bank decides whether or not to grant credit.
6. Households compute their desired consumption levels.
7. The labor market opens. Employers and employees are matched. Production takes place. Households receive their wages.
8. The goods market opens. Firms and consumers are matched.
9. Firms and the bank compute their profits and distribute dividends to households. Households calculate their realized consumption expenditure and their savings.

10. At the end of each time step, aggregate variables (e.g., GDP, investment, employment) are computed by summing over the corresponding microeconomic variables.

2.2 Central bank policy

The weekly inflation rate is defined as:

$$\pi_t = \frac{\bar{P}_t - \bar{P}_{t-1}}{\bar{P}_{t-1}}, \tag{1}$$

where $\bar{P}_t = \sum_{f=1}^{F} P_{f,t} s_{f,t}$ is the average price set by firms at time t, weighted by their market shares $s_{f,t}$. Every six weeks the central bank computes the average inflation rate of the past "year" (i.e., the average inflation of the past 52 weeks $\tilde{\pi}_t = \frac{\sum_{k=1}^{52} \pi_{t-k}}{52}$), and it uses it to set the reference interest rate ρ_t^0 by using a single-mandate Taylor Rule to steer the economy towards a target inflation rate π^*:[4]

$$\rho_t^0 = \rho^* + \phi(\tilde{\pi}_t - \pi^*), \tag{2}$$

where $\rho^* > 0$ is a "target" interest rate and $\phi > 1$ represents the reaction coefficient to the inflation gap.[5]

2.3 The expectation formation process

Following Salle et al. (2013), we assume that inflation expectations by firms and households are a linear combination between the last period inflation and an inflation anchor.[6] This formulation is a special case of the First Order Heuristic (FOH) introduced by Heemeijer et al. (2009) to interpret the forecasting behavior of human subjects in laboratory experiments. The FOH combines an anchoring term with a trend-extrapolating term and can be expressed as

$$\hat{\pi}_t = [(1-\chi)\pi_{t-1} + \mu_{exp}\hat{\pi}_{t-1} + (\chi - \mu_{exp})\pi^*] + \gamma_{exp}(\pi_{t-1} - \pi_{t-2}), \tag{3}$$

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[4] The inflation target π^* in the central bank's Taylor rule is a time-invariant parameter while the inflation rate used as a reference by the central bank, $\tilde{\pi}_t$, is a moving average of past realized inflation. In a model like ours with a relatively fine-grained time resolution, the choice for aggregating past realized inflation is motivated by the need to avoid the monetary authority being too reactive to short-run price fluctuations.

[5] A zero lower bound is enforced to prevent ρ_t^0 falling below zero. Parameter values in the baseline setting of the model are reported below, in Table 1.

[6] The relevance of past inflation for the expectation formation process has been recently highlighted by Candia et al. (2023). Furthermore, the expectation formation rule here adopted is grounded on the laboratory experiments by Anufriev and Hommes (2012) and Assenza et al. (2021), among others.

where χ and μ_{exp} are non-negative parameters, assumed homogeneous across firms, satisfying $\mu_{exp} \leq \chi$. The first term – in square brackets – represents the anchoring, expressed as a weighted average of lagged inflation (π_{t-1}), past expectations ($\hat{\pi}_{t-1}$), and the inflation target (π^*).The second term captures the trend extrapolative behavior of the agents and is proportional to the lagged first difference of inflation ($\pi_{t-1} - \pi_{t-2}$).[7]

For the sake of simplicity, in the baseline parametrization of our model, we adopt a simplified version of the FOH, where $\mu_{exp} = \gamma_{exp} = 0$. This implies that agents' expectations are fully anchored and are a weighted average between lagged inflation and the inflation target, with no trend-extrapolating force. This aligns with empirical evidence documenting the anchoring of inflation expectations since the 1980s (see Blanchard, 2016), which does not appear to have been undermined by the recent inflation surge (Baumann et al., 2025). Nevertheless, in Section 3.3 we also simulate the model with alternative combinations of μ_{exp} and γ_{exp} to better investigate the effects exerted by the anchoring and trend extrapolating behaviors on inflation dynamics.

2.4 Production, wages, and prices

In each period, firms set their production level and the price and wage they offer to workers. At the same time, households set their desired consumption. Output is perishable and cannot be stored for the next period.

The production of the consumption good takes place by a linear production function employing only labor ($n_{f,t}$) as input:

$$q^s_{f,t} = a_{f,t} n_{f,t}, \tag{4}$$

where $a_{f,t}$ is the firm-specific labor productivity, which we assume to be subject to idiosyncratic mean zero random shocks.

In the second experiment of Section 4 we hit the economy with a 5% reduction of labor productivity $a_{f,t}$ at $t^* = 1600$, to study the impact of this kind of shock on the model dynamics. The dynamics of the

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[7] For further details on the FOH and its implications for behavioral learning equilibria, see Hommes and Zhu (2014). An application of these behavioral rules to a macroeconomic ABM with high forecasting performance can be found in Poledna et al. (2023).

shock is the following:

$$a_{f,t} = a_{f,t^*}(1-\eta_t) \text{ where } \begin{cases} \eta_t = 0 \text{ if } t < t^* \\ \eta_t = \mu_\eta \text{ if } t \in (t^*, t^*+3) \\ \eta_t = \rho_\eta \eta_{t-1} \text{ if } t > t^*+3 \end{cases} \tag{5}$$

It follows that firms' labor productivity decreases by an amount μ_η for a 4-weeks period. Starting from the fifth week, the shock decays at a rate ρ_η. (we set $\mu_\eta = 0.05$ and $\rho_\eta = 0.95$).

Firms set their desired production ($\widehat{q}_{f,t}$) according to:

$$\widehat{q}_{f,t} = \tilde{q}_{f,t} + \alpha^g z^{good}_{f,t-1}, \tag{6}$$

with $\alpha^g > 0$. The term $\tilde{q}_{f,t}$ captures the reference or "normal" production level, in line with the insights from behavioral economics about reference-dependence and satisficing behavior by firms (see e.g. Cyert and March, 1963; Simon, 1955), while the term $z^{good}_{f,t-1}$ is the excess demand experienced by firm f at time $t-1$ or, in other words, the difference between received orders and production: $z^{good}_{f,t-1} = q^d_{f,t-1} - q^s_{f,t-1}$.

The above rule implies that deviations from the reference level of production are due to past excess demand. The reference level itself evolves adaptively with past sales:

$$\tilde{q}_{f,t} = \tilde{q}_{f,t-1} + \alpha^g(q_{f,t-1} - \tilde{q}_{f,t-1}) \tag{7}$$

Substituting Equation 7 into Equation 6 we obtain the following adaptive rule:

$$\widehat{q}_{f,t} = (1-\alpha^g)\tilde{q}_{f,t-1} + \alpha^g(q_{f,t-1} + z^{good}_{f,t-1}). \tag{8}$$

The above rule implies that firms set their desired production by adapting their reference levels to observed market signals (represented by the gap between demand and supply). To see this, consider that the level of realized sales in the model, $q_{f,t-1}$, is determined by the short side of the market (see also Section 2.7.2): $q_{f,t-1} = min\{q^d_{f,t-1}, q^s_{f,t-1}\}$. Therefore, if firm demand was higher than firm supply in the previous period ($q^d_{f,t-1} > q^s_{f,t-1}$), one gets $q_{f,t-1} = q^s_{f,t-1}$ and $q^s_{f,t-1} + z^{good}_{f,t-1} = q^d_{f,t-1}$. In this case, firm desired production is a linear combination of the past reference production level $\tilde{q}_{f,t-1}$ and of past demand $q^d_{f,t-1}$. In other words, desired production is increased with respect to the previous reference level by a factor proportional to observed demand $q_{f,t-1}$. In contrast, if past demand was lower than supply, one gets $q_{f,t-1} = q^d_{f,t-1}$, and production rises less than demand because $(q_{f,t-1} + z^{good}_{f,t-1}) \leq q^d_{f,t-1}$.[8]

Each firm f sets the money wage $W_{f,t}$ as follows:

$$W_{f,t} = W_{f,t-1}(1 + \hat{\pi}^+_{f,t})^{\beta^l}(1 + z^{lab}_{f,t-1})^{\alpha^l}, \tag{9}$$

with $\beta^l > 0$, $\alpha^l > 0$ and $\hat{\pi}^+_{f,t} = max\left\{\hat{\pi}_{f,t}, 0\right\}$. More precisely, we assume that firms use the monetary wage posted the previous week as a benchmark, and they adjust it according to the expected current inflation level (if positive) to account for formal and informal indexation mechanisms operating in the wage formation process.

Furthermore, nominal wage growth is influenced by the state of the labor market through the term $z^{lab}_{f,t-1}$, which represents the ratio between the vacancies left unfilled in the previous period and the total opened vacancies. This implies that an increased gap between open and filled vacancies will push a firm to increase its wage to attract more workers (see e.g. Mortensen and Pissarides, 1999; Diamond, 1982). On the contrary, labor market slack resulting in a decrease in the above gap will also result in lower nominal wage growth. This formulation can be considered a formal representation of the idea expressed by Tobin (1972) of wage growth being the sum of two components, an equilibrium component (represented in the model by anchored inflation expectations), or the rate at which wages would grow with no vacancies, and a disequilibrium one, which can be considered a function of excess demand.

However, note that labor market slack in our model never results into negative nominal wage growth, as the rate of unfilled vacancies at each period $z^{lab}_{f,t}$ can only take non-negative values. This implies that our model features downward nominal rigidity in accordance with a large amount of empirical evidence

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[8] It is worth noting that, if we interpret the production target $\widehat{q}_{f,t}$ as the expectation by the firm over the demand it is going to face in period t, the adaptive rule outlined in Equation 8 can be thought as analogous with the First Order Heuristic rule for inflation expectations in Equation 3, with $(1 - \alpha^g)$ representing the weight on the long-run or reference value of production, and α^g the weight on observed last period demand, no trend extrapolating term and no autoregressive term. However, an important difference from Equation 3 is that here the normal value of production $(\tilde{q}_{f,t})$ is not exogenous and static like the inflation target (π^*), but it is itself a moving average of past realized sales. In addition, the firm past demand contribution depends on the observed gap with supply.

on the functioning of the labor market.[9]

The assumption of downward money-wage rigidity does not prevent real wages from adjusting. On the contrary, even if money wages cannot be compressed, the firm has always the power to set prices above wages with the rate of profit margins being determined by the market structure (see below Equation 11). Therefore, real wages can fall, but this happens because of a higher price growth in relation to money wage growth, and not because of a decrease in money wages. This makes our model different from New-Keynesian models that generate involuntary unemployment by assuming real wage rigidities (e.g. Blanchard and Galí, 2006). In other words, in line with Tobin (1972), our economy has an "inflationary bias", displaying positive long-run inflation as a natural outcome when the economy is close to full employment, breaking therefore the "divine coincidence" feature of New Keynesian models (Blanchard and Galí, 2007).

Firms employ a full-cost pricing heuristic (see e.g. Hall and Hitch, 1939) to set their prices. Being labor the only factor of production, the unit production cost $C_{f,t}$ of a firm is equal to:

$$C_{f,t} = \frac{W_{f,t}}{a_{f,t}} \tag{10}$$

Firms apply a variable mark-up ($\mu_{f,t}$) over their unit costs of production. The price ($P_{f,t}$) posted by the firm therefore is:

$$P_{f,t} = C_{f,t}\left(1 + \mu_{f,t}\right). \tag{11}$$

While our benchmark specification of the model includes a single input (labor), later in the analysis (see Section 4) we operate an extension to account for a second, non-labor input. The aim is to assess the consequences of an energy price shock akin to the one experienced by most European economies after Russia invaded Ukraine in February 2022. To keep this extension as simple as possible, we assume a fixed-proportion production process wherein a firm employs $\frac{1}{a_{f,t}}$ units of labor and energy, such that the unitary cost of production becomes:

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[9] For the U.S., see Akerlof et al. (1996), Kahn (1997) and Daly and Hobijn (2014), among many others. Individual-level evidence for a large number of countries is in Dickens et al. (2007). Kahneman et al. (1986), Bewley (1999, 2007) provide extensive anecdotal and survey evidence on downward nominal wage rigidities in the United States and Germany. Holden and Wulfsberg (2008) provide multi-country evidence from industry-level data.

$$C^*_{f,t} = \frac{W_{f,t} + k_{f,t}}{a_{f,t}} \tag{12}$$

where $k_{f,t}$ denotes the price of the energy input. Thus, the price-setting equation for a generic firm then reads:

$$P^*_{f,t} = \frac{W_{f,t} + k_{f,t}}{a_{f,t}}(1 + \mu_{f,t}) \tag{13}$$

Mark-up rates change over time according to the variation in the firm's market share $s_{f,t} = \frac{q_{f,t}}{\sum_g^F q_{g,t}}$:

$$\mu_{f,t} = \mu_{f,t-1} + \nu(s_{f,t-1} - s_{f,t-2}), \tag{14}$$

with $\nu > 0$. Such a rule implies that firms consider the variation of their market shares as a proxy of the degree of their market power (as in Dosi et al., 2010, 2013). In addition, the above rule is in line with the recent empirical evidence indicating that industries with larger firms and more concentrated market structures are associated to higher mark-up rates (see e.g. Autor et al., 2020; De Loecker et al., 2020).

2.5 Consumption

We assume that households set their desired consumption $\widehat{c}_{h,t}$ according to a buffer-stock consumption rule, analogous with the one developed in Carroll et al. (1992) and Carroll (1997). In particular, households make their consumption decisions by targeting a given "cash-on-hand ratio", defined as the ratio between wealth and "normal income" $\frac{A_{h,t}}{\bar{Y}_{h,t}}$ (see Carroll, 2001). $A_{h,t}$ indicates the household's stock of nominal wealth, which evolves according to the past household's savings flow (see equation 27). The "normal income" $\bar{Y}_{h,t}$ (also expressed in nominal terms) evolves adaptively according to past realized income, which includes both wage and dividends (cf. equations 17 and 27):

$$\bar{Y}_{h,t} = \left[\bar{Y}_{h,t-1} + \alpha_y \left(Y_{h,t} - \bar{Y}_{h,t-1}\right)\right](1 + \pi_{t-1}) \tag{15}$$

with $\alpha_y > 0$ being a parameter that captures the speed of adjustment. Household's desired consumption is written as:

$$\widehat{c}_{h,t} = \bar{Y}_{h,t}\left[1 + \delta_0\left(\delta_1\frac{A_{h,t}}{\bar{Y}_{h,t}} - 1\right)\right] \tag{16}$$

with $\delta_0 > 0$ and $\delta_1 > 0$ representing respectively the consumption adjustment and the cash-on-hand ratio sensitivity. If the actual cash-on-hand ratio is greater than the target, the agent has been "overcautious" and will save less; if cash-on-hand is below the target instead, the household will save more to bring the wealth ratio back toward the target $\frac{A_{h,t}}{\bar{Y}_{h,t}}$. Finally, if the real wealth $\frac{A_{h,t}}{\hat{P}_t}$ of a household is not sufficient to cover planned expenses (i.e., the desired consumption is outside the feasible consumption set), the household will consume all its real wealth without any form of saving.

The main difference between Carroll's buffer-stock saving rule and our setup is that we assume households to have adaptive expectations about normal income (cf. equation 15) instead of facing a given income distribution centered around a "permanent" income mean. In line with the empirical evidence about excess smoothness (Flavin, 1993), our assumption also implies that, after an income shock, a household needs some weeks to adjust to the new level of consumption.

Total savings $S_{h,t}$, computed at the end of the period, are equal to the difference between the effective levels of nominal income and nominal consumption. Nominal consumption is equal to $\sum_{f=1}^{F} P_{f,t} c_{h,t}$, while nominal income corresponds to the sum of the earned wage $W_{h,t}$, the fraction of firms and bank profits paid as dividends, $D_{h,t}$, and returns on deposits $\rho_t^d A_{h,t}$:

$$S_{h,t} = W_{h,t} + D_{h,t} + \rho_t^d A_{h,t} - \sum_{f=1}^{F} P_{f,t} c_{h,t} \tag{17}$$

2.6 The credit market

The banking sector is constituted by one commercial bank. In analogy to Popoyan et al. (2017), we assume the interest rate on deposit is equal to the reference rate fixed by the central bank, i.e. $\rho_t^d = \rho_t^0$, while the interest rate on loans is $\rho_t^l = \rho_t^0 + \varsigma$, with $\varsigma > 0$ being a fixed positive spread. The bank has a positive initial net worth NW^b and, like firms, it redistributes a fixed share of its profits to households at each period.

The demand for credit stems from firms' production plans. More specifically, each firm computes its demand for credit ($L_{f,t}^d$) as the difference between the production costs it expects to sustain in the next period and its internal financial resources, that is $L_{f,t}^d = max\left\{n_{f,t} W_{f,t} - NW_{f,t}, 0\right\}$.

When a firm applies for credit, the bank checks its loan-to-value ratio ($\frac{L_{f,t}^d}{NW_{f,t}}$) and fully satisfies firms' credit demand if $\frac{L^d_{f,t}}{NW_{f,t}} \leq \mathscr{E}_t$. Otherwise, the bank provides credit just up to $\mathscr{E}_t NW_{f,t}$, and the rationed firm is forced to scale down its production accordingly. The credit threshold coefficient $\mathscr{E}_t > 0$ is time-varying, and it is a decreasing function of the real interest rate, in accordance with the literature on the bank-lending channel of monetary policy (Bernanke, 2007; Disyatat, 2011):

$$\mathscr{E}_t = \mathscr{E}[1 - \theta(\rho^0_t - \pi_t)], \tag{18}$$

where $\theta > 0$ represents the sensitivity of the credit threshold to the weekly real interest rate ($\rho^0_t - \pi_t$). The variable $\mathscr{E}$ represents the baseline threshold level (that is, the maximum credit ratio the bank would be willing to accord if the real interest rate was zero). The intuition behind this relation is that the perceived strength of the bank's balance sheets affects its willingness to supply loans. Whenever an indebted firm is unable to repay the loan and goes bankrupt, the bank absorbs the corresponding "bad debt". As a rise in interest rates reduces the capability of firms to pay back their loans, the bank tightens its credit supply to hedge against the increasing default probability. Although this mechanism is not modeled explicitly here, our assumption is in line with ample evidence showing that banks react to monetary tightening by decreasing lending (Altunbaş et al., 2002; Gambacorta, 2005; Gambacorta and Marques-Ibanez, 2011) conditional to their capitalization, risk profile and liquidity.

2.7 The search and matching process in the labor and goods markets

Firms and workers interact locally in both the goods and labor markets according to a search and matching protocol similar to the one introduced in Guerini et al. (2018). We first describe the search and matching process in the labor market and, next, the one in the market for goods.

2.7.1 The labor market

Firms in the labor market hire workers to fulfill their production plans. Labor demand ($n^d_{f,t}$) is equal to:

$$n^d_{f,t} = \frac{\widehat{q}_{f,t}}{a_{f,t-1}} \tag{19}$$

Each worker supplies one unit of labor inelastically and has a zero reservation wage.

The matching between firms and workers is local. Firms post their vacancies and wage quotes. Workers sort firms randomly and sequentially decide whether to queue up or not for the open vacancies with a probability that is increasing in the offered salary. More formally, a worker decides to queue up or not for a job according to a binomial draw with probability $p^{LM}_{f,t}$:

$$\Phi^{LM}_{h,t} = \begin{cases} 0 \text{ with probability } 1 - p^{LM}_{f,t} & \text{(not queuing up)} \\ 1 \text{ with probability } p^{LM}_{f,t} & \text{(queuing up)} \end{cases} \tag{20}$$

The probability of queuing $p^{LM}_{f,t}$ is proportional to the wage offered by the firm, relative to the market-average one:

$$p^{LM}_{f,t} = 1 - \varrho^{LM} \left[1 - \left(\frac{W_{f,t} - \bar{W}_t}{\bar{W}_t} \right) \right]. \tag{21}$$

$\bar{W}_t$ is the market average wage and $\varrho^{LM} \in (0, 1)$ is a parameter determining the degree of search frictions and imperfect information in the labor market. Note that the probability of queuing is an increasing function of ϱ^{LM}. Therefore, the lower the value of ϱ^{LM}, the higher the probability that workers will queue up for any given difference between the firm's wage and the average one. When a firm has filled all of its vacancies, workers stop looking for jobs at that specific firm, regardless of the wage posted.

Finally, the effective units of labor at the firm level ($n_{f,t}$) are determined by the short side of the market according to:

$$n_{f,t} = min(n^d_{f,t}, n^s_{f,t}) \tag{22}$$

Note that decentralized matching implies that frictional unemployment (or labor rationing) may arise even when the notional aggregate labor demand and aggregate labor supply are equal.

2.7.2 The goods market

Right after the labor market closes and workers have been allocated to the firms, the production of goods takes place by the linear production process specified in Equation (6) and the goods market opens.

The allocation of total consumption demand across firms is determined by a local search and matching process similar to the one described above for the labor market. The main difference is that consumers do not sort firms randomly but according to their market share, and they start looking for sellers with a preferential attachment to the largest companies.[10] The assumption that consumers sort firms according to their size in the above matching protocol proxies the fact that larger firms have also better distribution channels and are therefore more visible to customers and able to grow. It also implies that the selection process of firms in the goods market is imperfect, as it does not just depend on prices but also other firm characteristics (like firm size). Finally, it generates dynamic increasing returns in market selection, as larger firms can match with more customers for any given price posted (see Fontanelli et al., 2023, for a similar approach to the analysis of international trade dynamics). The above micro-foundation of market selection builds on customer market models with imperfect competition and stochastic matching between consumers and producers (see for example Phelps and Winter, 1970; Bils, 1989; Rotemberg and Woodford, 1991; Greenwald and Stiglitz, 2005). Furthermore, the presence of dynamic increasing returns in market selection is in line with several evolutionary models of market dynamics (see e.g. Arthur, 1989; Dosi and Kaniovski, 1994; Pagano and Schivardi, 2003; Dosi et al., 2019).

Once firms are sorted according to their size, consumers decide whether to queue up or not for the goods sold by the firms in their list with a binomial trial with probability $p^{GM}_{f,t}$.

$$\Phi^{GM}_{h,t} = \begin{cases} 0 \ \text{ with probability } \ 1 - p^{GM}_{f,t} & \text{(not queuing up)} \\ 1 \ \text{ with probability } \ p^{GM}_{f,t} & \text{(queuing up)} \end{cases} \tag{23}$$

A household queues up at one firm only, demanding $\widehat{c}_{h,t}$ units of the good. [11] The probability of queuing is proportional to the price posted by the firm relative to the market average:

$$p^{GM}_{f,t} = \rho^{GM} - \frac{P_{f,t} - \bar{P}_t}{\bar{P}_t} \tag{24}$$

With $\rho^{GM} \in (0, 1)$. Once all the households have queued up, the effective amount of product sold by a firm is determined by the short side of the market:

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[10] The preferential attachment process has been largely empirically verified over several domains. See, e.g., Barabási and Albert (1999) among many.

[11] This also implies that, if a firm cannot satisfy the demand of a consumer, then the consumer gets rationed.

$$q_{f,t} = min\{q^d_{f,t}, q^s_{f,t}\} \tag{25}$$

By varying the value of the parameter ρ^{GM} in Equation 24, one can tune the intensity of the firm size advantage in the matching process between firms and customers and therefore the degree of imperfection in the market selection process. In particular, higher values of ρ^{GM} imply a higher probability of matching for any given price, capturing a higher advantage for larger firms (i.e., those that can exploit their "prominence" on the market and are sorted first by consumers). In the simulation analyses in sections 3 and 4 we exploit the above properties intensively, and we present results for different values of ρ^{GM}, which capture scenarios where market selection is more or less imperfect. [12]

At the end of the firm-customers matching process, households determine their effective real consumption $c_{h,t} \leq \widehat{c}_{h,t}$ and their consumption expenditures $\sum_{f=1}^{F} P_{f,t} c_{h,t}$. According to the scenario analyzed (see Section 3.1 and 4), final consumption can be shocked, to simulate a rise or a fall in personal consumption expenditure.

More precisely, we consider a uniform change in the value of household consumption at time $t^{\star}$. The dynamics of the shock is the following:

$$c_{h,t} = c_{h,t^{\star}}(1+\eta_t) \qquad \text{with} \begin{cases} \eta_t = 0 & \text{if1} \quad t < t^{\star} \\ \eta_t = \mu_\eta & \text{if } t \in (t^{\star}, t^{\star}+3) \\ \eta_t = \rho_\eta \eta_{t-1} & \text{if } t > t^{\star}+3 \end{cases} \tag{26}$$

Households increase their consumption by an amount μ_η for a 4-weeks period. Starting from the fifth week, the shock decays at a rate ρ_η.

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[12] The above assumptions about how firms and customers interact also allow us to retain an important property of the model by (Guerini et al., 2018), namely the emergence of coordination failures in labor and goods markets which, through the amplifying role of positive demand feedbacks, can generate involuntary unemployment even when real wages are falling.

2.8 Financial conditions, exit, and entry

After the matching process in the goods market, households also compute savings as in (17) and update their wealth ($A_{h,t+1}$) according to:

$$A_{h,t+1} = A_{h,t} + S_{h,t} \tag{27}$$

Households store at each time step all of their savings as deposits at the bank.

Firms' profits $\Pi_{f,t}$ are equal to total sales revenues net of labor costs and interest payments:

$$\Pi_{f,t} = q_{f,t}P_{f,t} - n_{f,t}W_{f,t} - \rho^l L_{f,t} \tag{28}$$

Whenever profits are positive, firms distribute a fraction ω_1 as dividends to households, and then a fraction ω_2 to a fund that bails in bankrupted firms (firms' bankruptcy protocol is illustrated in the next paragraph) The law of motion of the firm's net worth is therefore:

$$NW_{f,t} = \begin{cases} NW_{f,t-1} + (1-\omega_1)(1-\omega_2)\Pi_{f,t} & \Pi_{f,t} \geq 0 \\ NW_{f,t-1} + \Pi_{f,t} & \Pi_{f,t} < 0 \end{cases} \tag{29}$$

We assume that firm and bank ownership are symmetric across households. Accordingly, each household receives a fraction $1/H$ of the dividends paid by each firm and by the bank. If profits are negative, the firm's net worth is reduced accordingly. A firm is declared bankrupt whenever its net worth becomes negative. In such a situation, the firm exits the market, and it is replaced by a new entrant. The net worth of the new firms is drawn from a bail-out fund, and it is equal to its initialization value (indexed by price level), while the bank absorbs bad debt. The bailout fund is financed through a contribution by incumbent firms, that put a share of profits $\omega_2 > 0$ into the fund every week they realize a positive profit. [13]. Households own an equal share of the new firm, receiving its future dividends (if any). Finally, prices, wages and desired production of the entrant are computed as the weighted (by market shares) average of the incumbents.

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[13] The bail-out fund makes the model stock-flow consistent, in the sense that all the resources needed to finance firm entry are drawn from firm profits within the model (see Godley and Lavoie, 2006, for an extensive illustration of stock-flow consistency.)

Table 1: Baseline parametrization

	Parameter Description	**Parameter Value**
T	Simulation length	2000
MC	Number of Monte Carlo Simulations	100
H	Number of households	500
F	Number of firms	50
χ	Expectation anchoring coefficient	0.7
γ_{exp}	Expectation trend-extrapolating coefficient	0.0
μ_{exp}	Expectations AR coefficient	0.0
α^l	Wage adjustment coefficient	0.1
α^g	Supply adjustment coefficient	0.1
ν	Mark-up sensitivity to market shares	0.8
β^l	Inflation indexation parameter	1
δ_0	Consumption adjustment coefficient	0.5
δ_1	Consumption - Cash-on-hand ratio	0.2
α_y	Consumption - Permanent income adjustment	0.5
$\mathscr{E}$	Debt to Equity threshold	10
θ	Real interest rate effect on credit	300
π^*	Inflation target	2 %
ρ^*	Baseline weekly deposit rate	0.02 %
ρ^1	Baseline weekly loan rate	0.05 %
ϕ	Monetary policy intensity	1.1
γ^{LM}	Matching friction labor	0.2
ρ^{GM}	Firm size advantage in market selection	0.4
ω_1	Firm share of profit distributed to households	0.5
ω_2	Firm share profits distributed to “bailout fund”	0.5

3 Simulation Results

We calibrate our model using the Method of Simulated Moments (see Windrum et al., 2007; Chen et al., 2012; Fagiolo et al., 2019). First, we repeatedly simulate the model for a set of points located in the high-dimensional parameter space. We then select as our baseline configuration the parameter vector that minimizes a loss function built on the distance between a set of empirical moments and their simulated counterparts. The empirical moments that we would like to match include the average of inflation, unemployment, mark-up rates, price dispersion, market concentration, and the nominal wage growth for the European Union over the past 25 years. To limit the computational search, only the most relevant parameters are calibrated, namely the degree of competitiveness in the goods and labor markets (ρ^{GM}, γ^{LM}), the sensitivity of wages to labor shortages (α^l), the link between mark-ups and market shares (ν) and the degree of anchoring of expectations (χ). Table 2 provides a direct comparison of the average value of the main macroeconomic variables in our baseline calibration and the real-world data. Our calibration exercise provides a satisfactory matching for all the moments of interest.

Table 2: Baseline output validation

Variable	Model	EU data
Inflation	2.7% (0.06%)	2.1%
Unemployment	8.6% (0.2%)	8.8%
Mark-up	20.6% (0.4%)	20%
Cross-sectional price dispersion	2.8% (0.13%)	3%
Market concentration (HHI)	15.8% (0.4%)	18%
Nominal wage growth	2.74% (0.3%)	2.5%

Inflation: FRED Consumer Prices average for 2000-2022.
Unemployment: FRED average for 2000-2022.
Mark-up rates: Christopoulou and Vermeulen (2012) for 1981-2004.
Price dispersion: (Reiff and Rumler, 2014)
Market concentration: Christopoulou and Vermeulen (2012) for 1981-2004.
Nominal wage growth: FRED Hourly Earnings: Private Sector average for 2000-2022
Real wages: Difference between nominal wage growth and price growth

We investigate the properties of the calibrated model by extensive Monte Carlo simulations. More precisely, we perform $MC = 100$ Monte Carlo runs for the baseline parametrization of the model (see Table 1). Each Monte Carlo run is iterated over 2000 periods (or “weeks”), which are enough for the model to converge to a statistical equilibrium for all the aggregate variables of interest.[14]

Figure 1 shows the dynamics of a typical run of the model for key macroeconomic variables: output, inflation, mark-up and unemployment. To facilitate comparisons with real-world data, we apply a centered moving average (MA) filter of order 12 to consolidate the weekly data points into quarterly data, thus getting rid of higher-frequency variability. The plots in Figure 1 reveal the emergence of endogenous business cycles of varying amplitude and duration in the model-generated time-series. We also compute cross-correlation functions to study the relationships among the macro variables across business cycle

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[14] The first 1500 simulated periods are then discarded from the analysis to allow the model to exit the transition phase.

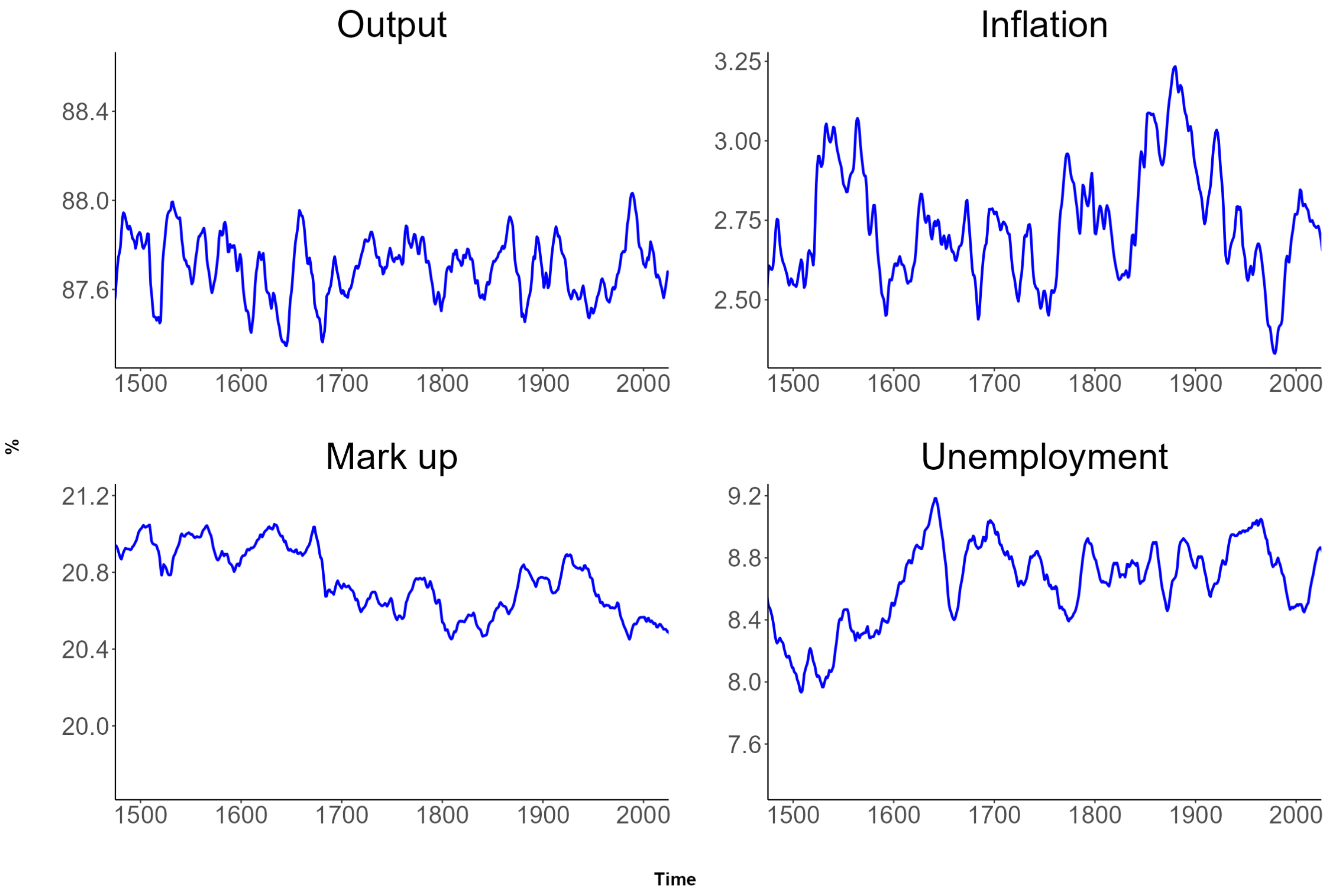

Figure 1: A typical run of the model for key macroeconomic variables: output (top-left), inflation (top-right), mark-up rate (bottom-left) and unemployment rate (bottom-right) as a function of simulation time.

frequencies. The results are reported in Figure 2. In accordance with the empirical literature (Stock and Watson, 1999; Napoletano et al., 2006), we find that unemployment is countercyclical, while inflation is procyclical and lags the business cycle. Moreover, agreeing with the evidence provided by Bils et al. (2018), the mark-up rate is countercyclical.

After showing the ability of the calibrated model to replicate realistic features of macroeconomic dynamics, we focus our investigation on the different sources and drivers of inflation dynamics, both at the macro and at the micro levels. Such analysis explicitly considers how the intensity of goods market selection affects firms' market power and, in turn, inflation dynamics. In the model, the intensity of market selection can be controlled by changing the parameter ρ^{GM} in Equation 24. In that respect, recall that low values of ρ^{GM} capture a scenario wherein market selection has fewer frictions because firm size plays a smaller role in the matching process between firms and customers, and competition is mostly driven

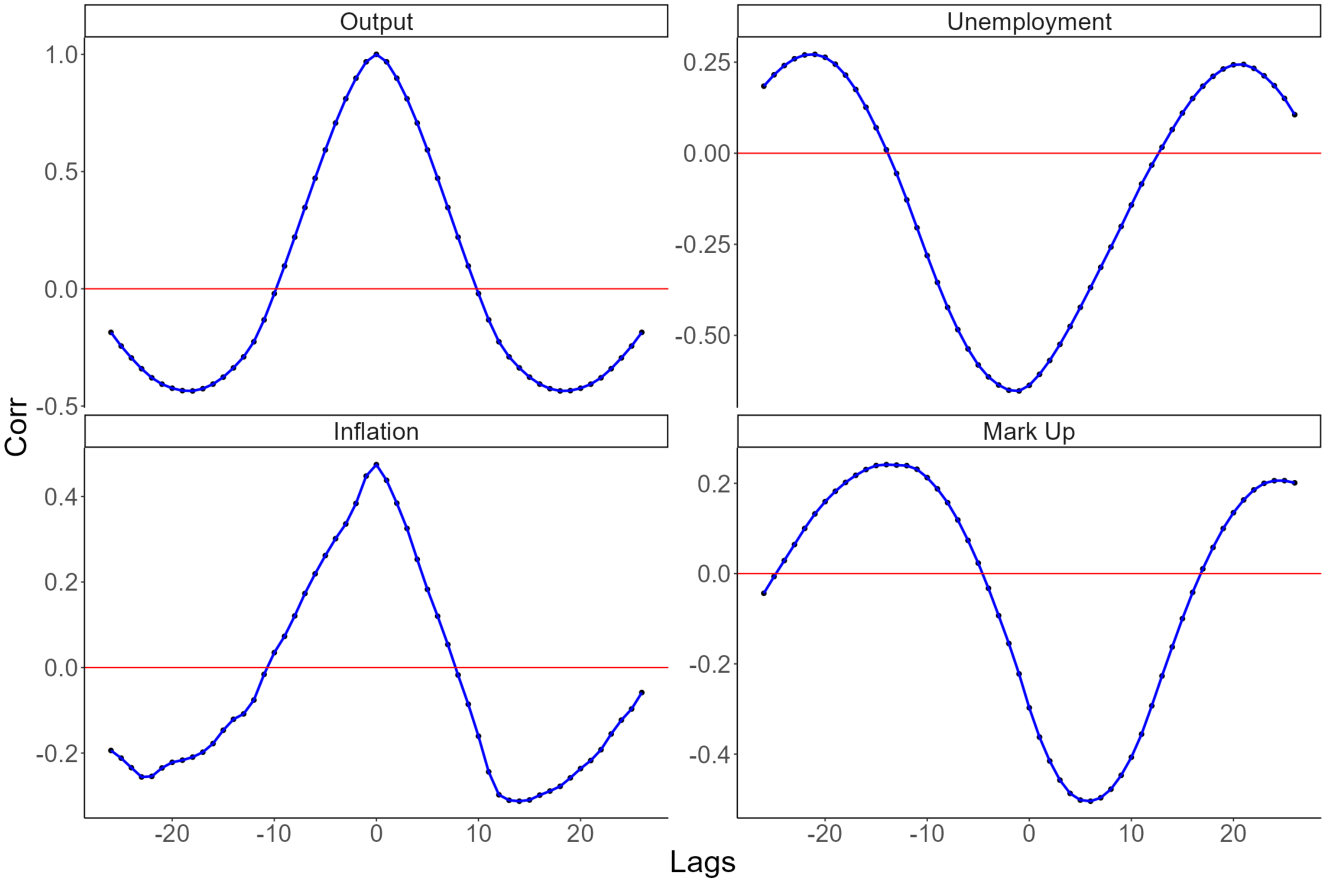

Figure 2: Autocross-correlations ($corr(x_t, y_{t+k})$) between output and unemployment, inflation, mark-up.

by price differences among firms. On the contrary, if ρ^{GM} is high, market frictions are pervasive, and large firms can capture larger market shares even when they are less price-competitive than their smaller competitors.

3.1 Aggregate evidence on inflation

In this section, we hit the model under the baseline parameterization with different shocks to study how inflation responds to demand and supply fluctuations. In all the experiments, we run 100 Monte Carlo simulations.

Labor market tightness and inflation

We first consider aggregate demand shocks. More specifically, we consider a shock to household consumption of the type illustrated in Equation 26, setting $\mu_\eta = -0.15$ and $\rho_\eta = 0.95$. By exploiting the variability generated by this shock, we can assess the relation between inflation and unemployment over a wider domain with respect to business cycle fluctuations in the baseline no-shock scenario. Under this setting, and in line with the empirical evidence documented by Gagnon and Collins (2019); Benigno and Eggertsson (2023) among others, the model shows the emergence of a non-linear Phillips Curve, jointly with a non-linear Beveridge Curve (see Figure 3 and Table 3). [15] The negative relation between unemployment and inflation is stronger when the economy is close to full employment and the labor market is tight. However, it flattens out as the unemployment rate increases and the labor market loosens.

The explanation for this result can be traced back to the interactions between the goods and labor markets in our model. First, and analogously to Guerini et al. (2018), Keynesian coordination failures between the good and labor markets stemming from the decentralized matching protocols are responsible for the inflation-unemployment trade-off. When aggregate demand increases in the goods market, firms production levels and labor demand are high, which brings about labor scarcity. Firms then struggle to fill the vacancies they open to meet their desired production, and this pushes upward money wages and prices. When demand is weak, firms revise their production plans downwards and subsequently lay off employees. Labor market slack is therefore followed by disinflation.

Second, labor market behavior at different levels of aggregate demand in the goods market, together with our assumptions on wage determination, explain why the Phillips Curve "bends" at high levels of unemployment. To this end, Figure 3, shows the Beveridge curve generated by our model, i.e., the ratio

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[15] We estimate our "simulated" Phillips curve by carrying out an exercise similar in spirit to (Blanchard et al., 2015; Blanchard, 2016). These contributions regress inflation against the unemployment gap, past inflation, and long-term inflation expectations. These two terms combined constitute the inflation expectations of the agents. In our model, this last term amounts to a constant (the Central Bank inflation target). See also Figure 14 and Table 8 in Appendix B for an alternative non-linear specification.

of vacancies left unfilled in relation to the unemployment rate. It indicates that the job vacancy rate tends to zero in the model at high unemployment rates while it reaches high values when the unemployment rate approaches zero, as firms are increasingly struggling to fill their job openings. Given Equation 9, this labor market behavior implies that upward pressure on nominal wage (and therefore price) growth will be very high at low unemployment rates while it will disappear when unemployment is very high.[16]

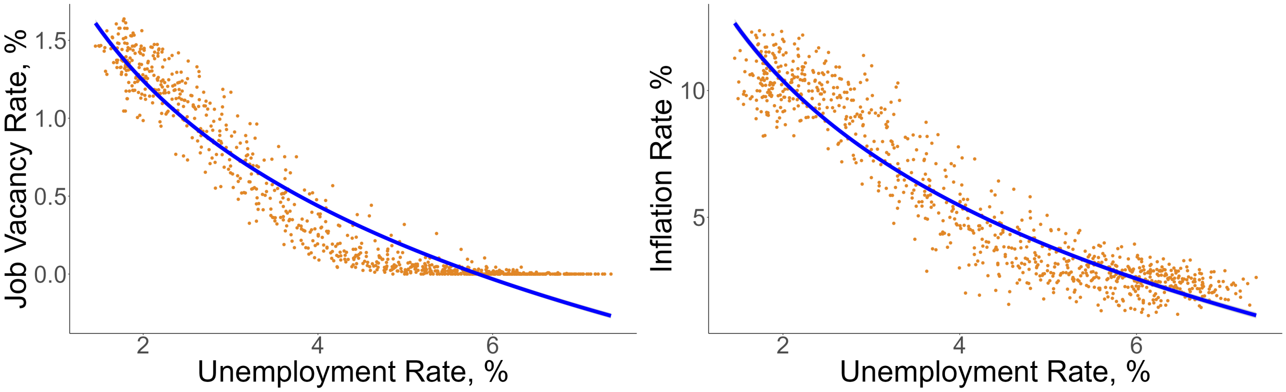

Figure 3: Level-log estimations of the Beveridge Curve (left panel) and Phillips Curve (right panel) with an aggregate demand shock. The shaded area represents standard error bands at the 95% confidence interval. Asymmetries in wage-setting generate a non-linear relationship between unemployment and price growth.

	Beveridge Curve	**Phillips Curve**
$Const.$	2.04^{***}	2.11^{***}
	(0.001)	(0.023)
π_{t-1}		0.47^{***}
		(0.026)
$log(u)$	-1.15^{***}	-3.77^{***}
	(0.008)	(0.072)
$Nobs.$	1300	1300
R^2	0.91	0.92

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Coefficients of the level-log regressions for the Beveridge and Phillips Curves with an aggregate demand shock. Standard errors are reported in parentheses.

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[16] This is also in line with Tobin (1972).

Supply shocks and stagflation

Next, we analyze the response of the model to a negative supply shock due to a sudden decrease in the productivity of labor. We consider a shock of the type illustrated in Equation 5, with $\mu_\eta = 0.05$ and $\rho_\eta = 0.95$. Under this setup, the model generates a positive relationship between unemployment and inflation, with the emergence of a positively sloped Phillips Curve (Panel 2 in Figure 4), while the Beveridge Curve (Panel 1 in Figure 4) maintains its natural downward-sloping structure. This implies that for this specific type of shock, the underlying dynamics of the labor market are left unaffected. In this case, the surge in inflation is driven by the sharp increase in costs generated by the adverse labor productivity shock. In short, and in line with standard theory (e.g. Blinder and Rudd, 2013), a large productivity shock generates a ”stagflation” outcome with a joint increase in unemployment and prices due to the joint increase in costs and reduction in productive capacity.

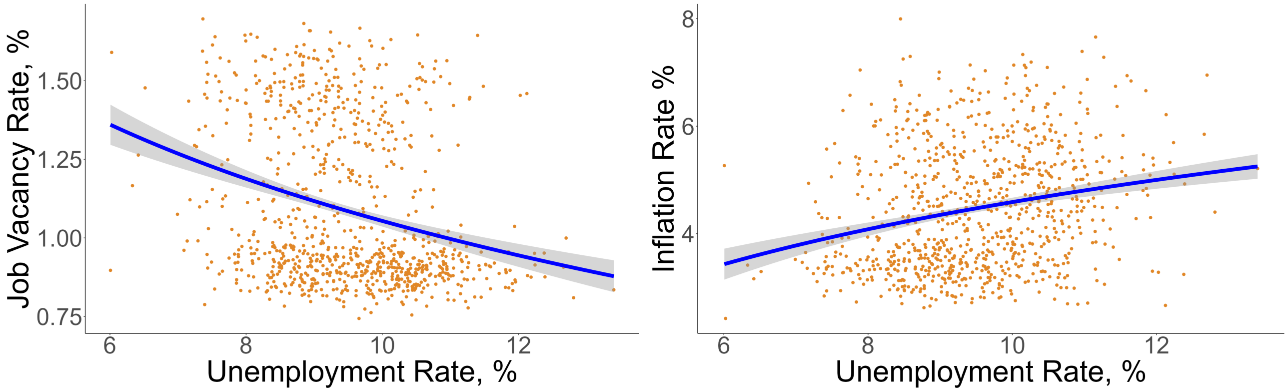

Figure 4: Level-log estimations of the Beveridge Curve (left panel) and Phillips Curve (right panel) In presence of an aggregate supply shock. The shaded area represents standard error bands at the 95% confidence interval.

Demand & supply shocks and inflation

Finally, in the third simulation exercise, we simultaneously shock the system with both the demand and supply shocks described above. In this third battery of simulations, the standard downward-sloped Phillips Curve is restored, even if the non-linearities have disappeared (the logarithmic fit line is almost flat) and the unemployment variation can explain only a residual part of the variability in inflation (see the lower R squared in Table 5). In other words, the overlap of demand and supply shocks can partly “hide”

	Beveridge Curve	**Phillips Curve**
$Const.$	2.43^{***}	-0.43
	(0.15)	(2.18)
π_{t-1}		0.80^{***}
		(0.026)
$log(u)$	-0.60^{***}	0.59^{***}
	(0.07)	(0.19)
$Nobs.$	1300	1300
R^2	0.20	0.75

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Coefficients of the level-log regressions for the Beveridge and Phillips Curves with an aggregate supply shock. Standard errors are reported in parentheses.

the structural Phillips Curve relationship in the model, leading to a weaker price-unemployment nexus than the one we would observe in the absence of supply shocks. This result can explain the flattening of the Phillips Curve observed in many countries across the world resonating with, for example, Hobijn (2020): when economic fluctuations are mainly driven by supply shocks, the downward demand-side pressures on prices are (totally or partially) offset by the supply side upward pressures.

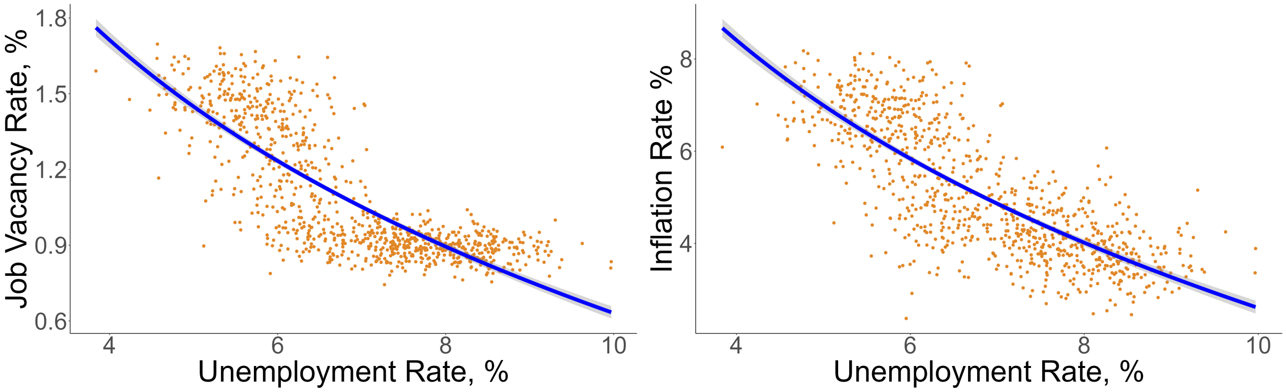

Figure 5: Level-log estimations of the Beveridge Curve (left panel) and Phillips Curve (right panel) In presence of an aggregate demand and supply shock. The shaded area represents standard error bands at the 95% confidence interval.

	Beveridge Curve	**Phillips Curve**
$Const.$	3.34^{***}	1.93^{***}
	(0.05)	(0.51)
π_{t-1}		0.66^{***}
		(0.026)
$log(u)$	-1.18^{***}	-2.08^{***}
	(0.03)	(0.25)
$Nobs.$	1300	1300
R^2	0.39	0.63

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Coefficients of the level-log regressions for the Beveridge and Phillips Curves with an aggregate demand and supply shock. Standard errors are reported in parentheses.

3.2 Goods market imperfections and inflation

Now that we have described the basic properties of inflation in our model conditional on different shocks, we proceed to assess the role of market imperfections. To carry out this task, we simulate the model under the same sequence of random draws, but by varying the parameter ρ^{GM} affecting the degree of imperfect selection in the goods market. Figure 6 displays the median value (across Monte Carlo) of four aggregate variables for different values of this market selection parameter.

The plots show a non-monotonic relationship between the degree of imperfect selection and the inflation rate. In fact, even if the model converges to a steady state characterized by a strictly positive inflation rate for all parameter values, a lower average inflation rate is associated with good markets with low and high levels of frictions ($\rho^{GM} \leq 0.09$ and $\rho^{GM} \geq 0.33$). In contrast, there is a monotonically increasing relationship between the degree of imperfections in the market selection process on the one hand and the unemployment rate, the market concentration, and the firm mark-ups on the other. In particular, less selective markets give rise to a more concentrated economy with higher profit margins. This last result is due to the presence of dynamic increasing returns in demand allocation, which is a feature of our matching protocol, as explained in Subsection 2.7.2. In turn, higher mark-ups imply lower labor shares, lower consumption (only a fraction of profits is distributed back to households as dividends) and production levels, and higher unemployment. Unemployment, market concentration and profit margins behavior also explains the non-monotonic relation between inflation and imperfect market selection mentioned before. On the left side of the graph (i.e., when imperfect selection is low), the economy is almost in full

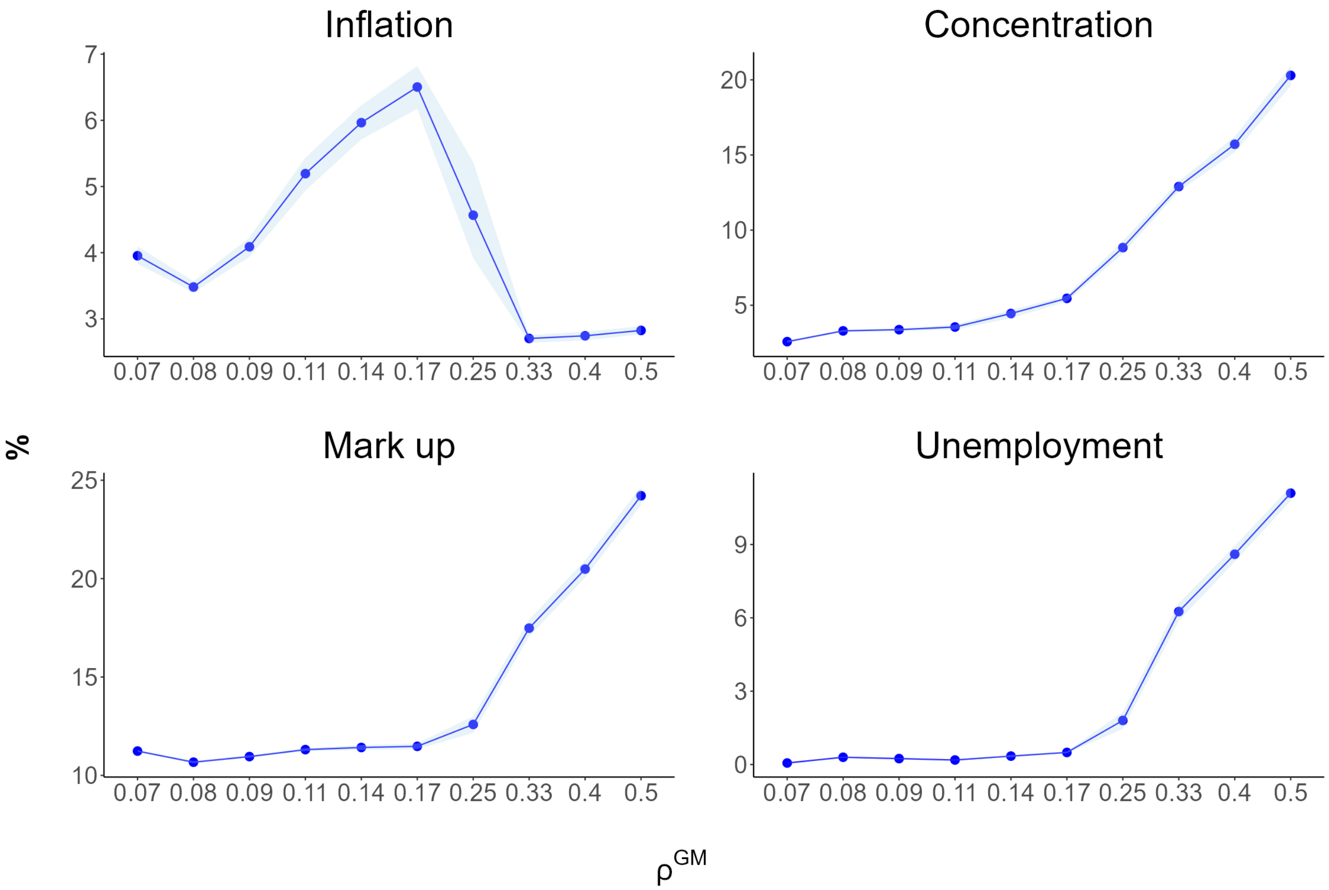

Figure 6: Median value (blue dot) of the Monte Carlo distribution for inflation rate (top-left), market concentration (top-right), mark-up rate (bottom-left) and unemployment rate (bottom-right) as a function of the degree of imperfection in the goods market, ρ^{GM}. For each value of ρ^{GM}, the shaded area is defined by the 10th and 90th percentile values out of 100 Monte Carlo simulations.

employment and an increase in the degree of imperfection leads to a higher inflation rate. However, in the right part of the graph (i.e., when imperfect selection is already high), a further rise in market imperfections leads to a decline in inflation due to the decline in aggregate demand associated with larger unemployment rates.

3.3 Expectations' persistence, trend following behavior and inflation target

In our baseline calibration of the model, we shut down the trend extrapolating component of the expectation formation process, as well as the autoregressive part, by setting $\mu_{exp} = \gamma_{exp} = 0$ (see also Section 2.3). This choice allows us to interpret the dynamics of the model focusing solely on the role of market selection. However, to enrich our understanding of inflation, in this section we turn to investigate the role of the expectation formation process. For this reason, we perform a sensitivity analysis aimed at studying study how the model reacts to the introduction of positive μ_{exp} and γ_{exp}, as is expected in an environment with positive feedback (Heemeijer et al., 2009). More precisely, we run a battery of 100 Monte Carlo simulations where we vary the expectation persistence (μ_{exp}) and the trend following strength (γ_{exp}) of Equation 3. The degree of anchoring of expectations remain instead fixed at its baseline value ($\chi = 0.7$). We then study the effect that these two parameters exert upon average inflation across Monte Carlo runs. Results are shown in Table 6.

The results suggest that increasing both parameters increases average inflation, which reaches a maximum value of 6% when $\mu_{exp} = \gamma_{exp} = 0.6$). This is consistent with experimental evidence, where more prevalent trend-following strategies induce larger and more persistent deviations of expectations from the fundamental benchmark (see Heemeijer et al., 2009). Over this parameter space, however, the model shows no evidence of fundamental instability or the occurrence of runaway inflation. This suggests that, even with the introduction of moderate trend-following elements found in the empirical literature, agents in our model can coordinate around a sustainable inflation trend, pointing in the direction of a behavioral learning equilibrium (see Hommes and Zhu, 2014), at least as long as expectations are sufficiently anchored to their long-run value π^*.

μ_{exp}	0.0			0.3			0.6		
γ_{exp}	0.0	0.3	0.6	0.0	0.3	0.6	0.0	0.3	0.6
Mean	2.73	3.47	4.94	2.80	3.56	4.95	3.54	4.70	5.99
Std. dev.	(0.06)	(0.08)	(0.09)	(0.06)	(0.07)	(0.08)	(0.07)	(0.08)	(0.07)

Table 6: Mean values of inflation across different values of γ_{exp} and μ_{exp}. Standard deviations in parentheses.

Furthermore, in our baseline parametrization, the Central Bank's inflation target (π^*) is equal to 2%. In a second sensitivity analysis exercise, we let this parameter vary in a finite range of values $\pi^* \in \{0, 1\%, 2\%, 3\%, 4\%\}$. Results are displayed in Table 7. As expected, the long-run average level of inflation increases with the central bank target. This is a natural consequence of the expectations channel of monetary policy (see also Woodford, 2003), as the inflation target in our model constitutes the "normal" or "long-run" inflation anchor for private expectations, and therefore it affects inflation realizations to the extent that the environment is sufficiently stable (i.e., as long as expectations are anchored). This result is indicative of the predominance of the expectations channel in the model (see also Salle et al., 2013, for further analysis of the role of inflation targets).

	0%	**1%**	**2%**	**3%**	**4%**
Mean	1.45	1.96	2.73	3.62	4.51
Std. dev.	(0.1)	(0.06)	(0.06)	(0.05)	(0.06)

Table 7: Mean values of inflation across different values of the central bank's inflation target π^*. Standard deviations in parentheses.

3.4 A closer inspection at the sources of inflation

To sum up, the previous simulation results indicate that negative productivity shocks in the model lead to inflation surges. Second, the model can generate a non-linear Phillips Curve, which arises from the asymmetric wage dynamics at high and low unemployment rates. Third, changes in market selection intensity can jointly explain the emergence of higher mark-ups (and decreasing labor shares) and higher market concentration documented by the empirical literature for the United States (see e.g Stansbury and Summers, 2020; De Loecker et al., 2020), as well as declining employment trends (e.g. Abraham and Kearney, 2020).

We shall now exploit our wage and price setting mechanisms (see Section 2.4) to decompose price changes along two different dimensions. We first decompose aggregate price variations into a *within-firms* component, which originates in the price adjustments operated by the single firms, given their market share, and a *between-firms* component, stemming from the continuous reallocation of market shares between firms which affect the aggregate price through their market weights for given firm prices. The second decomposition, instead, focuses on price changes at the individual firm level and on their possible drivers, i.e., state of the labor market, firm market power, and wage indexation.

The between and within inflation decomposition

The aggregate price index in our model is defined as a market-shares weighted average of the individual firm prices. In logs, this writes:

$$log(P_t) = \sum_{f=1}^{F} s_{f,t} log(P_{f,t}) \tag{30}$$

Exploiting this definition, the changes in the aggregate price index can be decomposed as follows (see also Baily et al., 1992):

$$log(P_t) - log(P_{t-1}) \approx \sum_{f=1}^{F} s_{f,t-1} \Delta log(P_{f,t}) + \sum_{f=1}^{F} \Delta s_{f,t} log(P_{f,t}) \tag{31}$$

The first term on the right-hand side of the equation measures the counterfactual inflation if the individual firm shares were constant (*within effect*), while the second term measures inflation caused by changes in market shares (*between effect*).

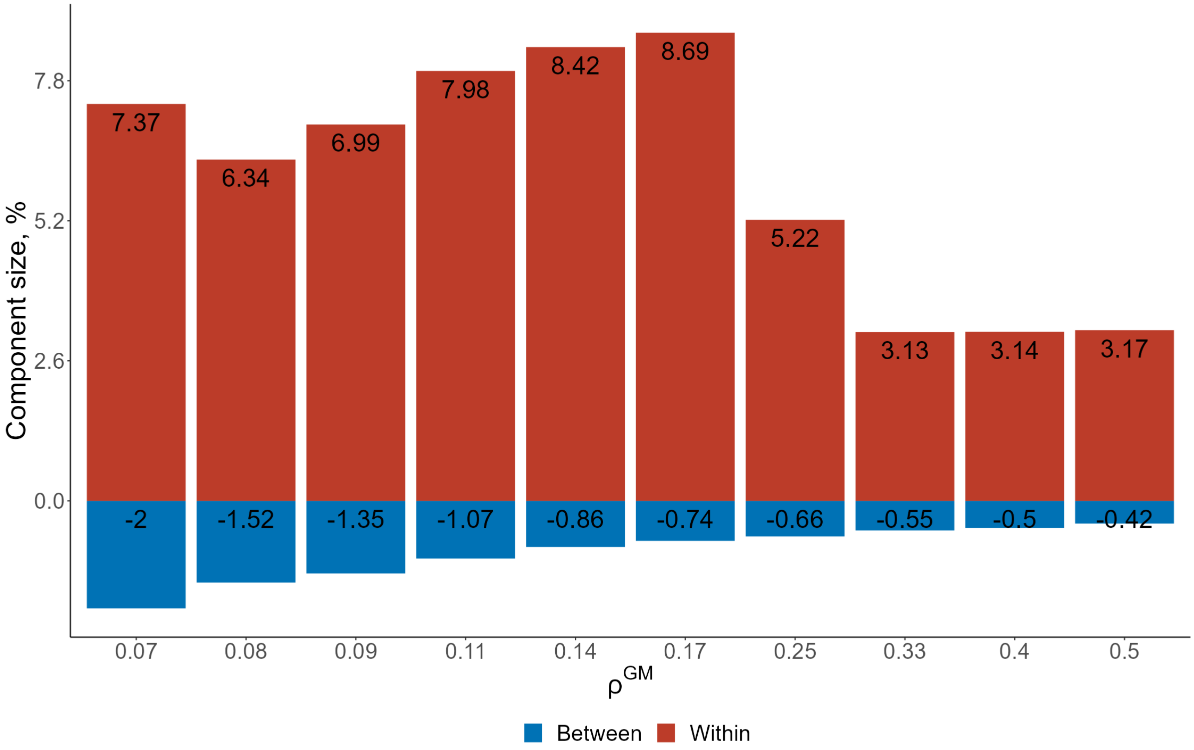

Figure 7: Monte Carlo averages of within and between firm components of aggregate price changes as a function of the degree of imperfection in the market selection process in the goods market. Higher values of ρ^{GM} imply a more imperfect market selection process. Numbers on bars indicate the magnitude of each component

We perform the aforementioned decomposition for different degrees of imperfection in the goods market selection. Monte Carlo averages are presented in Figure 7. Three main insights result from the analysis. First, and unsurprisingly, the within-firm effect is always positive while the between-firms effect is always negative. This stems from the fact that households continuously strive to reallocate their expenditures towards the firms posting lower prices, even when prices are generally rising. Second, the between effect is always smaller in absolute value than the within effect, implying a positive inflation rate for all values of market imperfections. Third, the absolute magnitude of the between-firms component decreases with the degree of imperfect selection in the goods markets. This means that, in markets with a relatively efficient selection, the customers quickly switch from firms charging higher prices to the ones with lower prices. When selection is imperfect, customers are less sensitive to price differences across firms, and big firms can increase their profit margins without significant repercussions on their market share. This result is consistent with several contributions linking market competition and inflation (see Janger et al., 2010; Przybyla and Roma, 2005; Torun and Yassa, 2023).

Dissecting firm inflation drivers

Starting from the equations of firm price and wage-setting behavior (Equations 9 and 11), we can decompose price changes at the individual firm level according to different sources. Let us start by deriving a "reduced form" equation for firm-specific price growth by simply taking the log-difference of the price setting Equation 11. This boils down to:

$$\pi_{f,t} = \log(W_{f,t}) - \log(W_{f,t-1}) - (\log(a_{f,t}) - \log(a_{f,t-1})) + (\mu_{f,t} - \mu_{f,t-1}) \tag{32}$$

After substituting wages with their expression from the wage setting Equation 9, we obtain:

$$\pi_{f,t} = \alpha^l z_{t-1}^{lab} + \beta^l \hat{\pi}_{f,t} - \Delta \log(a_{f,t}) + \Delta\mu_{f,t} \tag{33}$$

This decomposition shows the four fundamental channels through which firms increase their prices in our model. The first driver of inflation is excess demand in the labor market, captured by $\alpha^l z_{t-1}^{lab}$. Whenever the firm labor market is tight, the firm has to increase the offered nominal wage and this leads to price growth in the following period. The first inflation driver is akin to the standard interpretation of a "demand-pull" inflation (see Lipsey, 1960, among the others). The second cause of inflation is captured by the wage indexation $\beta^l \hat{\pi}_{f,t}$, which is intimately linked to expectations and acts as a propagation channel by linking today's firm-level price adjustments to past realized inflation at the aggregate level. Third, inflation can arise from productivity shocks $\Delta \log(a_{f,t})$ which have an immediate impact on the unit cost of output $\frac{W_{f,t}}{a_{f,t}}$ and, therefore, on prices. This is the so-called "cost-push" source of inflation (Porter, 1959). The fourth and final driver of inflation is the mark-up rate variation, $\Delta\mu_{f,t}$ which implies that firms' market power affects inflation.[17] The idea that market power affects firms' pricing behavior can be traced back to the administered price literature (Means, 1972; Blair, 1974) Note that the cost-push and mark-up components can take either positive or negative values, while the excess demand and expectations component can only take non-negative ones.

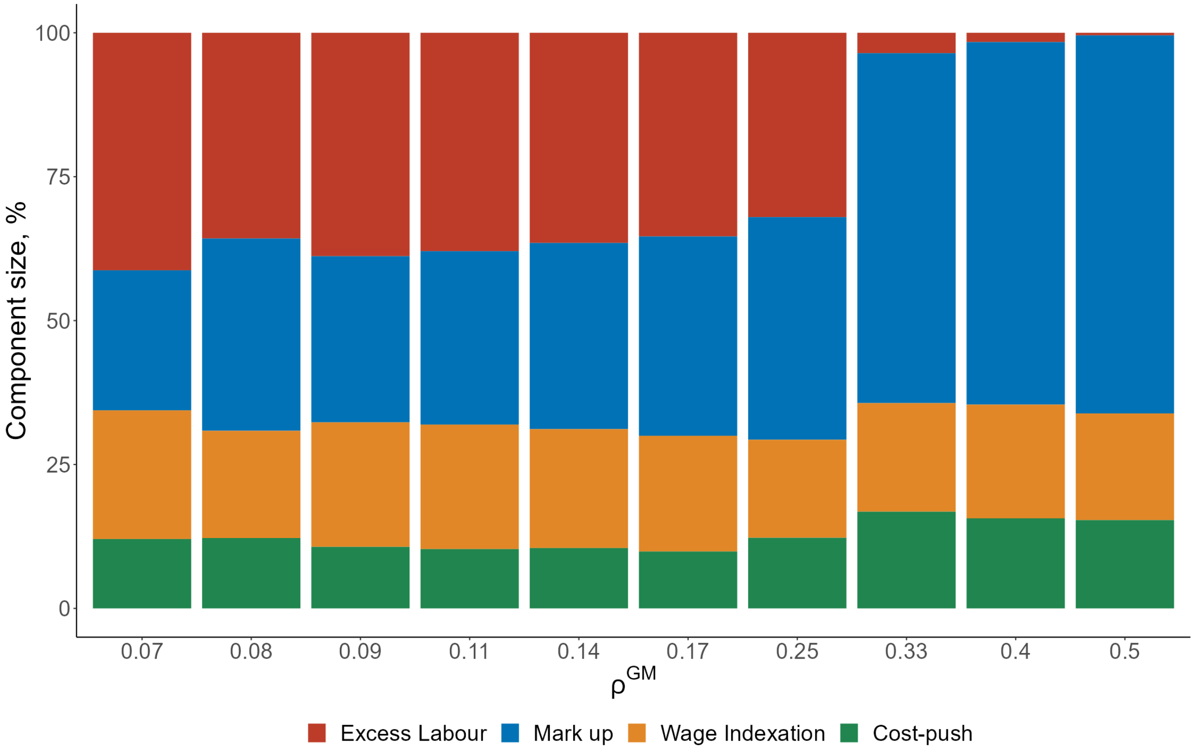

Figure 8: The absolute value of the Monte Carlo averages of the components of firm-level price growth as a function of the degree of imperfection in the market selection process in the goods market. Higher values of ρ^{GM} imply a more imperfect market selection process.

Figure 8 highlights the relative importance of the above four factors by displaying a bar plot with their relative values (rescaled for the components to sum up to 100%), for different degrees of imperfec-

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[17] It is not necessary to have a time-increasing aggregate mark-up rate to have positive trend inflation, as long as we assume asymmetries in the money-wage adjustment process. Even if firms' mark-ups oscillate symmetrically around a fixed average due to continuous disequilibrium adjustments, wages will respond more to increases in the price index than they do to decreases, resulting in positive long-run inflation rates.

tion in the goods market selection. The decomposition reveals that all the four factors always play a role in driving inflation in the model, although their relevance changes with the degree of imperfect selection in the goods market. When market selection is sufficiently efficient (i.e., for low values of ρ^{GM}) the excess labor demand driver plays a prominent role and the model behaves as a standard New-Keynesian model where inflation is demand-pull. These scenarios are also characterized by low concentration, high aggregate demand, and low unemployment (see Section 3.2). The excess labor demand component becomes less and less important when market imperfections become more pervasive (i.e., for high values of ρ^{GM}). In the latter scenarios, inflation is mostly driven by variation in the mark-up rates, and in turn in firms' profit margins. Therefore, when goods market imperfections are relevant, inflation is mainly driven by *firms' market power*.

Taking stock

Overall, all the previous results indicate that the nature of inflation depends on the efficiency of market selection in the goods market. This is in contrast with the traditional explanation of inflation as a phenomenon generated only by an excessive level of demand and a tight labor market. This view holds only as long as price signals are efficient in reallocating market shares across firms. In such a scenario, market share (between effect) contributes significantly to inflation at the macro level, while, at the micro level, inflation is mostly driven by labor market excess demand.

In stark contrast, when goods market selection is less efficient due to pervasive imperfections, the signaling role of prices is weakened and larger firms get a competitive advantage in their local interactions with consumers. In this case, the contribution of the between effect vanishes and inflation is mostly driven by increases in mark-up rates at the firm level. The latter effect is in particular determined by the fact that larger firms can increase market shares even if they practice prices that are not below their competitors prices due to the inefficient selection of markets. In this setting, where there are no exogenous shocks to production costs, the role of the cost-push component is marginal. We investigate more in detail the importance of cost-push shocks in the following section.

The inability of customers to select the most price-competitive producer via localized interaction highlights one interesting property of the model: the emergence of finite, heterogeneous demand elasticities among firms due to their non-price characteristics (in this case, size). Larger firms are rewarded by the imperfect matching protocol and can post relatively higher prices without fear of losing customers. Conversely, smaller firms are bound to compress profit margins to attract demand that otherwise would be drawn towards the market leaders.

Imperfect information as outlined in our search and matching protocol, therefore, provides a plausible microfoundation to the emergence of market power in the long run, in analogy with results from imperfect information theory (e.g Stigler, 1961; Phelps, 1969), and it can explain the emergence of a long-run price distribution, in continuity with standard imperfect information models (Stiglitz, 1979, 1989), even assuming homogeneous technology.[18]

4 The emergence of sellers' inflation

While many works have focused on demand pressures to explain inflation, ascribing the surge in prices to loose monetary policy, increasing government spending, and labor shortages (Bianchi et al., 2023; Benigno and Eggertsson, 2023; Cevik and Miryugin, 2024), others have focused instead on monopolistic behavior by firms, rent-seeking and profits as the main drivers of inflation (see Weber and Wasner, 2023). The final battery of Monte Carlo experiments assesses the possible multiple sources of inflation, possibly detecting whether large, persistent aggregate demand and supply shocks can trigger fluctuations in firms' market power and income distribution, leading to the emergence of a so-called "sellers' inflation", wherein firms can increase their prices to protect or even increase their profit margins (more on that in the ECB Economic Bulletin paper by Hahn 2023; see also the IMF Working Paper by Hansen et al. 2023). Our last exercise thus provides a counterfactual analysis test of the two competing hypotheses over the determinants of the 2021-2023 inflationary surge. Has inflation been increasing due to excessive spending, or because firms were able to pass to price the cost increases? In this respect, the results of the previous section suggest that our model provides a framework in which both drivers always play a role, albeit with different weights depending on the degree of imperfection in market selection. Nevertheless, it is also worth investigating which of the two drivers becomes more relevant following shocks of different

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[18] Furthermore, in terms of macroeconomic implications, some degree of information imperfection is related to the emergence of resource underutilization (Alchian, 1969)

types.

We consider three separate shock scenarios.[19] The first one is a positive demand shock, involving a sharp increase in household consumption $c_{h,t}$ (cf. Equation 26). In the second scenario, we consider a shock decreasing labor productivity (see Equation 5), which captures ubiquitous supply chain disruptions (such as restrictions to production, logistic bottlenecks, and intermediate input shortages). The third shock scenario is designed to represent the global energy crisis due to the Russo-Ukrainian War; it involves the introduction in the model of a new external non-labor cost, which proxies the cost of imported energy (more details in Equations 12, 13 and 34). The different shocks are studied for different market selection scenarios captured by the parameter ρ^{GM}.

Demand shock

We first hit the economy with a $AR(1)$ shock that entails an increase in household consumption at time $t^\star = 1600$. More specifically, households increase their consumption by an amount $\mu_\eta = 15\%$ for a 4-weeks period; starting from the fifth week, the shock decays at a rate $\rho_\eta = 0.95$ (cf. Equation 26).

Figure 9 displays the effect of the demand shock on aggregate output, inflation, mark-up rates and profit shares for five different values of the market imperfection parameter ρ^{GM}. The shock exerts a positive impact on output (top-left panel), with the size of the effect being positively associated with market imperfections: scenarios with low values of ρ^{GM} display only a mild increase in mark-ups (bottom-left panel) and remain closer to the pre-shock steady state. The efficiency of the market selection process also determines the inflation response (top-right panel). The increase is larger for the scenarios where market selection is more imperfect.

Note that for the most inefficient scenarios (high ρ^{GM}), the model predicts a very short-lived deflation. This is due to the impact of the shock on the market structure. Indeed, the positive and homogeneous demand shock causes (by construction) a redistribution of market shares towards the smallest firms. Large and medium-sized firms lose market shares, thereby decreasing their mark-up rates and prices (see Figure 15 in Appendix C). However, this effect vanishes after the first few months, with the standard positive surge in inflation occurring thereafter in all scenarios with strong degree of market imperfections.

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[19] In reality, the three shocks may have occurred simultaneously. We here separate them to better understand the transmission mechanisms for each of them.

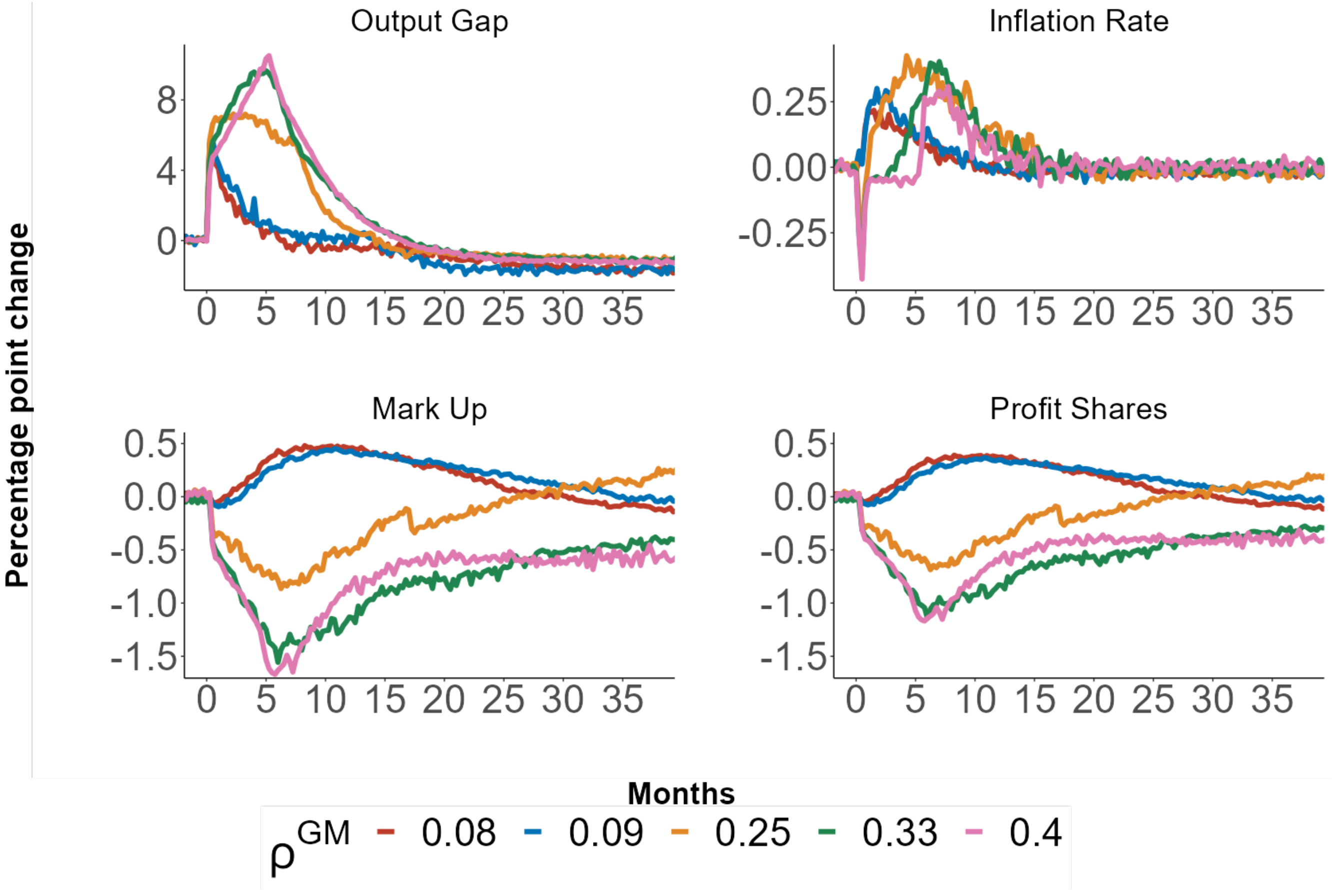

Figure 9: Impact of a positive demand shock on aggregate output (top-left), inflation rate (top-right), mark-ups (bottom-left) and profit shares (bottom-right) for different levels of the goods market imperfections. Lines represent Monte Carlo averages across 100 simulations. Time is measured in months (i.e., 4 simulation periods). The impact of the shock over time is measured in percentage point deviation from pre-shock level. Higher values of ρ^{GM} imply a more imperfect market selection process.

Nonetheless, the shock does not produce a long-run inflation acceleration due to excess demand, nor the occurrence of "wage-price spirals" (in line with the recent empirical evidence documented in Bluedorn et al. 2022), with prices stabilizing between 12–15 months from the shock.

The effect that the demand shock exerts on the market shares also significantly affects the aggregate mark-ups and the profit shares (cf. Figure 9 bottom-left and bottom-right panels respectively), which fall in the scenarios with a high value of the market imperfection parameter ρ^{GM}.

Productivity shock

We next consider a scenario where the economy is hit by a homogeneous adverse shock to the labor productivity coefficient $a_{f,t}$ (cf. Equation 5), with a magnitude of -5% on impact. Furthermore, this

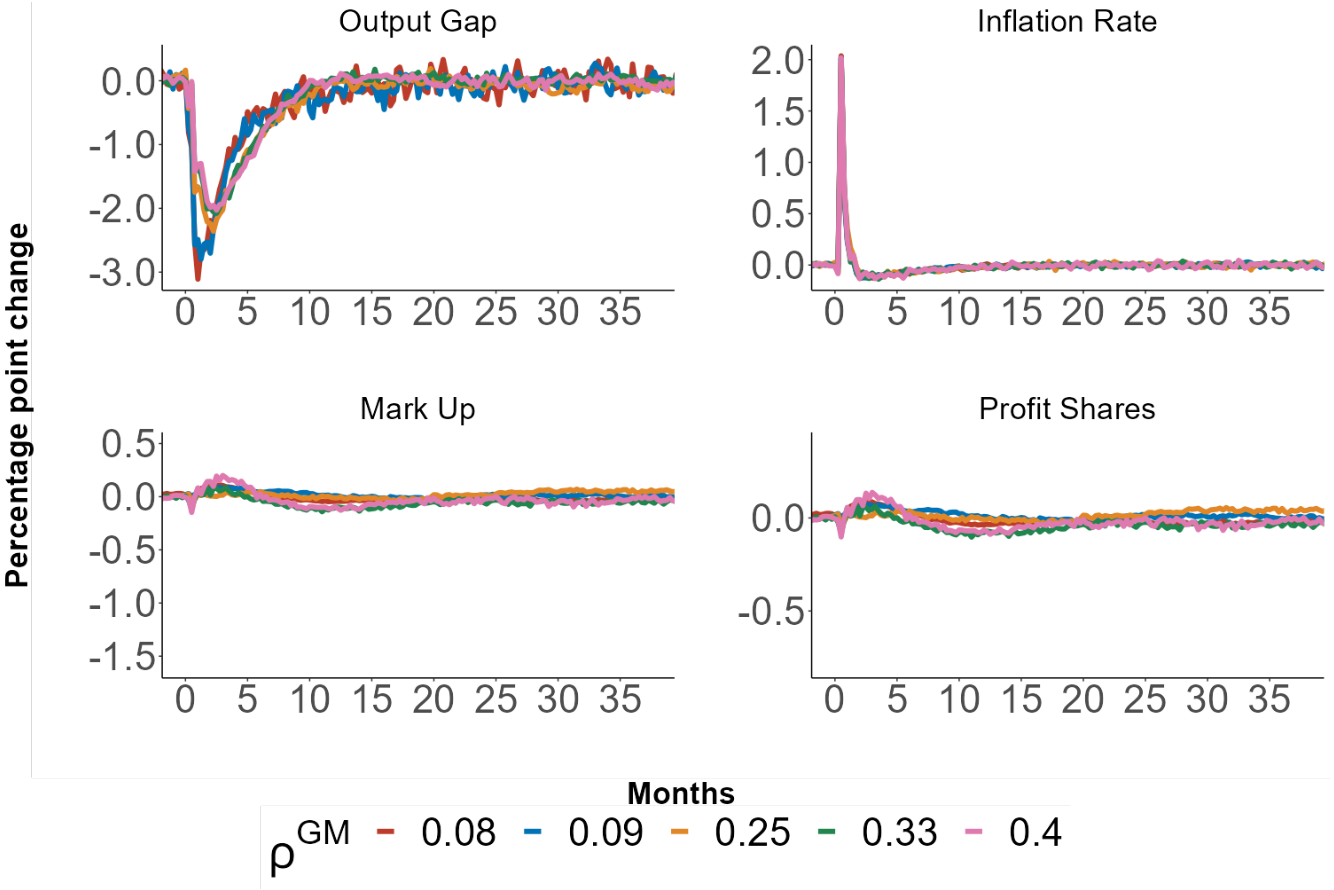

Figure 10: Impact of a productivity shock on aggregate output, inflation, mark-up and profit shares in different market selection regimes. Lines represent Monte Carlo averages across 100 simulations. Time is measured in months (4 periods). The impact of the shock over time is measured in percentage point deviation from pre-shock level.Higher values of ρ^{GM} imply a more imperfect market selection process.

productivity shock is autoregressive. It operates at full intensity for four weeks, and then decays at a constant rate $\rho_\eta = 0.95$ from the fifth week (see Equation 5).

The shock generates a decline in aggregate output and a short-living ramp-up in inflation for all the market selection regimes (top panels of Figure 10). These are standard results (see Blanchard, 1989, among the others). Furthermore, differently from the demand shock, it does not generate substantial variations in mark-up rates or the profit share (bottom panels of Figure 10). With a negative productivity shock, mark-ups shift only about 0.1 percentage points in the 12 months after the shock before returning to steady state values.

Energy price shock

In the third experiment, designed to simulate a spike in costs of non labor inputs, we model a shock in energy price $k_{f,t}$ exhibiting the following dynamics:

$$k_{f,t} = W_{f,t^*}(1+\eta_t) \text{ where } \begin{cases} \eta_t = 5\% \text{ if } t < t^* \\ \eta_t = \mu_\eta * 5\% \text{ if } t \in (t^\star, t^\star + 3) \\ \eta_t = \rho_\eta \eta_{t-1} \text{ if } t > t^\star + 3 \end{cases} \tag{34}$$

where again μ_η represents the intensity of the shock and ρ_η its persistence (we set $\mu_\eta = 3$ and $\rho_\eta = 0.95$). In other words, we set the cost of energy $k_{f,t}$ to be 5% of the labor cost before the shock and to increase to 15% of labor costs after the shock. Otherwise, the duration of the shock and its persistence are the same as for the demand and productivity shocks examined in this section. The calibration of the shock intensity is consistent with the 200% increase in the Global Energy Price Index between 2020 and 2022 (see FRED, 2023). Moreover, note that in this version of the model, an increase in the price of the non-labor input can trigger a shift from labor to non-labor costs with possible impacts on income distribution.

As expected, simulation results suggest that the energy price shock causes an output decline and a hike in the inflation rate regardless of the market selection regime (cf. Figure 11 top panels). In that respect, it is qualitatively similar to a negative labor productivity shock. However, in sharp contrast with the latter shock, the higher cost of energy significantly affects mark-up rates and, even more, the profit shares (see Figure 11 bottom panels). Moreover, the surge is higher in the presence of more pronounced market imperfections. These results are consistent with the empirical evidence provided by Arquié and Thie (2023), who find that a firm's pass-through of energy shock depends upon the industry-specific market power: less competitive industries (in our case represented by the scenarios with high values of ρ^{GM}) display higher pass through, even superior to 100%. The increase in mark-ups at the aggregate level is caused by the asymmetric impact of the shock on large and small firms. While large firms are relatively less affected, small firms lose market shares (see Figure 17 in Appendix C), inducing a temporary increase in market concentration. This implies that market leaders increase their mark-ups after the shock, while small companies reduce them to maintain their competitiveness. In other words, the shock does not only

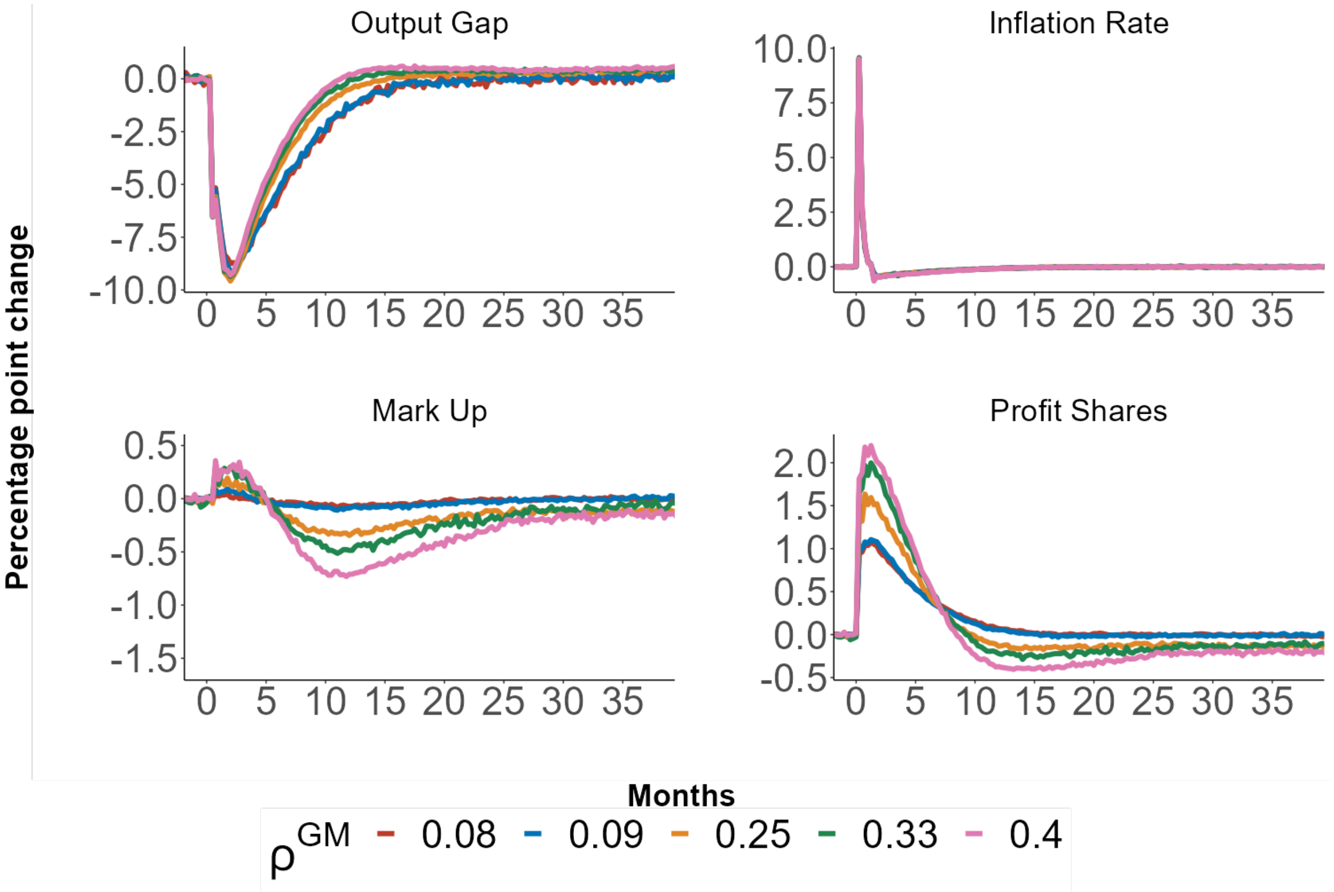

Figure 11: Impact of an adverse energy shock on aggregate output, inflation, mark-up and profit shares in different market selection regimes. Time is measured in months (4 periods). Lines represent Monte Carlo averages across 100 simulations. The impact of the shock over time is measured in percentage point deviation from the pre-shock level. Higher values of ρ^{GM} imply a more imperfect market selection process.

entail a redistribution from labor costs to profits. It also increases the divergence in market shares and profit margins between small and large firms.[20]

The bottom-right panel of Figure 11 reveals a second remarkable difference between the impact of the energy shock and those of the other two shocks examined before. For demand and labor productivity shocks, changes in the profit share were exclusively driven by the mark-up rate dynamics, and the two impulse response functions looked alike (see Figures 9 and 10). For the energy shock, an additional

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[20] The redistribution of market shares in favor of larger firms is driven by the impact that the shock has on households' real incomes. The rise in energy costs causes a fall in real wages and aggregate demand. Because of the imperfect selection mechanism characterizing the model, the fall of demand has an asymmetric impact across firms (see Figure 17 top-left panel in Appendix C), with large firms being relatively less affected (on impact) than small ones, which bear most of the fall in demand (relative to their size). As the shock decays and real wages recover, smaller firms catch up and eventually markups are restored to pre-shock levels.

transmission channel is at work, as the shift in firm cost structure from the labor component to the non-labor one causes a relative increase in profits with respect to wages even in the presence of invariant mark-ups. In other words, the rise in the profit share results both from higher profit margins and from the pass-through of the energy cost to prices (Blair, 1974; Weber and Wasner, 2023).[21]

Import prices, profits, and wages: bringing the model to the data

After analyzing the model's response to different types of shocks, we perform a final exercise by decomposing the price index to tease out the relative importance of different sources of inflation. To accomplish this, we use the data on aggregate wages, profits, and energy costs generated by our model. While this decomposition should not be interpreted in a causal sense, it provides a straightforward way to observe how changes in prices are reflected in labor compensation per unit of real consumption (unit labor costs), profits per unit of real consumption (unit profits), and energy costs (import prices). This decomposition is comparable to similar exercises performed with real data (see Hansen et al., 2023; Haskel, 2023; Dhingra and Page, 2023) and allows us to assess the ability of the three shock scenarios to be consistent with the empirical evidence.

In Figure 12, we compare the cumulative change in three components of inflation (i.e., labor costs, profits, and import prices) over the first two years after each of the three shocks with the empirical results provided by Hansen et al. (2023) and Haskel (2023) for the Euro Area and the United States respectively.

The contributions of labor cost and profits to inflation dynamics are almost equivalent in the demand and productivity shock scenarios.[22] Turning to the energy shock scenario, we highlight three main findings. First, import prices account for about a quarter of the increase in inflation. Second, most of the increase in inflation is due to an increase in profits (about 60%) rather than an increase in labor costs (about 15%). In fact, profits per unit of consumption rise by about 8% per year, while wages rise by only 3%. Third, these results are qualitatively comparable to the empirical estimates of Hansen et al. (2023) for the Euro Area 2021-2022 inflation surge.[23] Similarly, in the United States, profits are a non-negligible

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[21] Note that when a non-wage cost k is introduced in the production process, the share of profits over total output is equal to $r = 1 - \frac{1}{1+\mu \cdot k}$. Therefore, an increase in the non-wage cost k implies a shift in the income distribution in favor of profits, even if the mark-up rate is unaffected.

[22] By construction, these two scenarios cannot compare well with the empirical decomposition, since they both lack the imported energy production factor.

[23] Hansen et al. (2023) claim that the Euro Area suffered the most from the worsening in the terms of trade due to the rise in

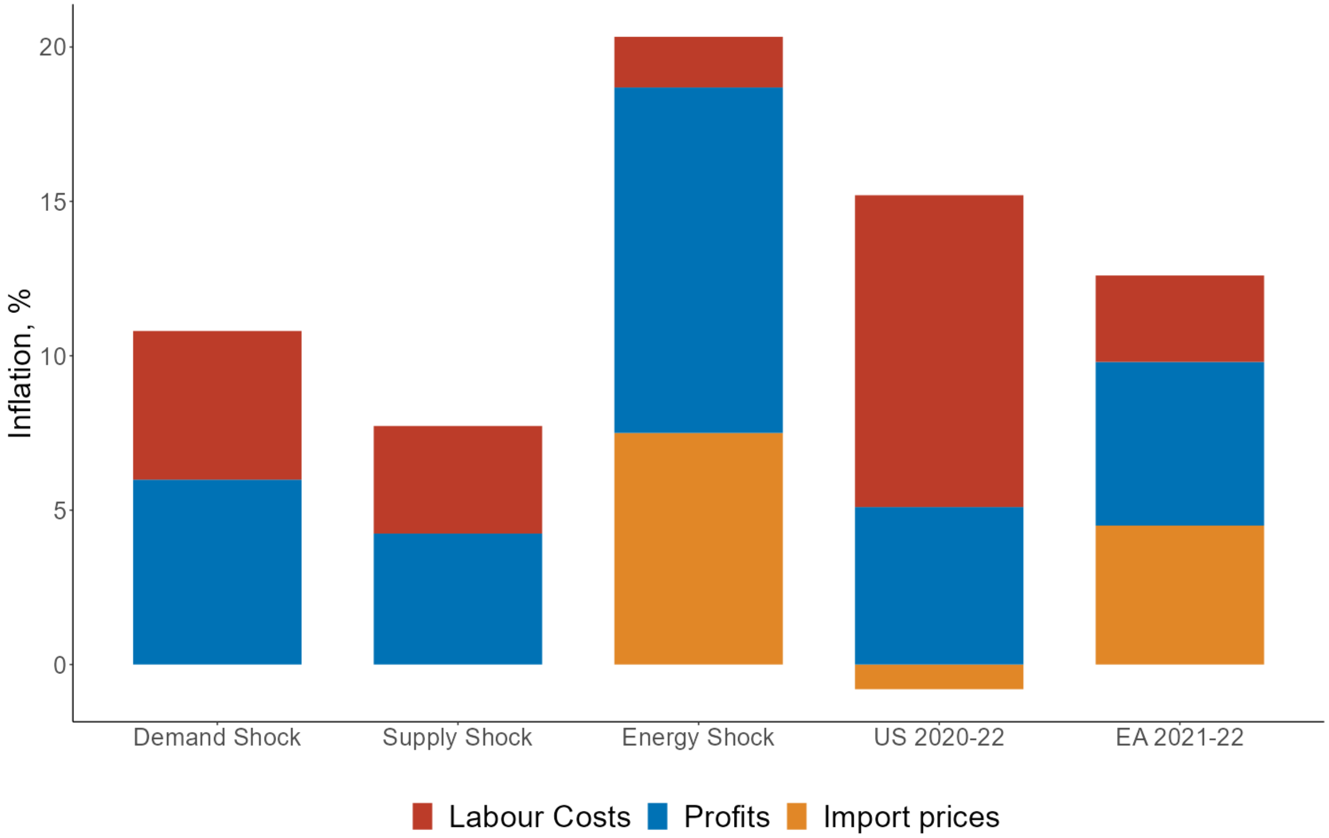

Figure 12: Contributions to cumulative change in consumer prices for the three scenarios and as observed in the United States and in the Euro Area. The cumulative change in prices in the model is measured over the two first years after the shocks. Data for the US is found in (Haskel, 2023) and refers to the period 2019Q4-2022Q4. Data for the EA is found in (Hansen et al., 2023) and refers to the period 2020Q4-2022Q4.

contributor to inflation, although the country has experimented with a small disinflationary shock from import prices in 2020-2023 due to being a net oil exporter.

Overall, our analysis confirms that our model can explain the dynamics triggered by the rise in imported energy prices observed in advanced economies in recent years. In particular, the energy shock scenario replicates the increase in unit profits and profit shares observed in most advanced economies since 2021 (Colonna et al., 2023; Hahn, 2023; OECD, 2023), as well as the short-lived increase in mark-ups in the aftermath of the shock(Gerinovics and Metelli, 2023; Arquié and Thie, 2023; Glover et al., 2023). It also replicates the qualitative features of the inflation process in the Euro Area, with the increase in unit profits contributing much more to price growth than the increase in labor costs.

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the prices of imported energy input, as well as from profits rising faster than wages.

5 Conclusions

In this work, we extend and calibrate the agent-based business cycle model developed by Guerini et al. (2018) to study i) the relationship between market selection efficiency and inflation dynamics; ii) the possible multiple sources of inflation; iii) the transmission mechanisms after a series of shocks to demand, productivity and non-labor costs.

Our model is rooted in the seminal contribution by Greenwald and Stiglitz (1987) which shows that imperfect information slows down the capability of the market to channel price information to consumers. Hence, relatively larger firms might enjoy an advantage in the goods market. In such a setting, the emergent "spontaneous order" (Hayek, 1975) is incapable of rewarding the most price-competitive firm and leads to suboptimal outcomes. Furthermore, Keynesian coordination failures might further amplify economic fluctuations (Howitt, 1986).

We first show that our model generates realistic inflation dynamics, as well as a non-linear Phillips curve, in line with the empirical evidence recently put forward by (Gagnon and Collins, 2019; Benigno and Eggertsson, 2023). We then examine the possible heterogeneous sources of inflation. We show that the traditional explanation of inflation as an excess-demand phenomenon stemming from a tight labor market holds only when market selection is efficient, i.e., when price signals can trigger a fast reallocation of market shares towards more price-competitive firms. On the contrary, in the presence of imperfect market selection, inflation mostly arises from changes in mark-up rates happening within the largest firms, which can benefit from a higher monopolistic power.

Next, we employ the model to study the response of inflation, output, and other economic variables to different shocks hitting consumption, labor productivity, and energy costs. We show that exogenous positive demand shocks trigger labor scarcity, thereby pushing up aggregate wages and prices. In turn, this leads to a temporarily persistently higher inflation rate. A supply side labor productivity shock spurs inflation as firms can fully pass through the shock to their customers. However, the shock does not significantly impact either on mark-ups or profit shares. Finally, a profit-led inflation (see Weber and Wasner, 2023) emerges after an energy shock via two complementary channels. The first one induces an increase in the profit share through changes in the relative cost structure of the firms, as wages do not change in response to the higher cost of the intermediate energy input (consistent with evidence provided by Manuel et al., 2024; Colonna et al., 2023). The second channel involves an increase in firms' profit margins (in line with results by Konczal, 2022; Gerinovics and Metelli, 2023). A decomposition exercise also shows that our results are coherent with the recent empirical evidence for the Euro Area (Hansen et al., 2023), as inflation is largely profit-led in the energy shock scenario.

Our work can be extended in several directions. First, the policy implications of our analysis are not fully explored. In particular, new interventions beyond conventional interest rate policy might be necessary to curb inflation at a lower social cost. Secondly, the model could be extended to investigate the role of sticky prices and wages in coordinating agents' interactions through the decentralized matching procedure. Finally, more sophisticated expectations rules could be considered in the model, possibly introducing different forms of learning (see e.g., Hommes, 2006; Dosi et al., 2020).

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A Monte Carlo distribution for key variables in the model

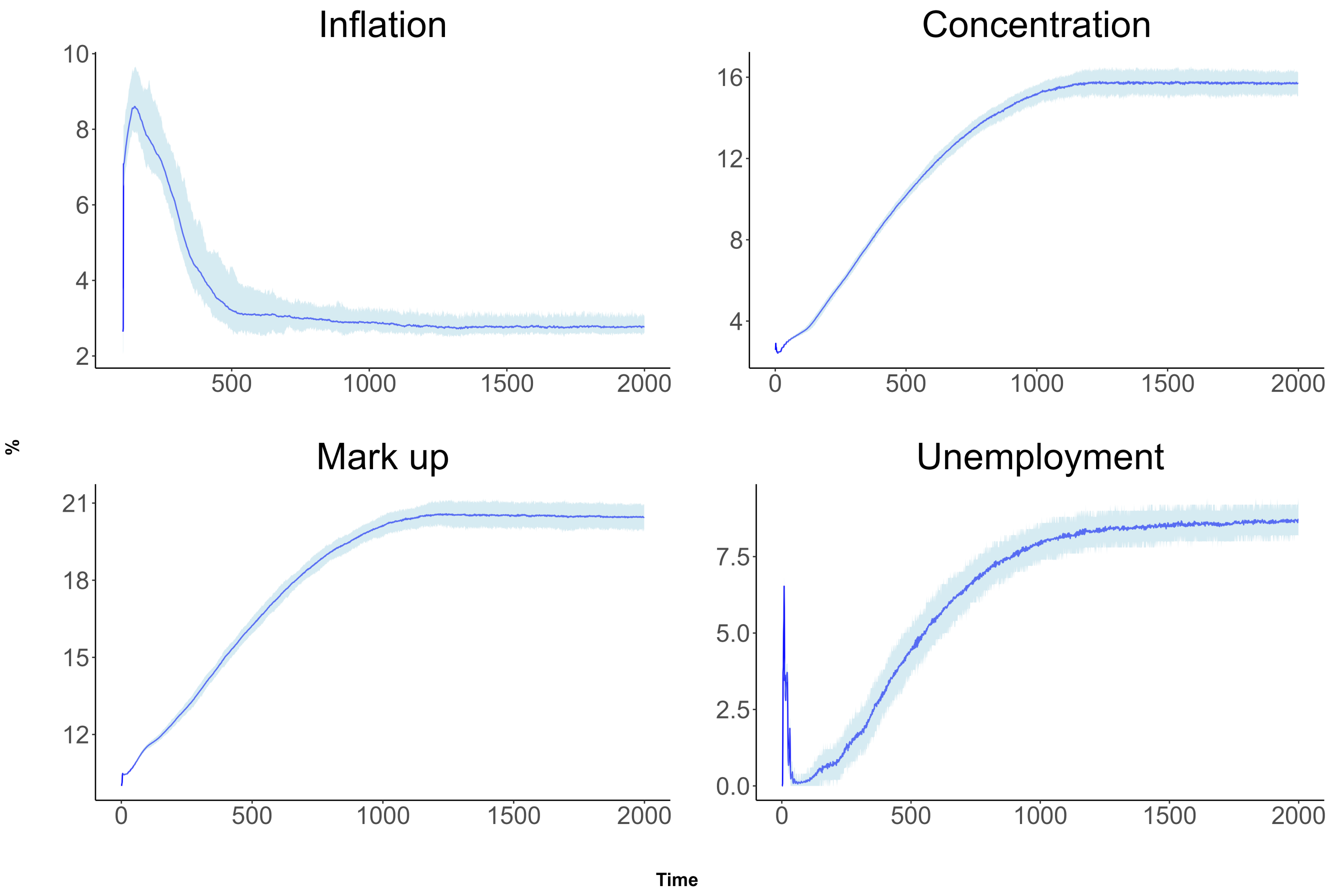

Figure 13: Median value (blue line) of the Monte Carlo distribution for inflation rate (top-left), market concentration (top-right), mark-up rate (bottom-left) and unemployment rate (bottom-right) as a function of simulation time. The shaded area is defined by the 10th and 90th percentile values out of 100 Monte Carlo simulations.

B Split-sample estimate of the non-linear Phillips Curve

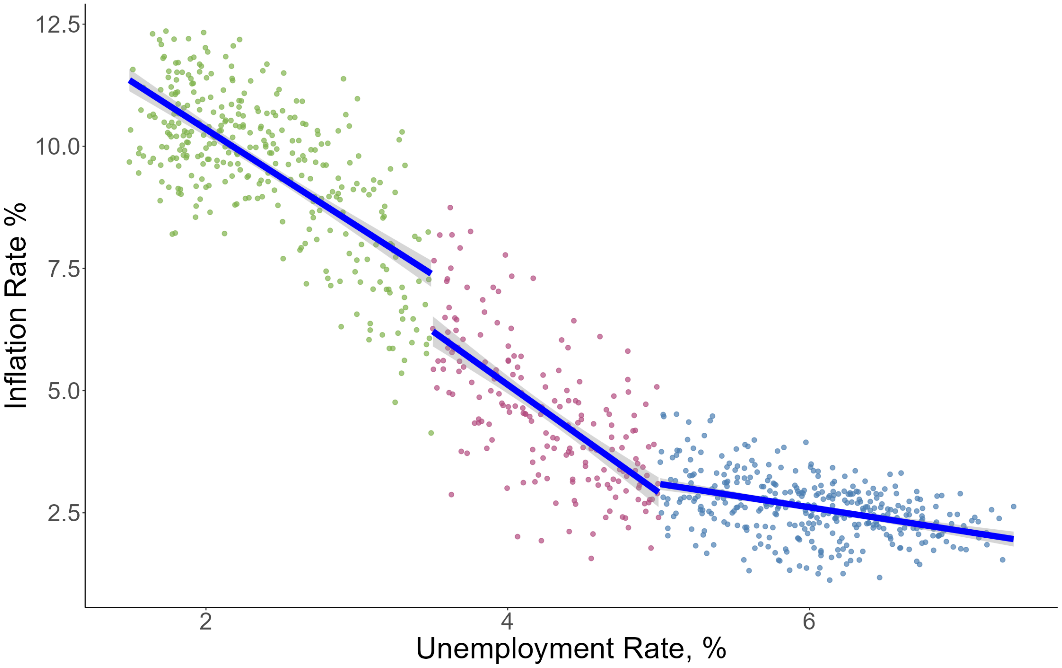

Figure 14: Split-sample estimate of the Phillips Curve generated by the model. The slope of the Phillips Curve in the model is conditional on the region of the (u, π) plane in which the model operates.

	$\mathbf{u < 3.5\%}$	$\mathbf{3.5\% < u < 6\%}$	$\mathbf{u > 6\%}$
$Intercept$	15.2^{***}	9.1^{***}	4.3^{***}
	(0.69)	(0.41)	(0.22)
$Slope$	-1.34^{***}	-2.60^{***}	-0.48^{***}
	(0.10)	(0.08)	(0.08)
$Nobs.$	489	396	415
R^2	0.84	0.43	0.27
* p < 0.1, ** p < 0.05, *** p < 0.01			

Table 8: Coefficients of the Split-sample estimate of the non-linear Phillips Curve. Standard errors are reported in parentheses.

C Impact of aggregate shocks on market structure

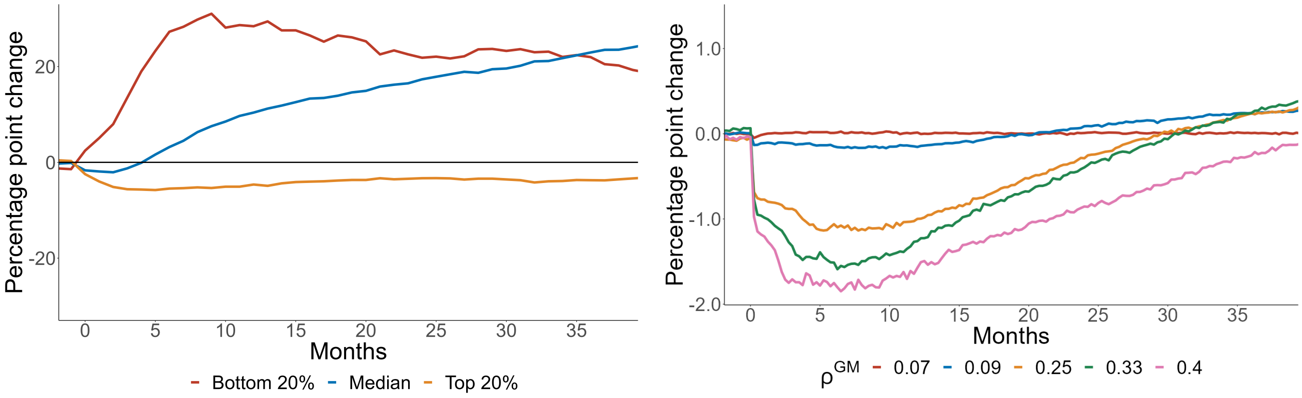

Figure 15: Left panel: Firm market share fluctuations after the positive demand shock in the baseline scenario ($\rho^{GM} = 0.4$). Right panel: Impact of the positive demand shock to Herfindahl-Hirschman Index (HHI) for different scenarios. Time is measured in months (4 periods). The impact of the shock over time is measured in percentage point deviation from the pre-shock level.

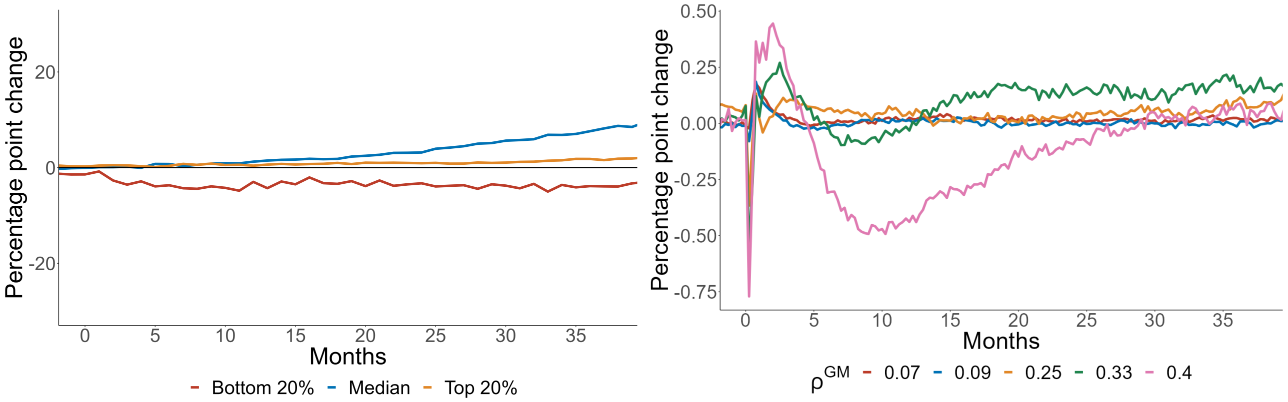

Figure 16: Left panel: Firm market share fluctuations after the negative productivity shock in the baseline scenario ($\rho^{GM} = 0.4$). Right panel: Impact of the negative productivity shock to Herfindahl-Hirschman Index (HHI) for different scenarios. Time is measured in months (4 periods). The impact of the shock over time is measured in percentage point deviation from the pre-shock level.

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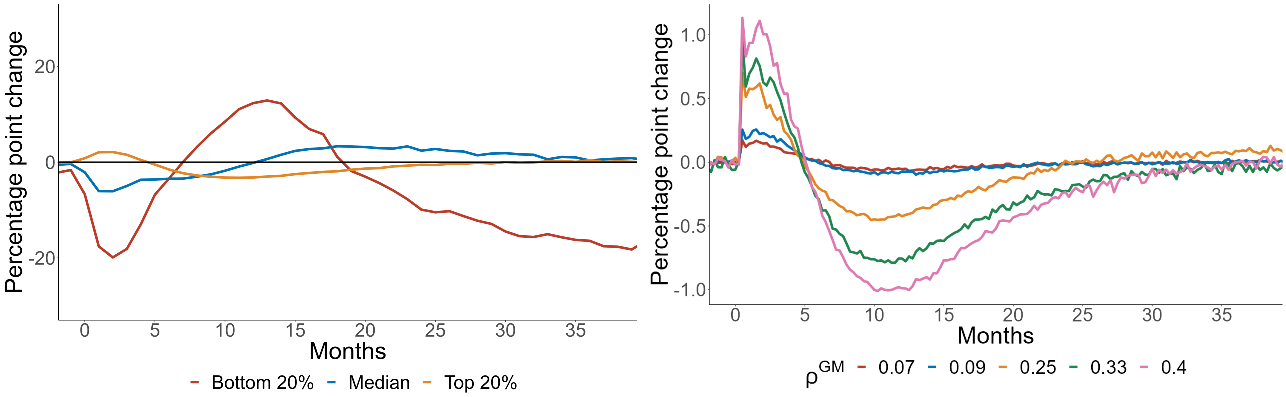

Figure 17: Left panel: Firm market share fluctuations after the adverse energy shock in the baseline scenario ($\rho^{GM} = 0.4$). Right panel: Impact of the negative energy shock to Herfindahl-Hirschman Index (HHI) for different scenarios. Time is measured in months (4 periods). The impact of the shock over time is measured in percentage point deviation from the pre-shock level.

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