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ESSAIS SUR LA COMPÉTITION IMPARFAITE DANS LE MARCHÉ DU TRAVAIL DANS LES MODÈLES MACROÉCONOMIQUES

THÈSE

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RÉSUMÉ

Cette thèse se compose de trois chapitres centrés sur l'analyse approfondie de la compétition imparfaite dans le marché du travail et son intégration dans les modèles de la nouvelle macroéconomie keynésienne, ainsi que sur les implications macroéconomiques qui en découlent, particulièrement dans le contexte de l'économie américaine.

Dans le premier chapitre, nous explorons deux paradigmes opposés du marché du travail. D'une part, la vision standard des modèles de la nouvelle macroéconomie keynésienne où, en raison de leurs compétences distinctes, les ménages exercent un pouvoir de monopole en déterminant les salaires. D'autre part, nous examinons une approche où, dans un marché du travail dans lequel les travailleurs ont des options limitées, les firmes exercent un pouvoir de monopsone en dictant les conditions d'embauche et les salaires. En calibrant les deux modèles de manière similaire, notre analyse révèle que l'introduction de la compétition de monopsone dans le marché du travail ne bouleverse pas de manière significative les propriétés cycliques traditionnellement identifiées dans la littérature standard, en ce qui a trait aux chocs structurels standards. Toutefois, les effets d'un choc specifique sur les salaires (plus précisément sur la marge ajoutée ou sur la minoration sur les salaires) sont significativement plus prononcés dans le modèle avec monopsone, mettant en exergue les différences d'incitatifs qu'ont les firmes et les ménages lorsque les premiers ou les seconds possèdent et exercent le pouvoir de marché. Par ailleurs, notre analyse et nos résultats ne nous permettent pas d'établir une supériorité de la performance empirique de la modélisation sur la base d'un marché du travail en concurrence imparfaite avec pouvoir de marché détenu exclusivement soit par les ménages soit par les entreprises.

Le deuxième chapitre adopte une perspective possiblement plus réaliste du marché du travail en introduisant une structure à trois segments. Nous avons la compétition de monopole dans un premier segment où les ménages détiennent le pouvoir de marché, leur permettant de fixer les salaires. Dans un deuxième segment, les firmes possèdent le pouvoir de marché, donnant lieu à la compétition de monopsone dans laquelle elles prennent les décisions d'embauche et de fixation des salaires. Enfin, dans un troisième segment, employés et employeurs évoluent dans un environnement purement concurrentiel dans lequel l'évolution des embauches et des salaires est dictée par les conditions générales du marché. Ce cadre démontre sa pertinence théorique en produisant des trajectoires de réponses cohérentes avec les études existantes sur le cycle économique. Nos analyses mettent en lumière l'interaction significative entre les chocs de politique monétaire, la composition du marché du travail et le degré de pouvoir de marché et de rigidité des salaires nominaux. En outre, notre modèle performe mieux que le modèle de la nouvelle macroéconomie keynésienne standard en terme de sa capacité à reproduire des moments empiriques tels que la volatilité cyclique de certaines variables macroéconomiques clé telles que a production, de l'investissement, du salaire réel, du travail, de la productivité marginale du travail et de l'inflation. Finalement, nous trouvons qu'une économie dans laquelle la proportion des travailleurs oeuvrant dans un segment de concurrence monopsonistique est plus faible affiche un niveau de bien-être plus élevé.

Le troisième chapitre s'appuie sur le modèle de la nouvelle macroéconomie keynésienne enrichi du deuxième chapitre et procède à son estimation en utilisant des méthodes bayésiennes. Face au défi que représente l'estimation de nouveaux paramètres en l'absence d'évidences empiriques et théoriques substantielles, nous adoptons une approche innovante, s'appuyant sur des preuves indirectes, des distributions à priori non informatives, et une intuition économique raisonnable. Nos résultats sont cohérents avec les contributions majeures de la littérature et capturent efficacement certaines caractéristiques clés de l'économie

américaine, notamment la diminution de la volatilité macroéconomique et l'augmentation du pouvoir de marché des entreprises observées depuis le début des années 1980. De plus, en réexaminant les sources des fluctuations du cycle économique, nous obtenons des perspectives contrastées et enrichissantes par rapport à la littérature.

INTRODUCTION

Les modèles de la nouvelle macroéconomie keynésienne standard dynamiques, stochastiques et d'équilibre général (NK-DSGE) ont gagné en popularité durant ces dernières décennies, que ce soit auprès des académiciens ou auprès des praticiens, en raison de leur rôle clé dans l'amélioration de la compréhension du cycle économique. En effet, ils permettent notamment de mieux comprendre les fluctuations à court terme de l'activité économique, les sources desdites fluctuations, ainsi que la conception et l'évaluation de certaines politiques économiques.

Les travaux de Christiano *et al.* (2005) et de Smets and Wouters (2007), notamment, définissent le cadre standard des modèles de la nouvelle macroéconomie keynésienne. Ces derniers incorporent non seulement des frictions réelles telles que l'utilisation variables du capital, la formation d'habitudes de consommation et les coûts d'ajustement de l'investissement, mais aussi des frictions nominales telles que les rigidités nominales de prix et salaires à la Calvo. En plus de ces ingrédients, cette classe de modèles prend pour acquis le fait que le marché du travail est caractérisé par des ménages qui possèdent des aptitudes différenciées leur conférant l'exercice d'un pouvoir de monopole qui implique la fixation des salaires nominaux. Ainsi, les modèles NK-DSGE standards communément employés dans la littérature présupposent donc que le marché du travail opère en concurrence monopolistique à l'avantage des ménages d'où on peut de parler "household-labor-market-power" ou HLMP-NK-DSGE.

Toutefois, à notre connaissance, aucune étude empirique n'a été produite dans la littérature en support à l'idée que les ménages détiennent et exercent un pouvoir de marché du travail qui soutiendrait que ce marché puisse être entièrement caractérisé par la concurrence monopolistique en faveur des ménages. À contrario, des études empiriques dans la littérature en économie du travail et des développements suggèrent plutôt la possibilité qu'une partie du marché du travail américain soit sujet à l'exercice de pouvoir de marché à l'avantage des entreprises, soit "firms' labor market power" ou FLMP. Malgré l'absence de données suffisamment fines qui permettraient d'associer de façon distincte des segments du marché du travail à un type concurrence HLMP, FLMP ou même possiblement de concurrence parfaite, il nous semble donc qu'il y a lieu de prendre en compte une vision potentiellement plus nuancée de la nature de la concurrence dans le marché du travail que ce qui a été généralement pris pour acquis dans les modèles du cycle économique.

n'a formellement démontré que les ménages détiennent et exercent un certain pouvoir de marché du travail étant donné le manque de granularité dans les données observées. Par ailleurs, certains développements récents dans le marché du travail américain remettent en question cette hypothèse de monopole des ménages et suggèrent une vision potentiellement plus nuancée.

En accord avec la théorie microéconomique, nous pouvons distinguer trois principaux types de compétition dans le marché du travail. Premièrement, dans un marché concurrentiel, le salaire réel d'équilibre est égal à la valeur de la productivité marginale du travail et il est pris comme donné par les ménages et les entreprises. Deuxièmement, dans un marché du travail avec concurrence monopolistique à l'avantage des ménages, le salaire reçu et déterminé par les ménages est majoré par rapport au taux marginal de substitution entre consommation et loisir par un "mark-up". Enfin, dans un marché du travail avec concurrence monopsonistique à l'avantage des firmes, le salaire réel reçu par les ménages et déterminé par les firmes est minoré par un "mark down" sur la valeur de la productivité marginal du travail. Ainsi, cette thèse, qui comporte trois chapitres sous forme d'articles, a pour but de montrer que l'hypothèse sur la compétition dans le marché du travail traditionnellement posée dans les modèles NK-DSGE repose sur des arguments qui non seulement peuvent être remis en question mais aussi dépeignent une vision potentiellement incomplète du marché du travail. Par ailleurs, cette hypothèse n'est pas triviale car elle peut avoir des implications dans la façon de comprendre le fonctionnement du cycle économique.

Le point de départ de cette thèse est un ensemble de développements observés dans l'économie américaine. Il s'agit notamment de la baisse des taux de syndicalisation, de la présence relativement importante des clauses de non-compétitivité et de "non-braconnage", telles que rapportées par Colvin and Shierholz (2019) et Krueger and Ashenfelter (2022), respectivement, et des estimés relativement petits de l'élasticité d'offre du travail rapportés par Sokolova and Sorensen (2021). Selon les travaux de Robinson (1969), remis en avant par Manning (2003a), ces faits sont caractéristiques d'un marché du travail en situation de monopsone, c'est-à-dire que les firmes possèdent et usent de leur pouvoir de marché en prenant les décisions d'embauche et de salaire.

Ainsi, l'objectif du premier chapitre se résume à comparer les conséquences macroéconomiques d'un marché du travail en situation de monopsone par rapport à un marché du travail en situation de monopole, les autres caractéristiques des modèles étant identiques. Pour ce faire, nous calibrons les paramètres des deux modèles de façon similaire, en nous basant sur des travaux représentatifs de la littérature tels que

Christiano *et al.* (2005), Justiniano *et al.* (2010), Justiniano *et al.* (2011) et Ascari *et al.* (2018). Ce premier chapitre montre que faire l'hypothèse de la concurrence de monopsone dans le marché du travail ne change pas drastiquement les propriétés standards du cycle économique établies dans la littérature de la nouvelle macroéconomie keynésienne, en ce qui concerne les chocs technologiques, d'efficience marginale de l'investissement et de politique monétaire. Par contre, les effets du choc sur la marge ajouté ou sur la minoration sur les salaires (plus simplement choc sur les salaires) sont significativement plus prononcés et plus persistants dans le modèle avec monopsone. Ce résultat met en exergue les différences d'incitatifs des firmes et ménages lorsque l'un ou l'autre agent possède le pouvoir de marché. De même, on trouve une plus forte interaction entre les paramètres qui gouvernent le pouvoir de marché des deux modèles et le choc sur les salaires. Ensuite, notre modèle rapporte que la minoration sur les salaires appliquée par les firmes est contracyclique, en ligne avec Depew and Sørensen (2013) et Hirsch *et al.* (2018). Toutefois, nos résultats ne nous permettent pas de soutenir que la modélisation d'une économie avec marché du travail entièrement monopolistique a une performance empiriquement supérieure à celle d'une économie avec marché du travail entièrement monopsonistique.

Une simple observation des relations de travail dans notre environnement permet de constater que le pouvoir relatif de négociation de certains travailleurs vis-à-vis des entreprises n'est pas uniforme ni dans toutes les entreprises ni dans tous les secteurs. Il peut notamment varier en fonction de l'expérience et des qualifications des travailleurs, de l'intensité de l'activité et de la mobilisation syndicale, des clauses d'exclusivité dans les arrangements contractuels implicites ou explicites d'emploi exigées par les entreprises, de la position dominante dans une région ou un secteur donné. En d'autres termes, le type de concurrence dans le marché du travail n'est en réalité pas unidimensionnelle, c'est-à-dire caractérisée soit par de la concurrence de monopole, de la concurrence de monopsone ou de la concurrence sans pouvoir de marché. Dans cette optique, le deuxième chapitre adopte une perspective plus réaliste du marché du travail prenant en compte les différents rapports de force possibles entre employé(e)s et employeur(e)s. Pour ce faire, nous proposons une structure de marché du travail à trois segments, chacun reflétant un type de compétition distinct. Nous avons la compétition de monopole dans un premier segment où les ménages détiennent le pouvoir de marché, leur permettant de fixer les salaires. Dans un deuxième segment, les firmes possèdent le pouvoir de marché, donnant lieu à la compétition de monopsone dans laquelle elles prennent les décisions d'embauche et de fixation des salaires. Enfin, dans un troisième segment, l'évolution des embauches et des salaires est dictée par les conditions générales du marché dans un environnement purement concurrentiel. Les caractéristiques restantes du modèle sont identiques au modèle NK-DSGE standard. Étant donné l'absence de données directes permettant d'identifier et de caractériser précisément les différents segments du marché du travail, le modèle est calibré sur la base de données indirectes, telles que celles de Starr (2018), et en postulant des intuitions raisonnables permettant d'établir des points de référence, dont la sensibilité pourra être vérifiée.

L'objectif de ce chapitre est triple. Dans un premier temps, on explore les implications de notre modèle sur le cycle économique. On trouve que nos sentiers de réponse sont en ligne avec des travaux tels que Gali (1999) et Justiniano *et al.* (2010). Par ailleurs, on trouve que le choc monétaire interagit avec les éléments de la composition du marché du travail, le degré de pouvoir de marché de travail des ménages et des firmes et le degré de rigidités salariales.

Deuxièmement, on compare les résultats de notre modèle à ceux du modèle NK-DSGE standard en termes de sentiers de réponse et de statistiques du cycle économique. On trouve que les effets cycliques induits par les chocs technologiques, d'efficience marginale de l'investissement et de politique monétaire sont moins forts dans notre modèle relativement au modèle standard. En outre, notre modèle a une meilleure capacité à reproduire la volatilité observée de la production, de l'investissement, du salaire réel, du travail, de la productivité marginale du travail et de l'inflation, comparé au modèle NK-DSGE traditionnel.

Enfin, notre modèle permet de proposer une façon d'évaluer une proposition de la Commission Fédérale du Commerce aux États-Unis qui veut bannir des contrats de travail des clauses donnant un pouvoir de marché excessif aux firmes car celles-ci seraient dommageables pour les ménages. Ainsi, notre analyse démontre qu'une économie dans laquelle la plus petite proportion des travailleurs exercent dans un segment de concurrence monopsonistique a un niveau de bien être plus élevé.

Le troisième chapitre se veut une extension du chapitre précédent en procédant à une estimation d'un modèle où coexistent trois segments du marché du travail caractérisé respectivement par des structures concurrentielles sans pouvoir de marché, avec concurrence monopolistique et concurrence monopsonistique, à l'aide d'une méthode d'estimation bayésienne. En nous inspirant de contributions importantes dans la littérature telles que Smets and Wouters (2007) et Justiniano *et al.* (2010), nous rapportons le modèle aux données non seulement afin de démontrer sa pertinence empirique mais aussi afin d'identifier et d'estimer des paramètres non traditionnels provenant de la nouvelle structure du marché du travail que nous imposons.

L'estimation du modèle par des techniques bayésienne produits des estimés des paramètres traditionnels qui sont en conformité avec la littérature sur l'estimation des modèles NK-DSGE standards. Par ailleurs, une de nos contributions est l'estimation de paramètres structurels qui étaient inexistants dans les modèles traditionnels où tout le marché du travail était conçu comme par une concurrence monopolistique à l'avantage des ménages.En particulier, nous estimons les parts respectives des travailleurs dans chaque segment du marché du travail, et le degré de rigidités des salaires respectifs de ces travailleurs.

Puis, la subdivision de notre échantillon d'estimation en deux sous-périodes, soit de 1948:T1 à 1983:T4 et de 1984:T1 à 2019:T4, nous permet d'évaluer si nos estimés sont similaires à la période précédant la Grande Modération, et pendant la Grande Modération. Nous trouvons que les paramètres structurels, les paramètres de persistance et la volatilité des chocs sont cohérents avec la baisse de la volatilité de la production et de l'inflation survenue pendant la Grande Modération. Par ailleurs, les changements dans les paramètres qui mesurent le pouvoir des firmes dans les marchés du travail et des biens et services sont en ligne avec une hausse du pouvoir de marché desdites firmes, en accord avec De Loecker *et al.* (2020). En outre, une comparaison des sentiers de réponse issus des estimations des deux sous-périodes suggère que les effets des différents chocs aggrégés sont plus forts pendant la sous-période avant 1984 relativement à la sous-période après 1984. Enfin, nous réévaluons les sources de fluctuations du cycle économique. Un résultat intéressant est que le choc sur la minoration des salaires appliqué par les firmes explique la plus grande proportion des fluctuations du salaire réel, par opposition à Justiniano *et al.* (2010) qui trouvent que c'est le choc sur la marge ajoutée sur les salaires qui est le principal responsable.

CHAPITRE 1

THE MACROECONOMIC IMPLICATIONS OF FIRMS' LABOR MARKET POWER

RÉSUMÉ

Modern New Keynesian models typically feature price and wage rigidities and embed various real shocks as well as a monetary policy shock. This study contrasts two distinct New Keynesian dynamic stochastic general equilibrium (NK-DSGE) models—one characterized by households' labor market power (HLMP) and the other by firms' labor market power (FLMP)—to discern their respective impacts on business cycle dynamics. We find that while the introduction of monopsonistic labor markets does not fundamentally disrupt the standard business cycle features identified in the HLMP-New Keynesian literature, notable differences emerge in the models' responses to wage shocks. The FLMP model, in particular, exhibits significantly amplified reactions, underscoring the distinct incentives for households and firms when labor market power is asymmetrically distributed. The study further delves into the cyclical behavior of wage markdowns and matches some business cycle moments, providing nuanced insights into the empirical relevance of monopsonistic labor market structures in a New Keynesian framework. This paper not only advances our understanding of labor market dynamics in macroeconomic modeling but also highlights the critical role of labor market power and its interaction with business cycles.

KEY WORDS: Labor Market Power; Monopsony; Business Cycle; New Keynesian DSGE Model.

JEL classification: E12, O32, J42, E52.

1.1 Introduction

Christiano *et al.* (2005)'s seminal paper introduced medium-scale New Keynesian dynamic stochastic general equilibrium (NK-DSGE) models that are extensively used for examining the impact of aggregate economic disturbances on macroeconomic variables, identifying the sources of business cycle fluctuations or assessing the macroeconomic implications of particular government economic policies. These models are crucially characterized by the existence of nominal wage rigidity in an economy where households hold some bargaining power over their wage rate, resulting from their distinct skill sets.[1]

However, recent economic observations in the U.S. suggest that firms might possess significant power in the labor market, as indicated by growing empirical evidence on monopsonistic labor markets. If true, this challenges the labor market structure typically assumed in medium-scale New Keynesian models. In this paper, we thus investigate the business cycle implications of firms' labor market power within the context of a medium-scale NK-DSGE model.

Robinson (1969) identifies three sources of frictions that hinder workers mobility, thereby restricting their outside options and granting employers some degree of monopsony power. First, informational frictions prevent workers from easily identifying job vacancies that align with their specific skills and requirements.[2] Second, workers may develop attachments to their current employers based on factors unrelated to compensation. Third, the process of transitioning from one job to another is often associated with significant time and financial costs for employees. These frictions, as discussed by Manning (2003b), result in a "thin" labor market from the workers' perspective.[3] Hence, workers do not perceive jobs as perfect substitutes, even with an equal compensation.

Additionally, three institutional sources contribute to firms' labor market monopsony power. First, workers are more likely to have larger bargaining power in highly unionized sectors or industries. However, data from the Bureau of Labor Statistics (BLS), reveal a decline in the share of unionized workers, dropping from 20.1% in 1983 to 10.8% in 2020.[4] Moreover, unionization rates have decreased even within specific industries. For instance, the unionization rate in transportation and utilities sectors fell from 26% in 2000

[1] For practical matters, the nominal rigidity is often represented by Calvo wage contracts.

[2] It might be argued that informational frictions have, however, been dampened by the development of information technology and the Internet.

[3] Labor market is thin in the sense that workers only have a limited set of options when it comes to finding a job.

[4] The year 1983 is the first year for which comparable data about union members are available.

to 16.6% in 2020.[5] Second, noncompete clauses (NCs) may be enforced by firms in some sectors, in some regions, and under some economic conditions. NCs are contractual provisions that prevent employees from joining or establishing competing firms within specified geographic boundaries and timeframes, or in the same line of activities. Starr *et al.* (2021) find that in 2014, approximately 20% of the U.S. private labor force had entered into labor contracts containing NCs. Colvin and Shierholz (2019) estimate that the prevalence of NCs among private sector workers range from 27.8% to 46.5%. These studies, along with the work of Bishara *et al.* (2015), show that not only low-skilled workers but also high-skilled employees are subject to NCs. Third, "no-poaching agreements" (NPAs) have also been used by firms.[6] NPAs occur when employers, either implicitly or explicitly, agree not to hire each other's workers to limit competition among them. Krueger and Ashenfelter (2022) examine contracts for 156 of the largest franchise chains in the U.S. to find statements that could directly or indirectly refer to NPAs among employers. Their findings suggest that 56% of more than 300 000 franchises and corporate units may have colluded in this way.

The main implication of these frictions is to limit workers' outside options and, hence, their mobility, making them less likely to quit their job when employers exercise their power by applying markdown on wages. In this context, it becomes difficult to argue that workers possess some wage-setting power, as traditionally assumed in medium-scale New Keynesian models. Instead, it is more likely that firms possess and may exert some wage-setting power. A large empirical literature is devoted to uncover evidence of employers labor market power and its implications, especially on wages.

A consensus in the literature is that the (wage) elasticity of labor supply is an adequate measure of the extent of firms' labor market power.[7] The elasticity of labor supply measures the sensitivity of hours worked to a change in the wage rate. Theoretically, a lower value of the elasticity of labor supply is associated with a larger employers' monopsony power. The range of estimates of the elasticity of labor supply is quite large (see, for example, studies like Webber (2015), Azar *et al.* (2022b) and Kroft *et al.* (2021)). Given the multitude of estimates of the elasticity of labor supply, Sokolova and Sorensen (2021) conduct a meta-

[5] Some sectors still have relatively high unionization rate, despite the downward trend. For example, according to the B.L.S., the public sector and the industry of utilities still have respectively 34.8% and 20.6% of their workers either as union's members or whose jobs are covered by a union, in 2020. Consequently, it may be that besides the mathematical appeal of Calvo modeling, the importance of unions at the sectoral level in some industry may still be thought as supportive of households/workers labor market power.

[6] Given that collusive actions between employers are illegal, they take the form of no-poaching agreements.

[7] See, for example, Khan and Metaxoglou (2021).

analysis to reckon an estimate that reconciles the literature. Based on 801 estimates from published papers and using Bayesian model averaging, they find an average elasticity of 2.75. Moreover, if labor market frictions decrease labor mobility, it also implies that they increase labor market concentration, at least for firms which possess and exercise some labor market power. Consequently, another way to measure the extent of labor market power is through the degree of labor market concentration. Azar *et al.* (2022a), Benmelech *et al.* (2022) Qiu and Sojourner (2023) and Rinz (2022) all find an increase in the local labor market concentration between 1977 and 2017.

Due to labor market frictions, firms have incentives to exert their wage-setting power by applying wage markdowns. Studies focusing on labor market frictions and/or measures of labor market power also investigate their effects on wages. For instance, Michaelides (2010) shows that the exploitation of workers' immobility by employers has a negative effect on wages. Lipsitz and Starr (2022) find that the ban of NCs in 2008 in Oregon has increased hourly wages by 2.2-3.1% on average. Moreover, Azar *et al.* (2022a), Benmelech *et al.* (2022) and Qiu and Sojourner (2023) find that a rise in labor market concentration leads to wage reduction ranging from 5% to 26%. In addition, studies that measure the elasticity of labor supply also estimate the implied wage markdown. For example, Azar *et al.* (2022b), Kroft *et al.* (2021) and Sokolova and Sorensen (2021) find wage markdowns ranging from 20% to 26.7% below the marginal revenue product of labor.

The relevance of this inquiry extends beyond academic curiosity. Understanding the dynamics of wage markdowns and the distribution of labor market power has profound normative implications, especially considering the recent economic climate marked by positive and high inflation and relatively stagnant wage growth. This is why questions pertaining to wage dynamics have percolated into the public and social debate. Economists, lawyers and anti-trust practitioner have been suggesting legal reforms to tackle anticompetitive behavior in the labor market (see for example Krueger and Posner (2018) or Marinescu and Posner (2019)). Furthermore, in the U.S., President Biden signed in 2021 an Executive Order to promote more fair competition in the U.S. economy in general and in the U.S. labor market in particular.

Considering that monopsonistic competition in the labor market might be an important characteristic of the U.S. economy at the aggregate level, which is typically absent in NK-DSGE models, this paper addresses two key research questions. First, are there implications of firms' labor market power compatible with the empirical characteristics of the U.S. business cycles? Second, does labor market monopsony in a medium-scale NK-DSGE model results in a different transmission mechanism of various macroeconomic shocks? To investigate these questions, we adapt Christiano *et al.* (2005)'s medium-scale DSGE model which embeds monopolistic goods market, nominal wage and price rigidities, by replacing monopolistic competition in the labor market with monopsonistic competition. We are thus able to compare and to contrast two polar views about the functioning of the labor market. In our models, aggregate fluctuations are driven by three types of traditional aggregate shocks i.e. a common neutral productivity shock, a shock to the marginal efficiency of investment (MEI) and a monetary policy shock to a Taylor feedback rule. In addition to traditional shocks, we embed the models with a wage shock which allows us to introduce some exogenous variations in the FLMP wage markdown and HLMP wage markup rates that are absent in the standard setup.

Our main results are the following. First, the size of the effects of neutral technology, MEI and monetary policy shocks on key macroeconomic variables are qualitatively similar in both polar models, although there are some very small quantitative differences, which align with Alpanda and Zubairy (2021)' findings.

Second, following the wage shock, we find large quantitative differences between the two models, even though the cyclical paths of key variables are quite qualitatively similar. A positive wage shock, which is akin to an exogenous variation in the relative bargaining power of workers, reduces the wage markdown, which raises labor supply, thus inducing an increase in aggregate labor and in aggregate output in the model with monopsony power in the labor market. Contrastingly, in the model with monopoly power in the labor market, households' wage-setting power allows them to increase wages, reducing firms' incentives to increase labor and output due the rise in the wage bill.

Third, by delving into the cyclicality of wage markdowns, we find that they are unconditionally counter-cyclical, in line with Depew and Sørensen (2013) and Hirsch *et al.* (2018) who respectively used U.S. and German data. However, conditional to monetary policy shocks, wage markdowns become procyclical. This second finding is broadly consistent with the result reported in Khan and Metaxoglou (2021). Using KLEMS data from 1987 to 2018, they find that aggregate wage markdown is procyclical.

Fourth, we obtain mixed results when comparing the ability of the two models to match some business cycle moments, which leaves us unable to clearly establish which model's performance is superior in reproducing volatilities, contemporaneous cross-correlations and autocorrelations.

Our paper contributes to the literature of business cycles studied through the lens of NK-DSGE models

(Christiano *et al.* (2005), Justiniano *et al.* (2010), Justiniano *et al.* (2011) and Ascari *et al.* (2018)) by showing that there is some interaction between the labor market structure imposed in a NK-DSGE model and business cycle properties. Our paper is also related to the literature of imperfect competition in the labor market within a macroeconomic model. In fact, monopsony and oligopsony have been exceptionally embedded in a theoretical macroeconomic framework by Dennery (2020) and Alpanda and Zubairy (2021). We contribute to that literature by providing an alternative way to model a monopsonistic labor market structure that differs from the modeling strategy adopted in these two papers. The analysis provided in this paper can be seen as a useful and instructive step towards the assessment of how polar assumptions on the nature of the labor market imperfect competition may impact our comprehension of business cycle in the context of a NK-DSGE models.

The paper is structured as follows. In the next section, we describe the models' structure, the economic agents problems, and their optimal solution, highlighting the similarities and differences between our model and the standard NK model. In section 3, we discuss the choice of the models' parameter values. Section 4 presents the main results of the stochastic simulations, including impulse response functions, business cycle volatilities and comovements. Finally, concluding remarks are provided in section 5.

1.2 The models

We will be contrasting two alternatives models that take polar views about the nature of the interaction between labor demand and labor supply. Both models share many similarities with the standard NK model.[8] In particular, the economy consists of the following agents: households, labor intermediaries, the final good producer, intermediate good producers and a monetary authority. Households derive utility from consumption and leisure while supplying specialized labor skills to the labor intermediaries. Intermediate goods producers create differentiated goods using physical capital services and labor. They evolve in a monopolistically competitive setup that allows them to set prices. Operating in a perfectly competitive market, the final good producer transforms differentiated intermediate goods into output. The monetary authority sets the nominal interest rate according to a Taylor rule. Common features in both models also include the following frictions: nominal rigidities in the form of Calvo wage and price contracts, habit formation in consumption, investment adjustment costs, and variable utilization of physical capital.

[8] See, for example, Christiano *et al.* (2005).

The main difference between our model and the standard NK framework pertains to the labor market structure. In the standard model, the labor market is monopolistic, driven by market power on the supply side, making households wage-makers. Labor intermediaries, which are added for convenience, operate in a perfectly competitive labor market. They combine specialized labor skills into an aggregate labor input used by intermediate firms.[9] Households make wage-setting decisions while the hiring decisions are left to firms. There is a monopolistic rent because the wages received by households are markups over their marginal rate of substitution between consumption and leisure (MRS). We refer to this model as the HLMP (Households with Labor Market Power) model.

In our adapted version of the standard NK model, the labor market is monopsonistic, driven by market power on the demand side, making intermediate firms wage-markers (while households are wage-takers). Operating in a monopsonistically competitive labor market, labor intermediaries exert the wage-setting power and undertake hiring decisions on behalf of firms. Thus, there is a monopsonistic rent arising from the applied markdown on the marginal revenue product of labor (MRPL). We refer to this model as the FLMP (Firms with Labor Market Power) model.

We now provide a detailed presentation of the economy. For each agents, as necessary, we present the common features, specific features related to the HLMP model and specific features related to the FLMP model, in the appropriate order.

1.2.1 Households

1.2.1.1 Common features

The economy is populated by a continuum of households indexed by $i \in [0, 1]$, where i denotes a particular type of labor supplied to intermediate goods producers via the labor intermediaries. A household i's intertemporal preferences over consumption, $C_t(i)$, and labor, $L_t(i)$, is given by the expected utility function over an infinite horizon

$$E_t \sum_{t=0}^{\infty} \beta^t \left(\ln(C_t(i) - bC_{t-1}(i)) - \eta \frac{L_t(i)^{1+\psi}}{1+\psi} \right), \tag{1.1}$$

where E_t is the expectation operator conditional on all the information available and known as of period t,

[9] It is a modeling ”trick” akin to standard NK DSGE model to simplify the presentation and the treatment of the households' problem. We follow a similar modeling strategy in the FLMP model.

$0 < \beta < 1$ is the subjective discount factor, $0 < b < 1$ is a parameter governing internal habits formation, η is the weight on labor disutility and ψ is the inverse Frisch elasticity of labor supply.

Each period, a household i divides its time between hours of work, $L_t(i)$, and leisure, $l_t(i)$. The total time at its disposal is normalized to one, so that the time constraint is

$$L_t(i) + l_t(i) = 1. \tag{1.2}$$

A household i's time t nominal budget constraint equates one's amount of resources to its expenses, according to:

$$P_tC_t(i) + P_tX_t(i) + B_{t+1}(i) + P_ta(u_t(i))K_t = W_t(i)L_t(i) + Q_tu_t(i)K_t(i) + (1 + R_{t-1,t})B_t(i) + D_t(i). \tag{1.3}$$

At time t, a typical household i supplies labor and receives the nominal wage rate, $W_t(i)$. It rents the services of physical capital, $u_t(i)K_t(i)$ (or $\hat{K}_t(i)$) to intermediate firms at a competitive nominal rate, $Q_t(i)$. The capital utilization rate, $0 \leq u_t(i) \leq 1$, allows households to vary the intensity and the quantity of physical capital rented each period. A typical household i receives an income from its purchase of a one-period bonds, B_t, in the previous period with a gross nominal interest rate, $(1 + R_{t-1,t})$.[10] Furthermore, as the households own the intermediate firms, the final good producer and the labor intermediaries, their income also includes nominal dividends paid by these firms. These economic profits, denoted by $D_t(i)$, may arise from the exercise of monopoly or monopsony power. We give more details about $D_t(i)$ in the subsequent sections.

A household's current income is devoted to the nominal consumption in the final good, $P_tC_t(i)$, the level of nominal investment in capital goods, $P_tX_t(i)$, the purchases (or sales) of one-period bonds, $B_{t+1}(i)$, and the nominal cost of adjusting physical capital, $P_ta(u_t(i))K_t(i)$. The resource cost of the variable utilization of physical capital is proportional to the capital stock, with $a(u_t(i))$ being given by the following convex function:

$$a(u_t(i)) = \left(\chi_1(u_t(i) - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{1}{Z_t}, \tag{1.4}$$

with $\chi_1 \geq 0$ and $\chi_2 \geq 0$, two parameters governing the resource cost. Z_t is a common stochastic shock

[10] B_t can be either negative or positive depending on the household being creditor or debtor. However, as this is a closed economy, the aggregate equilibrium condition is B_t=0.

to the marginal efficiency of investment (or MEI shock) that affects the efficiency of transforming units of investment into new units of capital and is defined as:

$$lnZ_t = \rho_Z lnZ_{t-1} + \epsilon_{Z,t}. \tag{1.5}$$

Furthermore, we assume that the transformation of today's investment into tomorrow's capital is costly (investment adjustment costs) and also depends on the MEI shock. Therefore, the law of physical capital accumulation is:

$$K_{t+1}(i) = Z_t \left(1 - \tau/2 \left(\frac{X_t(i)}{X_{t-1}(i)} - 1\right)^2\right) X_t(i) + (1-\delta)K_t(i), \tag{1.6}$$

where $0 < \delta < 1$ is the depreciation rate and $\tau \geq 0$ governs the magnitude of the cost.

As in Erceg *et al.* (2000), we assume there exists an implicit insurance contract (except for labor) which ensures that households are identical along all dimensions other than labor supply and wages. Therefore, index i is retained only for wages and labor supply while being removed from other household variables.

Each period, a typical household must decide how much to consume, C_t, how many hours to work, $L_t(i)$, how much physical capital it wants next period, K_{t+1} (thus how much to invest in physical capital, X_t), the intensity of the utilization of physical capital, u_t, and how many bonds to hold, B_{t+1}. Hence, the associated maximization problem to be solved is:

$$\max_{\{C_t, K_{t+1}, B_{t+1}, u_t, X_t, L_t(i)\}_{t=0}^{\infty}} E_t \sum_{t=0}^{\infty} \beta^t \left(\ln(C_t - bC_{t-1}) - \eta \frac{L_t(i)^{1+\psi}}{1+\psi}\right), \tag{1.7}$$

subject to:

- the sequence of budget constraints:

$$P_t C_t + P_t X_t + B_{t+1} + P_t \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right) \frac{K_t}{Z_t} = W_t(i)L_t(i) + Q_t u_t K_t + (1 + R_{t-1,t})B_t + D_t(i), \tag{1.8}$$

- each period time constraint:

$$L_t(i) + l_t(i) = 1, \tag{1.9}$$

- and the law of physical capital accumulation:

$$K_{t+1} = Z_t \left(1 - \tau/2 \left(\frac{X_t}{X_{t-1}} - 1\right)^2\right) X_t + (1-\delta)K_t. \tag{1.10}$$

Finally, Υ_t and μ_t are the Lagrange multiplier for the households' budget constraint (equation 1.8) and the law of physical capital accumulation (equation 1.6), respectively.

1.2.1.2 The differences between the two models

Two things differentiate the HLMP model from the FLMP model, as far as the households are concerned: the intuitive interpretation of index i and the definition of dividends.

First, in the HLMP model akin to the standard NK model, index i denotes a particular type of labor skills. Because households' specialized labor skills are imperfect substitutes, it gives them some degree of market power. However, in the FLMP model, index i denotes a typical intermediate firm and the associated labor supply of a household that is specific to a particular firm i. In this case, the market power is assumed to belong to the firm i, while a worker does not possess any market power.

Second, in the HLMP model, monopolistic power is held exclusively by intermediate firms in the goods market, whereas the final good producer and labor intermediaries operate in competitive goods and labor markets, respectively. Therefore, nominal dividends consist of profits made by the monopolistically competitive intermediate good producers, i.e. $D_t(i) \equiv \Pi_{F,t}$, thus enabling us to the rewrite the budget constraint in the HLMP model as follows:

$$P_tC_t + P_tX_t + B_{t+1} + P_t\left(\chi_1(u_t-1) + \frac{\chi_2}{2}(u_t-1)^2\right)\frac{K_t}{Z_t} = W_t(i)L_t(i) + Q_tu_tK_t + (1+R_{t-1,t})B_t + \Pi_{F,t}, \tag{1.11}$$

where $\Pi_{F,t}$ is the nominal profit function of intermediate firms.

In the FLMP model, dividends encompass not only the economic profits generated by monopolistically competitive intermediate firms in the goods market, $\Pi_{F,t}$, but also the monopsonistic rent from intermediate firms in the labor market, $D_t(i) \equiv \Pi_{EA,t}$. Consequently, the budget constraint in the FLMP model is

$$P_tC_t + P_tX_t + B_{t+1} + P_t\left(\chi_1(u_t-1) + \frac{\chi_2}{2}(u_t-1)^2\right)\frac{K_t}{Z_t} = W_t(i)L_t(i) + Q_tu_tK_t + (1+R_{t-1,t})B_t + \Pi_{F,t} + \Pi_{EA,t}. \tag{1.12}$$

1.2.2 The labor intermediaries

In both models, the labor intermediaries ensure the match between households' labor supply and firms' homogenous labor demand. However, the type of competition the labor intermediaries face, the decisions they undertake as well as the constraints they are subject to, are different, depending on whether they operate within the HLMP or the FLMP model.

1.2.2.1 In the households' labor market power model

In the HLMP model, the labor intermediaries operate in a perfectly competitive labor market. We can think of a representative labor union that aggregates households' specialized labor skills, $L_t(i)$, and turns them into a combined labor input, L_t, employed by intermediate firms, according to

$$L_t = \left(\int_0^1 L_t(i)^{\frac{\gamma-1}{\gamma}} di \right)^{\frac{\gamma}{\gamma-1}}, \tag{1.13}$$

where L_t is the aggregate labor input and γ is the elasticity of substitution between specialized labor skills.

The hiring decision

The labor union takes as given the real aggregate wage rate, defined as $w_t \equiv \frac{W_t}{P_t}$, as well as household i' real wage rate, defined as $w_t(i) \equiv \frac{W_t(i)}{P_t}$. It determines the quantity of labor input of type i, in the same proportion as firms would choose, by solving the following profit maximization problem:

$$\max_{L_t(i)} \pi_{U,t} = w_t L_t - \int_0^1 w_t(i) L_t(i) di, \tag{1.14}$$

subject to the labor aggregation function (equation 1.13). The solution of this problem yields the demand for specialized labor skills i as a negative function of its relative wage rate

$$L_t(i) = \left(\frac{w_t(i)}{w_t} \right)^{-\gamma} L_t. \tag{1.15}$$

The wage-setting decision

The labor union also undertakes the wage-setting decision on behalf of households, taking into account the existence of nominal wage rigidities modelled in the form of Calvo wage contracts. In fact, the labor union is not freely able to adjust all the individual wages each period. In a given period, it can renegotiate only a constant fraction, $(1-\theta_w)$, of individual wages while the other fraction, θ_w, is the same as in the previous period. The labor union faces the same problem everytime it renegotiates the wage of a household i. In particular, it chooses the current value of the real wage, $w_t(i)$, that maximizes household i's expected utility weighed by the probability θ_w of not being allowed to renegotiate that wage, subject to the labor aggregation function and the downward-sloping labor demand functions. Formally:

$$\max_{w_t(i)} \pi_{U,t} = E_t \sum_{s=0}^{\infty} (\theta_w \beta_{t+s})^s \left\{ -\eta \frac{L_{t+s}(i)^{1+\psi}}{1+\psi} + w_t(i)(1+\pi_{t,t+s})^{-1} L_{t+s}(i) \right\}, \tag{1.16}$$

subject to

$$L_{t+s}(i) = \left(\frac{w_t(i)}{w_{t+s}} \right)^{-\gamma} L_{t+s}. \tag{1.17}$$

Accordingly, the optimal reset wage, $w_t^{\#}$, is implicitly defined by

$$d_{h1,t} = d_{h2,t}, \tag{1.18}$$

with auxiliary variables

$$d_{h1,t} = \eta \gamma w_t^{\gamma(1+\psi)} L_t^{1+\psi} + \theta_w \beta E_t (1+\pi_{t,t+1})^{\gamma(1+\psi)} d_{h1,t+1}, \tag{1.19}$$

$$d_{h2,t} = (\gamma - 1) w_t^{\#^{1+\gamma\psi}} w_t^{\gamma} \lambda_t L_t + \theta_w \beta (1+\pi_{t,t+1})^{\gamma-1} d_{h2,t+1}. \tag{1.20}$$

The aggregate wage index

From the zero-profit condition of the labor union under perfect competition, we obtain a relationship that links the real total wage bill to the sum of the individual real wage bill:

$$w_t L_t = \int_0^1 w_t(i) L_t(i) di, \tag{1.21}$$

which using equation (1.15), defines the aggregate wage index

$$w_t^{1-\gamma} = \int_0^1 w_t(i)^{1-\gamma} di. \tag{1.22}$$

Exploiting the fact that in period t, the economy is divided into two types of households, where a fraction θ_w of households cannot adjust their wages and the remaining share, $(1-\theta_w)$, is allowed to set the optimal wage, the aggregate wage index can be rewritten as

$$w_t^{1-\gamma} = \theta_w w_{t-1}^{1-\gamma}(1+\pi_{t,t-1})^{\gamma-1} + (1-\theta_w) w_t^{\#^{1-\gamma}}. \tag{1.23}$$

1.2.2.2 In the firms' labor market power model

In our modified NK model, we can think, instead, of a representative employer agency (hereafter EA) that acts on behalf of firms. The EA operates in a monopsonistically competitive labor market, making hiring and the wage-setting decisions.

The hiring decision

The EA aggregates households' labor supply to produce an homogeneous bundle of labor for intermediate firms, according to the labor aggregation function in equation (1.13). Each period, the EA chooses how much labor input to employ to maximize its profits given by equation (1.24). On one hand, the EA supplies aggregate labor, L_t, to intermediate firms at the real wage rate, w_t. On the other hand, each household i supplies $L_t(i)$ units of labor input and receives the real wage, $w_t(i)$, from the EA. We refer to $w_t(i)$ as the monopsonistic real wage. The EA solves the following real profit maximization problem:[11]

$$\max_{L_t(i)} \pi_{EA,t} = w_t L_t - \int_0^1 w_t(i) L_t(i) di, \tag{1.24}$$

subject to the labor aggregation function:

$$L_t = \left(\int_0^1 L_t(i)^{\frac{\gamma-1}{\gamma}} di \right)^{\frac{\gamma}{\gamma-1}}, \tag{1.25}$$

and each household i's labor supply curve:[12]

$$\eta L_t(i)^{\psi} = \Upsilon_t w_t(i). \tag{1.26}$$

[11] This maximization problem can also be interpreted as a cost minimization problem where the EA chooses the level of employment that minimizes the wage bill, taking into account the quantity of labor needed by the intermediate firms and the household's labor supply curve.

[12] The labor supply curve comes from the household i's FOC with respect to labor. In fact, since firms possess some monopsony power, they take into account the fact that they have to raise wages along the labor supply curve to attract more workers.

Solving this problem yields the individual labor demand for labor skills of type i:

$$L_t(i) = \left((1+\psi)\frac{w_t(i)}{w_t}\right)^{-\gamma} L_t. \tag{1.27}$$

In addition to the relative wage, the individual labor demand in the case of a monopsonistic labor market depends negatively on the inverse Frisch elasticity of labor supply. Recall that the Frisch elasticity of labor supply measures how the typical household adjusts its quantity of hours worked in response to wage changes. Therefore, it is somewhat a measure of the extent of firms' labor marker power: a higher ψ (or a smaller Frisch elasticity of labor supply) is associated with greater monopsony power, resulting in a smaller individual labor demand from employers.

The wage-setting decision

We also assume the existence of nominal wage rigidities in the FLMP model. The EA is not freely able to adjust all individual wages each period. In a given period, it can only adjust a constant fraction, (1-θ_w), of wages while the other fraction, θ_w, remains the same as in the previous period. Thus, the EA chooses the real wage rate, $w_t(i)$, that maximizes its expected discounted real profits, weighted by the probability of not being able to make a wage adjustment in a given period, according to:[13]

$$\max_{w_t(i)} \pi_{EA,t} = E_t \sum_{s=0}^{\infty} (\theta_w \Lambda_{t+s})^s \left\{ w_{t+s} L_{t+s} - \int_0^1 w_t(i)(1+\pi_{t,t+s})^{-1} L_{t+s}(i) di \right\}, \tag{1.28}$$

subject to

$$L_{t+s}(i) = \left(w_t(i) \Upsilon_{t+s} (1+\pi_{t,t+s})^{-1} \eta^{-1}\right)^{1/\psi}, \tag{1.29}$$

and

$$L_{t+s} = \left(\int_0^1 L_{t+s}(i)^{\frac{\gamma-1}{\gamma}} di\right)^{\frac{\gamma}{\gamma-1}}, \tag{1.30}$$

where $\Lambda_{t+s} = \beta^s \left(\frac{\Upsilon_{t+s}}{\Upsilon_t}\right)$ is the stochastic discount factor, and Υ_t is the marginal utility of an extra unit of real income received by the household.

[13] The probability of not being able to adjust wages for s periods is θ_w^s, with s=1, 2, ...

The solution of this problem yields the optimal reset wage or monopsonistic wage that is implicitly defined by the following equations:

$$d_{f1,t} = d_{f2,t}, \tag{1.31}$$

with auxiliary variables

$$d_{f1,t} = \eta^{\frac{1}{\gamma\psi}} w_t L_t^{\frac{1}{\gamma}} \Upsilon_t^{\frac{\gamma-1+\gamma\psi}{\gamma\psi}} + \theta_w \beta E_t (1+\pi_{t,t+1})^{\frac{-\gamma+1}{\gamma\psi}} d_{f1,t+1}, \tag{1.32}$$

$$d_{f2,t} = (1+\psi) w_t^{\#\frac{1+\gamma_t\psi_t}{\gamma_t\psi_t}} \Upsilon_t^{\frac{\psi+1}{\psi}} + \theta_w \beta E_t (1+\pi_{t,t+1})^{\frac{-\psi-1}{\psi}} d_{f2,t+1}. \tag{1.33}$$

Equations (1.31) to (1.33) define the optimal reset wage which is a markdown ($\frac{1}{1+\psi}$) over the marginal revenue product of labor.

The aggregate wage index

In a given period t, aggregate labor is composed of a proportion of workers, $(1-\theta_w)$, that receive the monopsonistic wage set at t, a proportion of workers, $\theta_w(1-\theta_w)$, that receive the monopsonistic wage set at $t-1$, a proportion of workers, $\theta_w^2(1-\theta_w)$, that receive the monopsonistic wage set at $t-2$, an so on. Therefore, we can write aggregate labor as:

$$L_t = (1-\theta_w)L_t^{\#} + \theta_w(1-\theta_w)L_{t-1}^{\#} + \theta_w^2(1-\theta_w)L_{t-2}^{\#} + ... \tag{1.34}$$

Substituting $L_t^{\#} = \left((1+\psi)\frac{w_t^{\#}}{w_t}\right)^{-\gamma} L_t$, $L_{t-1}^{\#} = \left((1+\psi)\frac{w_{t-1}^{\#}}{w_t}(1+\pi_{t-1,t})^{-1}\right)^{-\gamma} L_t$, ..., in L_t, yields the aggregate wage index

$$w_t^{-\gamma} = (1-\theta_w)(1+\psi)^{-\gamma} Aux_{2,t}, \tag{1.35}$$

with the auxiliary variable:

$$Aux_{2,t} = w_t^{\#^{-\gamma}} + \theta_w(1+\pi_{t-1,t})^{\gamma} Aux_{2,t-1}, \tag{1.36}$$

The EA's profit

The derivation of the EA's profit starts with equation (1.24). We need to take into account past reoptimized monopsonistic wages in the current EA's profit. In particular, at time t, there is a fraction, (1-θ_w), of reoptimized monopsonistic wages paid by the EA and set at t, a fraction, θ_w(1-θ_w), of reoptimized monopsonistic wages paid by the EA and set at $t-1$, a fraction, θ_w^2(1-θ_w), of reoptimized monopsonistic wages paid by the EA and set at $t-2$, and so on. Moreover, nominal wages rigidities also imply that in each period, L_t might be different than $L_t^{\#}$. Hence taking these specifities into account, we have the real EA's profit:

$$\frac{\Pi_{EA,t}}{P_t} = (1-\theta_w)\left(\frac{W_t}{P_t}L_t - \frac{W_t^{\#}}{P_t}L_t^{\#}\right) + \theta_w(1-\theta_w)\left(\frac{W_t}{P_t}L_t - \frac{W_{t-1}^{\#}}{P_{t-1}}\frac{P_{t-1}}{P_t}L_{t-1}^{\#}\right) + \theta_w^2(1-\theta_w)\left(\frac{W_{t-2}^{\#}}{P_{t-2}}\frac{P_{t-2}}{P_{t-1}}\frac{P_{t-1}}{P_t}L_{t-2}^{\#}\right) + ... \tag{1.37}$$

Rearranging the terms of the equation, we obtain

$$\pi_{EA,t} = w_t L_t - (1-\theta_w)\left(w_t^{\#}L_t^{\#}\right) - \theta_w(1-\theta_w)\left(w_{t-1}^{\#}L_{t-1}^{\#}(1+\pi_{t,t+1})^{-1}\right) - \theta_w^2(1-\theta_w)\left(w_{t-2}^{\#}L_{t-2}^{\#}(1+\pi_{t,t+1})^{-1}(1+\pi_{t-1,t})^{-1}\right) - .... \tag{1.38}$$

Substituting $L_t^{\#}$, $L_{t-1}^{\#}$, ..., we obtain an expression for the EA's profit:

$$\pi_{EA,t} = w_t L_t - (1-\theta_w)(1+\psi)^{-\gamma} w_t^{\gamma} L_t Aux_{1,t}, \tag{1.39}$$

with the auxiliary variable

$$Aux_{1,t} = w_t^{\#^{1-\gamma}} + \theta_w(1+\pi_{t-1,t})^{\gamma-1} Aux_{1,t-1}. \tag{1.40}$$

1.2.2.3 The wage shock

In the FLMP model, the wage markdown rate is a constant fraction of the marginal revenue product of labor (MRPL), where as the HLMP wage markup rate is a constant fraction of the marginal rate of substitution between consumption and leisure (MRS). While traditional shocks such as a neutral technology, a MEI and a monetary policy shocks induce variations in the MRPL and the MRS, these shocks do not highlight the different incentives between households and firms in the labor market which are important for our comparative approach. In fact, households want to maximize their utility by demanding higher wages and supplying fewer hours worked, while firms wants to maximize their profit by paying lower wages and demanding higher number of hours worked, in comparison with a perfectly competitive labor market.

To emphasize the difference between workers' and employers' incentives we introduce a wage shock. Chari *et al.* (2009) point out that a non-structural wage shock (or wage markup shock) can have two interpretations in the standard HLMP NK-DSGE model. It can be considered either as "fluctuations in the value of leisure of consumers" or as "fluctuations in the bargaining power of unions". The latter interpretation better fits our model and our purpose. More precisely, in both models, the wage shock will be an exogenous change in the relative bargaining power of firms or households.

There are many ways to introduce a wage shock. In the standard NK-DSGE model, wage shocks are modeled as a time varying elasticity of substitution between differentiated labor skills a stochastic variable.[14] However, as shown by Klima *et al.* (2015), this formulation does not allow a recursive solution to the model. The solution proposed by Klima *et al.* (2015) is to introduce the wage shock in the form of a stochastic disturbance in the wage equation. Therefore, the equation of the reset optimal wage in both models becomes

$$d_{j1,t} = d_{j2,t}\phi_t^w, \tag{1.41}$$

with $j \in \{f, h\}$, where f refers to the FLMP model and h refers to the HLMP model. ϕ_t^w is defined such that

$$ln\phi_t^w = (1-\rho_W)ln(Y_t/Y_{t-1}) + \rho_W ln\phi_{t-1}^w + \epsilon_{W,t}, \tag{1.42}$$

where ρ_W is the shock's persistence parameter and $\epsilon_{W,t}$ is the wage shock. ϕ_t^w reflects the dynamic adjustments in the bargaining power of firms or unions, depending on whether we are in the FLMP or the HLMP model. When ϕ_t^w equals one, it implies that there are no wage adjustments due to the shock. However, when ϕ_t^w deviates from one, it indicates a persistent impact on wages, potentially leading to longer-term effects on the labor market. Furthermore, by including the growth rate of output, i.e. $ln(Y_t/Y_{t-1})$, the current economic conditions are taken into account in the wage shock.

1.2.3 Firms

We now turn to the functioning of the goods market. We start by briefly presenting the main differences between the two models before describing the activities of the final good producer and the intermediate firms.

[14] See for example Smets and Wouters (2007) or Justiniano *et al.* (2011).

1.2.3.1 The differences between the two models

The main difference between the models is related to a modeling strategy that allows us to be consistent with the rationale behind households' index i. In particular, we index intermediate firms by j in the HLMP model, with j representing their differentiated production. In the FLMP model, instead of index j, we use index i because the typical household supplies labor to a specific firm i, which is not the case in the HLMP model. Except for the consistency of the modeling strategy, there are no other differences between the models regarding the type of competition, the decisions undertaken and the constraints face by firms in the goods market. Accordingly, in what follows, we choose to use index j to refer to firms for no particular reason since the same discussion is valid for firms in the FLMP model that are indexed by i.

1.2.3.2 The final good producer

There is a representative final good producer which aggregates the production of all j intermediate firms in order to produce a final consumption good, Y_t, according to the following technology:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{1.43}$$

where Y_t is the total output of the economy and ϵ is the elasticity of substitution among intermediate goods, $Y_t(j)$.

The final good producer evolves in a perfectly competitive environment, taking as given the price of aggregate output, P_t, and the prices charged by intermediate goods producers, $P_t(j)$. It thus solves the following profit maximization problem:

$$\max_{Y_t(j)} P_t Y_t - \int_0^1 P_t(j) Y_t(j) dj. \tag{1.44}$$

The solution of this problem yields the conditional demand for each intermediate good j, which depends negatively on its relative price and positively on the total output of the economy:

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} Y_t. \tag{1.45}$$

From the zero-profit condition of the final good producer under perfect competition, we obtain a relationship between the total nominal output and the sum of the nominal value of intermediate goods

$$P_tY_t = \int_0^1 P_t(j)Y_t(j)dj, \tag{1.46}$$

which, using (1.45), defines the aggregate price index

$$P_t = \left(\int_0^1 P_t(j)^{1-\epsilon}dj\right)^{\frac{1}{1-\epsilon}}. \tag{1.47}$$

1.2.3.3 The intermediate goods producers

The economy is populated by a continuum of intermediate firms indexed by $j \in$ [0, 1], where j denotes a particular type of good. Intermediate firms possess some monopoly power in the goods market which allows them to set prices. They take the rental rate of capital and wage rate as given, the latter being provided by the EA. In the HLMP set up, it results from the households' monopolist position, while in the FLMP framework, the EA was delegated the exercise of the intermediate firms monopsonistic position. Intermediate firms can employ all types of labor. The typical intermediate goods producer j combines physical capital services, $\hat{K}_t(j)$, and labor, $L_t(j)$, according to the following production function:

$$Y_t(j) = A_t\hat{K}_t(j)^{\alpha}L_t(j)^{1-\alpha} - \Gamma_t, \tag{1.48}$$

where A_t is the common level of technology that follows a first-order autoregressive process as

$$lnA_t = \rho_A lnA_{t-1} + \epsilon_{A,t}, \tag{1.49}$$

with $\epsilon_{A,t}$ the neutral productivity shock. With the production of good j required to be non-negative. Moreover, since intermediate firms operate in monopolistic competition in their intermediate good market, they typically generate positive economic profit. From a modelling's perspective, one way to ensure that each firm j makes zero profit in the long-run is to impose a cost variable, Γ_t, built in with the production function. Some questions related to dividends and their distribution across households or some other questions related to entry and exit of firms in the long-run might be interesting in their own right, but these are not the objects of our study.

Optimization problems

The solution of the optimization problem of a typical intermediate good producer j can be thought as a two-stage optimization. First, it minimizes its costs by choosing the quantity of labor, $L_t(j)$, and the quantity of the services of physical capital, $\hat{K}_t(j)$, needed to produce intermediate output:

$$\min_{\hat{K}_t(j), L_t(j)} w_t(j)L_t(j) + q_t\hat{K}_t(j), \tag{1.50}$$

subject to:

- the intermediate good production function

$$Y_t(j) = A_t\hat{K}_t(j)^{\alpha}L_t(i)^{1-\alpha} - \Gamma_t, \tag{1.51}$$

- and the demand for intermediate goods

$$Y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} Y_t. \tag{1.52}$$

Solving this minimization problem yields the capital-labor ratio, which is identical across intermediate firms:

$$\frac{\hat{K}_t}{L_t} = \frac{\alpha}{1-\alpha}\frac{w_t}{q_t}. \tag{1.53}$$

Combining the capital-labor ratio with the intermediate firm minimization problem first-order condition determines its real marginal cost:

$$\lambda_t = mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\frac{w_t^{1-\alpha}q_t^{\alpha}}{A_t}, \tag{1.54}$$

with λ_t the Lagrange multiplier of the intermediate goods demand constraint which is also equal to the marginal cost of production, mc_t.

In the second step, taking into account the costs of inputs, an intermediate firm j chooses the price that it charges. However, that pricing decision cannot be undertaken each period by all intermediate firms because of nominal price rigidities. Consequently, all intermediate firms face a constant probability, $(1-\theta_p)$, that they can adjust their prices. This also means that the probability for a firm to be stuck with a price for one period is θ_p, for two periods is θ_p^2, and so on.

An intermediate firm j that can reset its price will discount its real profits s periods into the future by the stochastic discount factor, $\beta^s\left(\frac{\Upsilon_{t+s}}{\Upsilon_t}\right)$, where Υ_t is the marginal utility of an extra unit of real income received by households.[15] Therefore, it maximizes its discounted real expected profits according to:

$$\max_{P_t(j)} E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \frac{\Upsilon_{t+s}}{\Upsilon_t} \left\{ \frac{P_t(j)}{P_{t+s}} Y_{t+s}(j) - mc_{t+s} Y_{t+s}(j) \right\}, \tag{1.55}$$

subject to:

$$Y_{t+s}(j) = \left(\frac{P_t(j)}{P_{t+s}} \right)^{-\epsilon} Y_{t+s}. \tag{1.56}$$

Solving this problem yields the optimal reset price,

$$P_t^{\#}(j) = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \Upsilon_{t+s} \left\{ mc_{t+s} P_{t+s}^{\epsilon} Y_{t+s} \right\}}{E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \Upsilon_{t+s} \left\{ P_{t+s}^{\epsilon-1} Y_{t+s} \right\}}. \tag{1.57}$$

Since all intermediate firms have the same markup and the same marginal cost, they choose the same optimal reset price. Hence, $P_t^{\#}(j) = P_t^{\#}$, which allows us to rewrite equation (1.57) as

$$P_t^{\#} = \frac{\epsilon}{\epsilon - 1} \frac{F_{1,t}}{F_{2,t}}, \tag{1.58}$$

with auxiliary variables:

$$F_{1,t} = E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \Upsilon_{t+s} \left\{ mc_{t+s} P_{t+s}^{\epsilon} Y_{t+s} \right\}, \tag{1.59}$$

$$F_{2,t} = E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \Upsilon_{t+s} \left\{ P_{t+s}^{\epsilon-1} Y_{t+s} \right\}. \tag{1.60}$$

Dividing both sides by P_t, we can rewrite equation (1.57) to represent the dynamics of inflation:

$$1 + \pi_t^{\#} = \frac{\epsilon}{\epsilon - 1} (1 + \pi_t) \frac{f_{1,t}}{f_{2,t}}, \tag{1.61}$$

with auxiliary variables

[15] Given that the households are the owners of the intermediate firms, real profits are discounted by the stochastic factor stemming from the households' Euler equation associated with the trade-off between current and future consumption.

$$f_{1,t} = \Upsilon_t mc_t Y_t + \theta_p E_t(1+\pi_{t+1})^{\epsilon}\beta f_{1,t+1}, \tag{1.62}$$

$$f_{2,t} = \Upsilon_t Y_t + \theta_p E_t(1+\pi_{t+1})^{\epsilon-1}\beta f_{2,t+1}. \tag{1.63}$$

1.2.4 The monetary authority

We assume that the central bank's monetary policy follows a Taylor type feedback rule but is subject to a stochastic component:

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R}\right)^{\rho_R}\left[\left(\frac{1+\pi_t}{1+\pi}\right)^{\alpha_\pi}\left(\frac{Y_t}{Y_{t-1}}g^{-1}\right)^{\alpha_Y}\right]^{1-\rho_R}\mu_{M,t}, \tag{1.64}$$

with $\mu_{M,t}$ such that

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t}. \tag{1.65}$$

The nominal interest rate responds to deviations of net inflation, π_t, from its target, π=0, as well as deviations of output growth from its trend growth, g^{-1}. $\epsilon_{M,t}$ is a monetary policy shock. α_π is the control parameter for inflation gap and α_Y is the control parameter with respect to the output growth gap. Finally, ρ_R accommodates the smoothing effect of the nominal interest rate.

1.2.5 Aggregation and equilibrium conditions

This section is devoted to the aggregate economy and the other equilibrium conditions pertaining to the two models.

1.2.5.1 Aggregate production

Using equations (1.45), (1.48) and (1.53) and integrating over all the j firms yields

$$A_t\left(\frac{\hat{K}_t}{L_t}\right)^{\alpha}\int_0^1 L_t(j)dj - \Gamma_{1,t} = Y_t\int_0^1\left(\frac{P_t(j)}{P_t}\right)^{-\epsilon}dj. \tag{1.66}$$

Since in equilibrium $\int_0^1 L_t(j)dj = L_t$, we have

$$Y_t = \frac{A_t \hat{K}_t^{\alpha} L_t^{1-\alpha} - \Gamma_{1,t}}{v_t^p}, \tag{1.67}$$

which defines aggregate output in the HLMP model, where v_t^p captures the price dispersion across intermediate firms and is defined as

$$v_t^p = \int_0^1 \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} dj. \tag{1.68}$$

By comparison, the corresponding aggregate output and price dispersion in the FLMP model are respectively defined as

$$Y_t = \frac{A_t \hat{K}_t^{\alpha} L_t^{1-\alpha} - \Gamma_{1,t}}{v_t^p}, \tag{1.69}$$

$$v_t^p = \int_0^1 \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} di. \tag{1.70}$$

1.2.5.2 The aggregate price index

From equation (1.47) and exploiting the fact that in period t, the economy is divided into two types of firms, where a fraction θ_p of firms, cannot adjust their prices and the remaining share, $(1-\theta_p)$, is allowed to set the optimal price, the aggregate price index can be written as

$$P_t^{1-\epsilon} = (1-\theta_p) P_t^{\#1-\epsilon} + \theta_p P_{t-1}^{1-\epsilon}. \tag{1.71}$$

The optimal price takes the same form in both models.

1.2.5.3 The aggregate resource constraint

From equation (1.11) in the HLMP model or from equation (1.12) in the FLMP model, and by aggregating over all firms and households, the aggregate resource constraint in both models is expressed as

$$Y_t = C_t + X_t + \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{K_t}{Z_t}, \tag{1.72}$$

which means that, each period, the economy's aggregate output in this economy is shared between consumption of final good, private investment in capital good and resources devoted to adjust the utilization rate of capital.

1.2.5.4 Other equilibrium conditions

In addition, the general equilibrium in this economy requires simultaneous equilibria in the labor market, the bond market, the final good market, the intermediate goods market, the physical capital market and the market of investment in physical capital, while being consistent with the Euler equations associated with each agent's optimization problems.

1.3 The calibration

The calibration of the models' parameters is based on U.S. quarterly empirical studies and the DSGE macroeconomic literature. Table 1.1 reports the choice of the parameter values. Although several parameters align with standard practices in calibrating NK-DSGE models and will be consistent across both models, the unique monopsonistic labor market structure in the FLMP model necessitates adjustments to certain parameters in line with some empirical literature that we further discuss below.[16]

1.3.1 Standard parameter values from the literature

The values assigned to the subjective discount rate, β=0.99, to the capital's share of income, α=1/3, and to the depreciation rate of physical capital, δ=0.025, are fairly standard and well-known in the DSGE macroeconomic literature. We set the parameter of habit formation in consumption, b to 0.8, which is consistent with estimates reported in Christiano *et al.* (2005), Justiniano *et al.* (2010) and Justiniano *et al.* (2011). We fix the Calvo parameter for price rigidity, θ_p, to 0.66 which corresponds to a median waiting time between

[16] The calibration we adopt implies that the great ratios in both models are similar. Moreover, we also check the sensitivity of the results to some variations in parameter values. As far as shocks' parameters are concerned, it can be argued their values should related to the specific structure of the model. This will be considered for future research.

price changes of 5.1 months.[17] This value is in line with the empirical estimate in Bils and Klenow (2004). We set the Calvo parameter for wage rigidity, θ_w, to 0.75, a choice that aligns closely with the range of values (between 0.760 and 0.83) that Justiniano *et al.* (2010) and Justiniano *et al.* (2011) find from a Bayesian estimation of a model close to our HLMP model with the US data from 1954Q3 to 2004Q4.

The value of the elasticity of substitution between goods, ϵ, is 6. This value is consensual in the literature and implies a 20% steady state price markup over the marginal cost. We also set the elasticity of substitution between each type of labor, γ, at 6, as typically assumed in New Keynesian models. In that class of models, γ=6 implies a 20% steady state wage markup over the MRS. In fact, since households supply differentiated labor skills, they are not perfect substitutes from the employers' point of view, thus giving them some wage-setting power. Therefore, γ determines the extent of households' labor market power. Nevertheless, in the FLMP model, the parameter γ does not play the same role. In fact, even though the aggregate wage index depends on γ, firms with monopsony power apply a markdown on the MRPL instead of a markup on the MRS.

We set χ_1 to 0.0351, one of the parameters that governs the cost of the variable utilization of physical capital, so that the steady state rate of utilization is one. We fix the second parameter that governs the cost of variable utilization of physical capital, χ_2, to 0.05. These two calibrations are consistent with Ascari *et al.* (2018).

With respect to the Taylor rule parameters, we use estimates in Justiniano *et al.* (2010) and Justiniano *et al.* (2011) i.e., a value of 0.8 for the smoothing parameter, ρ_R, a value of 1.3 for the inflation gap coefficient, α_π, and a value of 0.3 for the output growth gap parameter, α_Y.

[17] Cogley and Sbordone (2008) show that the relationship between the value of the θ_p and the median waiting time between a price change can be approximated by $-\frac{\ln(2)}{\ln(\theta_p)}$.

Tableau 1.1: Parameters baseline value

Parameter	Value	Description
		Non-shock parameters
β	0.99	Subjective discount rate
ψ	0.33	Inverse Frisch-elasticity of labor supply
η	6	Weight on disutility of labor
δ	0.025	Physical capital depreciation rate
γ	6	Elasticity of substitution between labor
ϵ	6	Elasticity of substitution between goods
α	0.29	Capital's share of income
θ_w	0.75	Calvo parameter for wages
θ_p	0.66	Calvo parameter for prices
ρ_R	0.8	Smoothing effect of the nominal interest rate
α_π	1.3	Inflation control parameter
α_Y	0.3	Output control parameter
b	0.8	Consumption habits formation
τ	2	Investment adjustment costs parameter
χ_1	0.0351	Parameter that governs the cost of the variable utilization of physical capital
χ_2	0.05	Parameter that governs the cost of the variable utilization of physical capital
		Shock parameters
ρ_A	0.95	Neutral technology shock persistence
ρ_M	0.2	Monetary shock persistence
ρ_Z	0.8	Investment shock persistence
ρ_W	0.99	Wage shock persistence
σ_A	0.008	Neutral technology shock standard deviation
σ_M	0.0013	Monetary shock standard deviation
σ_Z	0.01	MEI shock standard deviation
σ_W	0.018	Wage shock standard deviation

1.3.2 Parameters specific to the model with firms' labor market power

Traditionally, the inverse Frisch-elasticity of labor supply, ψ, primarily influences the elasticity of hours worked with respect to wages and does not directly impact wage dynamics. However, in our modified version, the wage markdown directly depends on the value of ψ, necessitating careful calibration. The value of ψ needs to be consistent with three criteria: the steady-state hours worked, empirical estimates of the wage markdown and the broader DSGE macroeconomic literature.

In line with these criteria, we set ψ to 0.33, resulting in steady state hours worked of 0.33 and a steady state wage markdown of 25%. This choice is within the range of empirical estimates of the wage markdown i.e.

typically falling between 17% and 28%, as observed in empirical studies such as Azar *et al.* (2022b), Azar *et al.* (2022a) and Sokolova and Sorensen (2021).[18]

Moreover, the value of the parameter ψ is often seen as somewhat controversial because of the ongoing and still incompletely resolved debate between micro and macro based estimates of the Frisch elasticity of labor supply. Given that ψ=0.33, this implies a value of 3 for the Frisch elasticity. Peterman (2016) finds that micro estimates of the elasticity range from 0 to 1/2 while, macro estimates vary from 2 and 4. However, in our model, a Frisch elasticity of labor supply between 0 and 1/2 is not compatible with empirical estimates of the wage markdown. We opt to follow macro estimates for two primary reasons.

First, Peterman (2016) reports a macro Frisch elasticity between 2.9 and 3.1 when relaxing two restrictions. He incorporates movements in hours from the whole population and includes fluctuations in both intensive and extensive margins.

Second, Keane and Rogerson (2012) argue that when embedding a basic life cycle model, which include factors like human capital accumulation, it is possible to reconcile small micro elasticities and large macro elasticities.

1.3.3 The calibration of parameters associated with the shocks

Moving on to the calibration of shock parameters, we draw upon the estimates of Gomme and Lkhagvasuren (2013) for the persistence of the neutral technology shock and its standard deviation. Accordingly, we set ρ_A=0.95 and σ_A=0.008. For the persistence of the monetary policy shock, ρ_M, and the MEI shock, ρ_Z, we rely on estimates provided by Justiniano *et al.* (2010), which suggest values of 0.2 and 0.8, respectively. As for the standard deviation of the monetary policy shock, σ_M, we set it to 0.0013, consistent with Justiniano *et al.* (2010). Regarding the MEI shock, we fix its standard deviation, σ_Z, at 0.01. This choice aligns with the results reported in Ascari *et al.* (2018), who calculate the variance of the MEI shock by employing estimates of the contribution of each type of shock (neutral technology, MEI, and monetary shocks) to aggregate output fluctuations.

Now, to calibrate the persistence, ρ_W, and the standard deviation, σ_W, of the wage shock, we aim to match the observed volatility of the real wage in our data sample. For that purpose, we perform a grid search to minimize the squared difference between the simulated and the observed volatilities of the real wage. The

[18] See Appendix B for the link between the empirical wage markdown and the theoretical wage markdown implied by our model.

results of this grid search lead us to set ρ_W = 0.99 and σ_W=0.018.

In the next section, we compare the cyclical responses of key macroeconomic variables to shocks in both the FLMP baseline model and the HLMP baseline model. Additionally, we will analyze and compare various business cycle statistics between these two models.

1.4 The results

We now turn to the comparison of the business cycle implications of the FLMP model to those of the HLMP model. To do so, we consider two dimensions along which we confront the two models. The first dimension pertains to the cyclical behavior of key macroeconomic variables through simulated impulse response functions to the models' shocks. The second dimension involves comparing some simulated business cycle moments. To ensure consistency in our analysis, we set the parameters of both models as in Table 1.1.

1.4.1 Comparing the cyclical behavior: under FLMP vs HLMP

We start our analysis with the models' cyclical responses following various types of aggregate shocks. Our model features four types of aggregate shocks: a neutral technology shock (described by equation (2.44) with ρ_A=0.95 and σ_A=0.008), a MEI shock (expressed in equation (1.5) with ρ_Z=0.8 and σ_Z=0.01), a monetary policy shock (defined by equation (1.65) with ρ_M=0.2 and σ_M=0.0013), and a wage shock (from equation (1.42) with ρ_W=0.95 and σ_W=0.001). To provide a comprehensive comparison, we put in perspective the responses at various horizons, including at the impact, at the peak, in the short-run (four quarters or less), in the medium-run (from five to fifteen quarters), and eventually in the longer-run (beyond fifteen quarters).

After comparing the impulse response functions between the two models, we study how the differences in the labor market structures interact with the models' frictions. Recall that these features include not only real frictions such as habit formation in consumption, investment adjustment costs and variable utilization of physical capital, but also nominal frictions such as nominal price and wage rigidities. First, we start with models that embed no frictions (baseline models) and assess the sensitivity of the gaps between the impulse responses when adding one friction at a time to the baseline model. Second, we begin with models that incorporate all frictions (complete models) and check how the discrepancies between the models' responses change following the removal of one friction at a time.[19]

[19] To be keep our work succinct, we do not include the generated impulse response functions. However, they are available upon

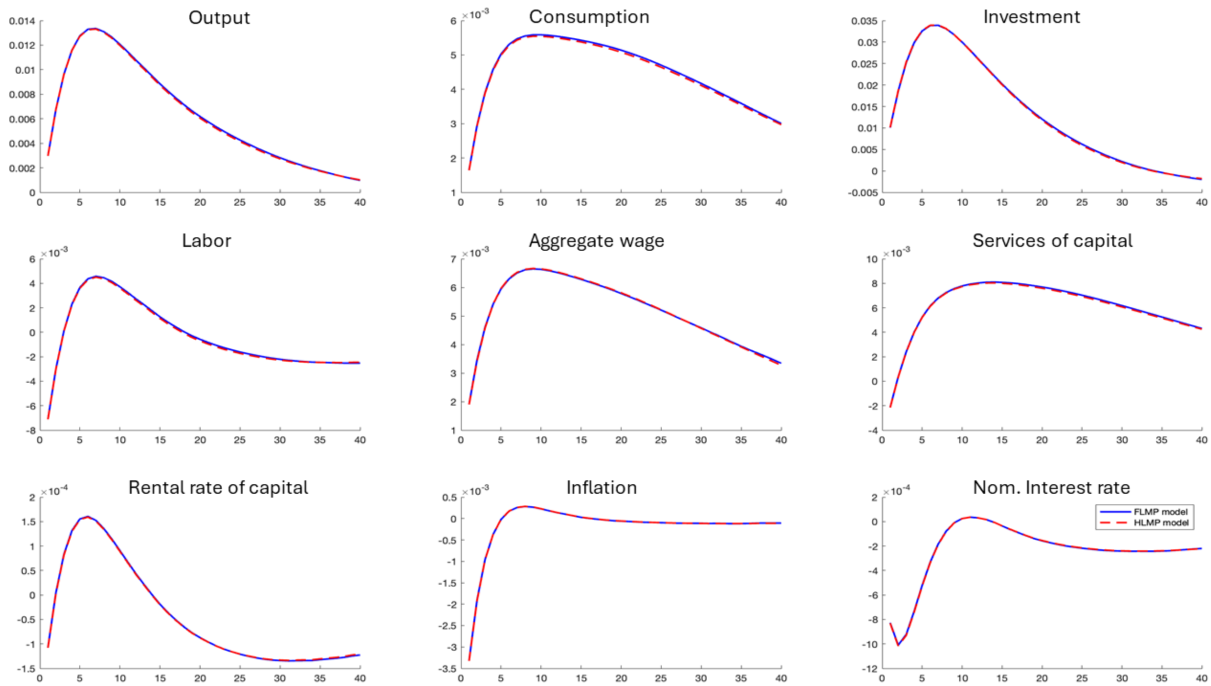

Figure 1.1: Impulse responses of the cyclical components of macroeconomic variables following a neutral technology shock: labor market monopoly versus labor market monopsony (one period is a quarter).

1.4.1.1 The transmission of positive neutral technology shocks

Figure 1.1 compares the impulse response functions generated by the FLMP and the HLMP models following a positive neutral technology shock. Both models exhibit transmission mechanisms that are quantitatively and qualitatively similar, i.e. an economic expansion characterized, for instance, by an increase in output, consumption, investment and aggregate.[20]

To delve deeper into how the labor market structure interacts with various model features following a neutral technology shock, we explore alternative model specifications that enable us to disentangle the role of the labor market structure and the role of the models' frictions. The assessment of these impulse responses reveals that the addition or the removal of real and nominal frictions do not differentiate the two models. In other words, there is no significant interaction between the labor market structures, the models' ingredients and the neutral technology shock.

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request.

[20] Since the transmission mechanisms of a positive neutral technology shock are well known in the literature we do not elaborate in detail.

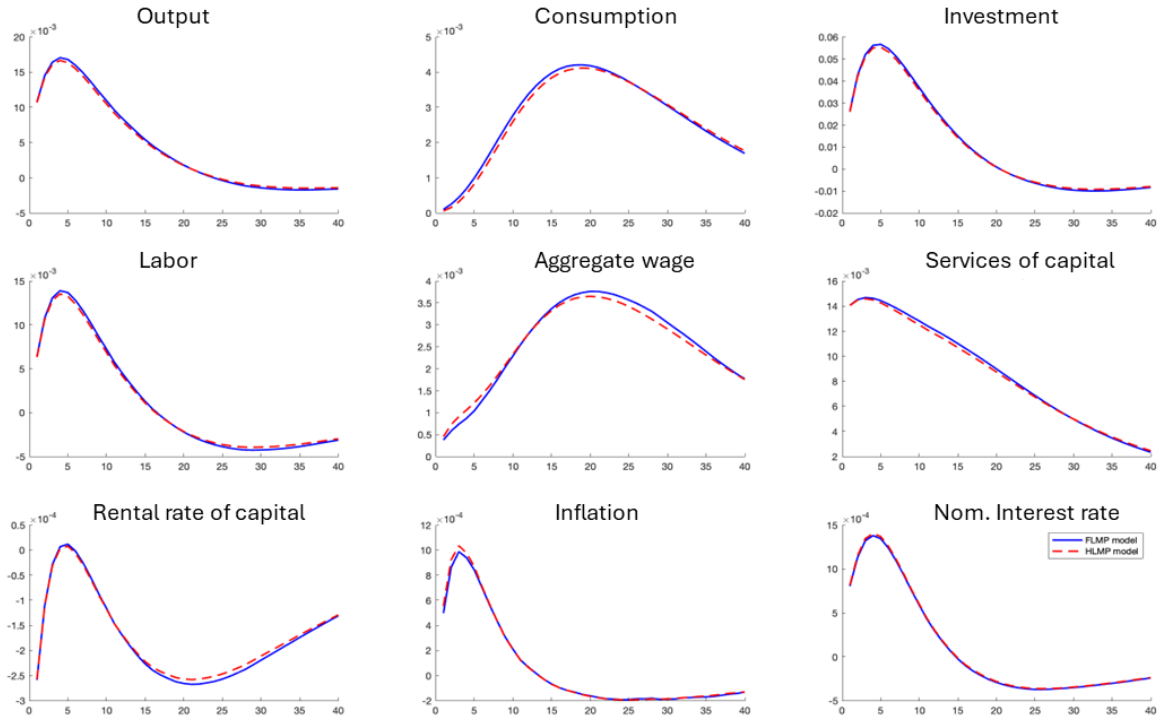

Figure 1.2: Impulse responses of the cyclical components of macroeconomic variables following a MEI shock: labor market monopoly versus labor market monopsony (one period is a quarter).

1.4.1.2 The transmission of positive MEI shocks

Figure 1.2 illustrates the comparative cyclical responses of key variables in both models following a positive MEI shock that increases the efficiency of investment.[21] By increasing the return on each unit of physical capital invested, a positive MEI shock raises the level of investment, as well as capital, labor and output, thus inducing a cyclical upturn.[22]. While both models exhibit qualitatively similar transmission mechanisms, there are small quantitatives differences to consider. In particular, the cyclical upturn induced by the MEI shock is slightly enhanced in the FLMP model. These differences can be attributed to the labor market structure and how it interacts with various features in the models.

On one hand, by increasing aggregate demand in an economy with nominal price rigidities, the MEI shock

[21] The impulse response functions following the MEI shock in the baseline models and alternative specifications suffer from Barro and King (1984)'s curse i.e. a non-positive comovement between output and consumption. Ascari *et al.* (2016) demonstrate that features such as roundabout production and long-run real per capita output growth generate consistent comovements between consumption and output following a MEI shock.

[22] See Justiniano *et al.* (2010) for a detailed exposition of the propagation mechanisms of a MEI shock in a macroeconomic framework.

prompts firms to raise their labor demand, leading to higher aggregate wages. However, since the FLMP intermediate firms apply a wage markdown, it dampens the rise in aggregate wage but enhances that in labor, especially in the short-run. Contrastingly, in an economy characterized by nominal wage rigidities and households monopoly in the labor market, the rise in HLMP aggregate wage is faster in the short-run but it does not reach a higher peak response in the medium-run, compared to FLMP aggregate wage. Accordingly, HLMP households do not have incentives to raise their labor supply in the medium-run as much as they do in the short-run.

On the other hand, Figure A.3 available in the Appendix A provides evidence that the models' ingredients play a role in explaining these differences. Indeed, by removing all real and nominal frictions, the gaps in the models' cyclical responses disappear.

Furthermore, when we assess the individual contribution of each model feature, only nominal wage rigidities seems to play an important role. Not allowing for nominal wage rigidities in both models results in smaller discrepancies relative to the baseline comparison.

1.4.1.3 The transmission of restrictive monetary policy shocks

Figure 1.3 compares the models' impulse response functions following a restrictive monetary policy shock induced by an increase in the policy rate. By increasing the nominal interest rate, the central bank prompts households to postpone consumption while firms cut down investment and production. This results in a decline in variables such as output and labor. The cyclical downturn generated by the increase in the policy rate does not create gaps between the models' impulse responses.

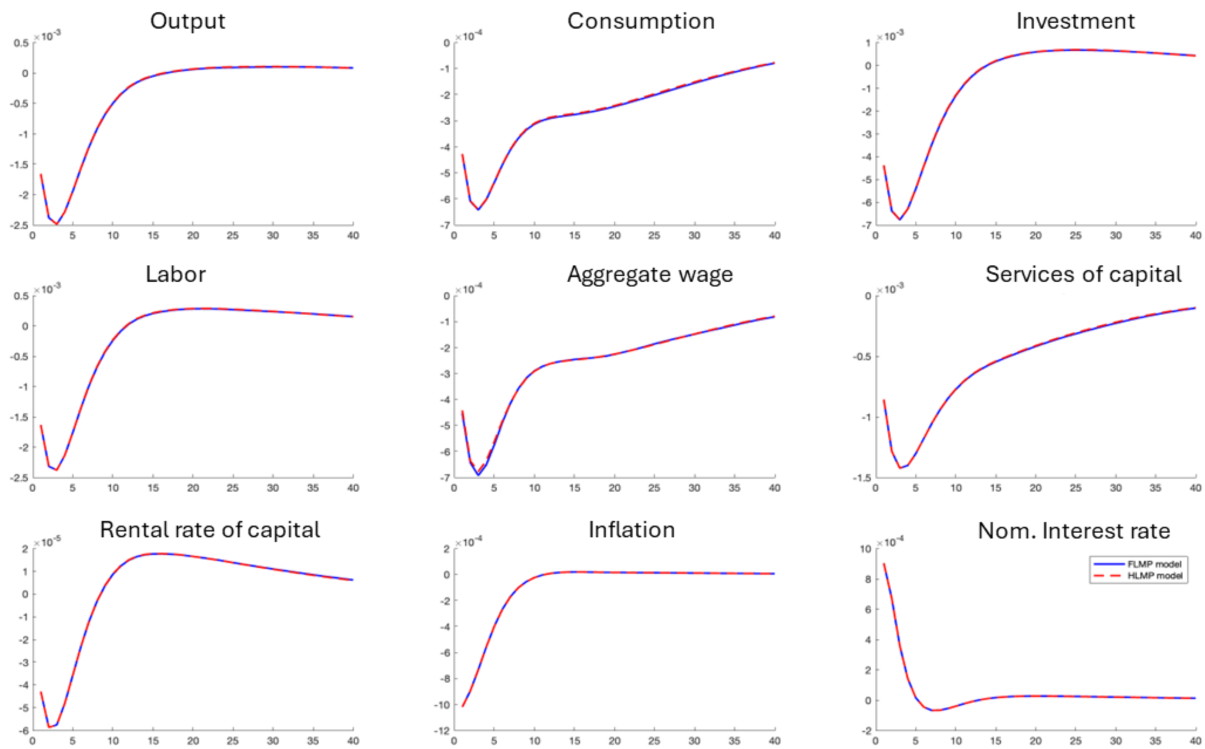

Figure 1.3: Impulse responses of the cyclical components of macroeconomic variables following a monetary policy shock: labor market monopoly versus labor market monopsony (one period is a quarter).

Furthermore, we investigate whether there are specific features present in both models that interact with the labor market structure. Our results demonstrate that except for investment adjustment costs, there is no interaction between the models' ingredients and the labor market structures. Specifically, removing investment adjustment costs leads to a more mitigated decline in consumption and aggregate wage in the HLMP model compared to the FLMP model.

Overall, neutral technology and monetary policy shocks don't tend to generate significant disparities between the models' impulse response functions, while the MEI shock creates some small discrepancies. An explanation for these general results might be the fact the FLMP model's wage markdown and HLMP model's wage markup are constant fraction of time-varying MPL and MRS, respectively. In the next paragraphs, we discuss how the models differentiate themselves when subjected to exogenous variation in the wage markdown and in the wage markup, that we refer to as a wage shock. Recall that a positive wage shock decreases the wage markdown in the FLMP model, whereas it decreases the wage markup in the HLMP model. Moreover, in the shock process specification, we include the growth rate of output to capture the effect of current economic conditions in each model.

1.4.1.4 The transmission of negative wage shocks

A comparison of the impulse responses following a wage shock is displayed in Figure 1.4. Overall, a negative wage shock triggers stronger and more persistent cyclical upturns in the FLMP model, particularly in output, consumption, investment and production's inputs. For instance, after ten quarters, output in the FLMP model responds more than twice as much as that of the HLMP model. These gaps in the models' responses highlight a greater interaction between the labor market structure and wage shocks compared to the interactions with the other shocks discussed earlier.

Initially, a negative wage shock directly shifts down aggregate wage in both models. However, the models' different labor market structures imply that the drop in aggregate wages affects aggregate labor differently. Due to the exercise of monopoly power, HLMP households are able to offset some of the decline in their wage rate, whereas FLMP households are not able to do so. Since FLMP firms (via the EA) internalize the fall in labor costs, they are more inclined to hire more labor. Additionally, there is a stronger negative wealth effect in the FLMP model that encourages households to increase their labor supply. Contrastingly, the fall in aggregate wage in the HLMP model is more mitigated, giving households fewer incentives to raise their labor supply. Consequently, FLMP labor rises more than the HLMP labor.

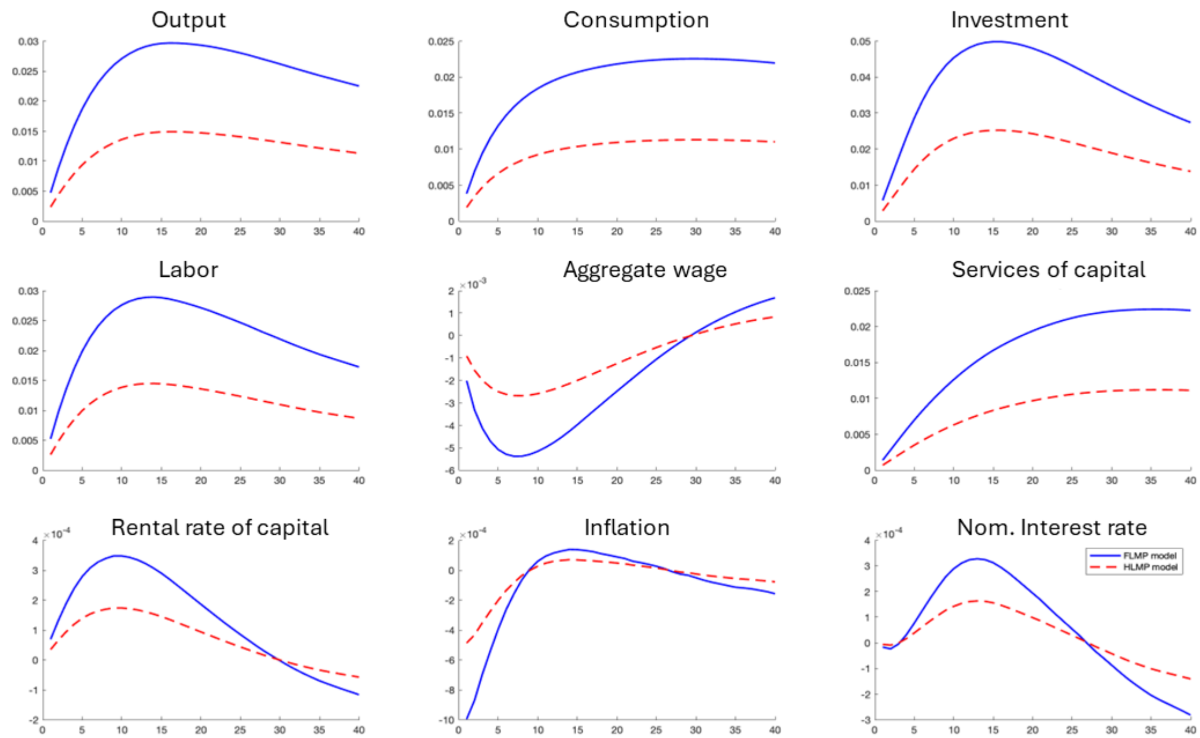

Figure 1.4: Impulse responses of the cyclical components of macroeconomic variables following a wage shock: labor market monopoly versus labor market monopsony (one period is a quarter).

Through the dynamic complementarity of inputs, FLMP labor induces stronger responses in the services of capital, the rental rate of capital and private investment. As a result, output, consumption and investment steeper increases in the FLMP model. Moreover, Figure 1.4 shows that the response of HLMP aggregate wages exceeds that of FLMP aggregate wages, while the FLMP rental rate of capital exceeds that of the HLMP model. Therefore, the responses of marginal cost, and thus that of inflation are quite similar in both models, respectively. Furthermore, the sharper rise in FLMP output prompts a more aggressive central bank reaction, especially since the gaps in the cyclical responses of inflation are not very large. Consequently, the response of FLMP policy rate exceeds that of HLMP policy rate.

We also investigate the interaction between the wage shock and the models' features, starting with the scenario in which all frictions are removed.[23] Even with all frictions removed, gaps in cyclical responses of key variables persist. This suggests that differences in wage shock propagation are primarily driven by disparities in labor market structure rather than the models' features. Moreover, some frictions seem

[23] As for the other shocks, the results are available upon request.

to have more effects than others. For instance, in the absence of habit formation in consumption, gaps between the models' responses tend to widen, especially in the short-run. In addition, when there is no investment adjustment costs or perfect flexibility of nominal wages, differences in the models' responses tend to narrow. However, in the absence of nominal price rigidities or variable utilization of capital does not significantly alter the baseline differences between the models compared to the baseline scenario. This suggests that these two frictions play a limited role in distinguishing the effects of wage shocks.

It can be argued that the negative comovement between output and real wage is not consistent with unconditional U.S. data that support a procyclical real wage. However, some empirical studies such as Foroni *et al.* (2018) report a negative conditional correlation between output and the real wage as shown from estimated empirical VAR models.

1.4.1.5 A sensitivity analysis

We previously established that the inverse Frisch elasticity of labor supply, ψ, and the elasticity of substitution between differentiated skills, γ, play important and distinct roles in the two models. More specifically, in the FLMP model, a higher value of ψ means a greater intermediate firms' monopsony power, while in the HLMP model, a smaller value of γ means a greater households' monopoly power. Therefore, we deem important to evaluate how changes in the values of these parameters affect the differences in the impulse responses presented in the previous sections.

Overall, Figures 1.5 to 1.7 show that an increase in ψ does not significantly change the sign and the size of the gaps between the models' impulse responses following the neutral technology, the MEI and the monetary policy shocks, as displayed in Figures 1.1, 1.2 and 1.3, respectively. In other words, there is no high interaction between the inverse Frisch elasticity of labor supply and these shocks.

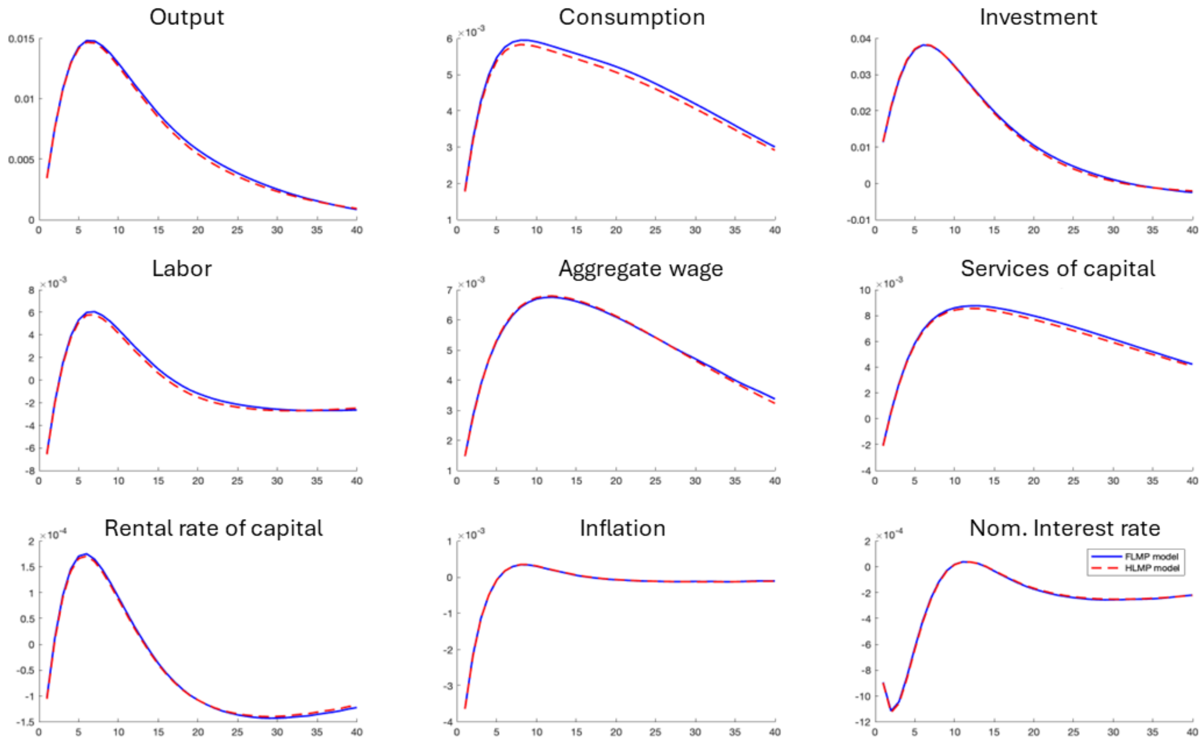

Figure 1.5: Impulse responses of the cyclical components of macroeconomic variables following a neutral technology shock: labor market monopoly versus labor market monopsony, with a higher value of ψ(one period is a quarter).

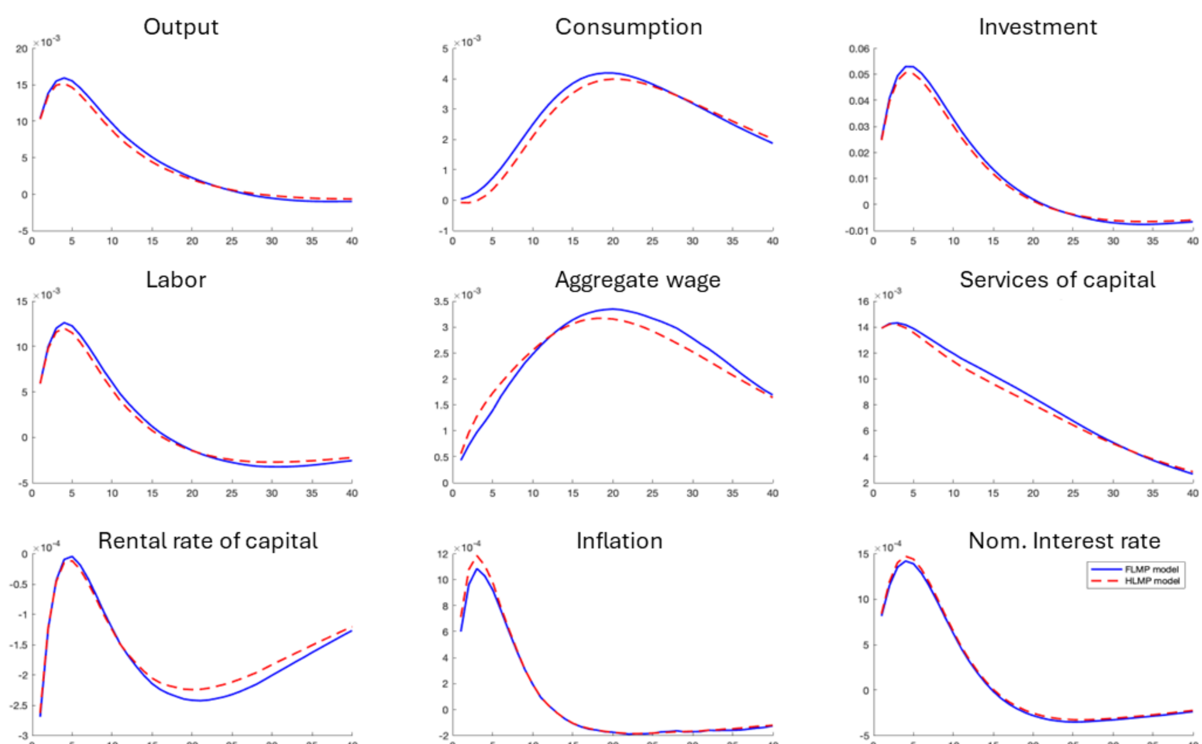

Figure 1.6: Impulse responses of the cyclical components of macroeconomic variables following a MEI shock: labor market monopoly versus labor market monopsony, with a higher value of ψ (one period is a quarter).

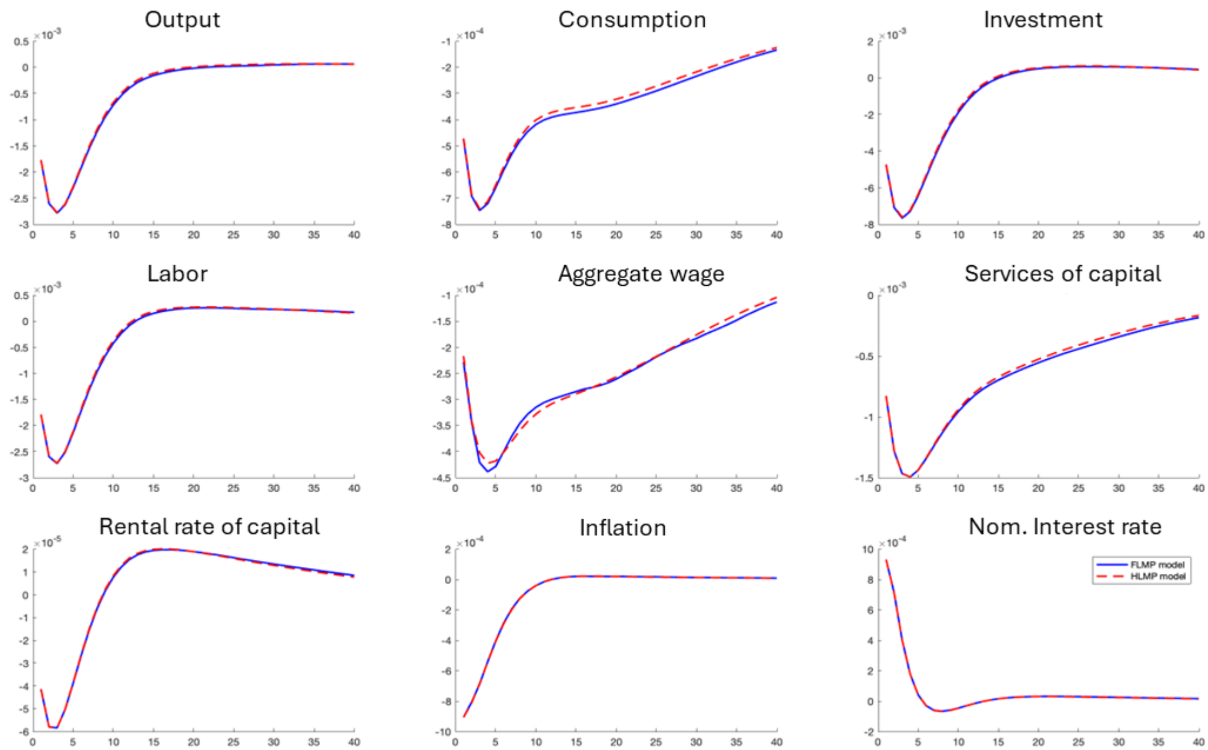

Figure 1.7: Impulse responses of the cyclical components of macroeconomic variables following a monetary policy shock: labor market monopoly versus labor market monopsony, with a higher value of ψ (one period is a quarter).

Figure 1.8 shows that, compared to the results reported in 1.4, a higher value of ψ causes the gaps between the two models' cyclical responses to be larger, especially in the short- and medium-run, following a wage shock. A higher value of ψ implies a deeper fall in the FLMP aggregate wage, leading firms to increase their labor demand. Simultaneously, households in the FLMP model experience a stronger wealth effect, thus increasing their labor supply and aggregate labor and aggregate output. In contrast, a higher ψ in the HLMP model does not directly affect aggregate wage, which mitigates its decline and the rise in labor demand. In such a context, by raising the relative price of leisure, the relatively stronger intratemporal substitution effect limits the rise in labor supply in the HLMP model. Therefore, aggregate labor and output rise more modestly in the HLMP model compared to the FLMP model, increasing the discrepancies between the models.

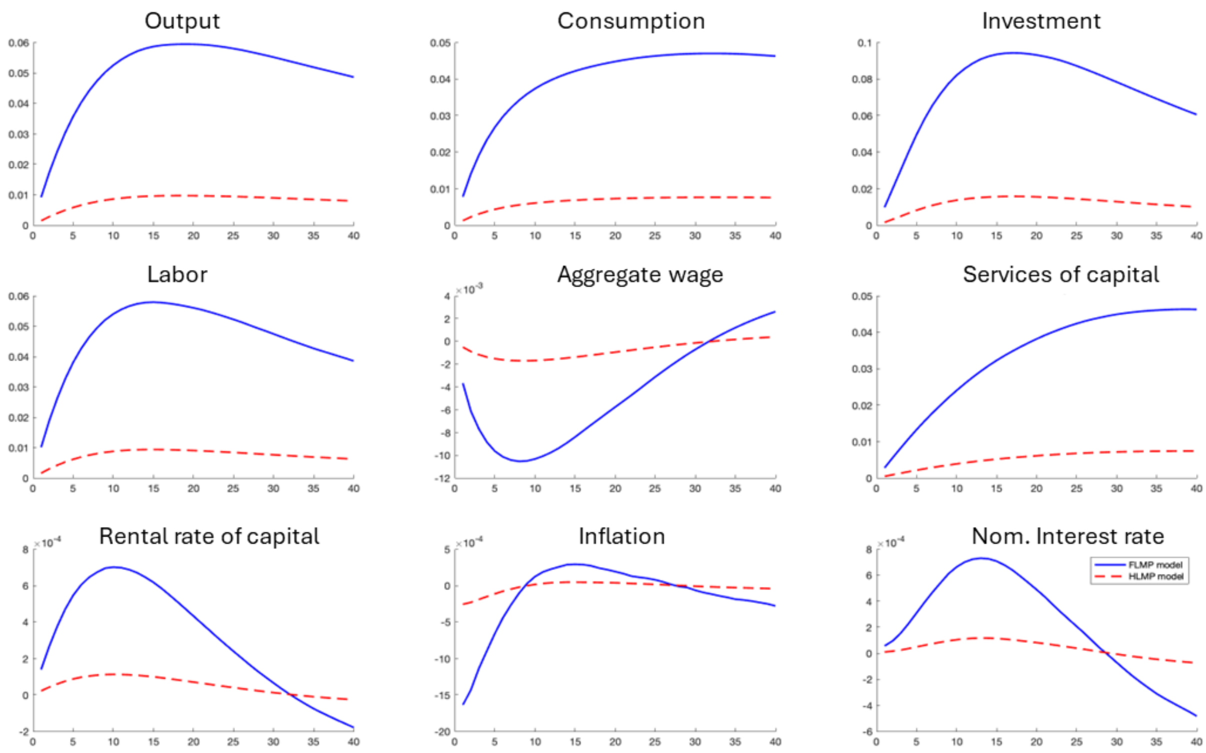

Figure 1.8: Impulse responses of the cyclical components of macroeconomic variables following a wage shock: labor market monopoly versus labor market monopsony, with a higher value of ψ (one period is a quarter).

Next, we turn to the comparison of the models' cyclical responses when the elasticity of substitution between specialized labor skills, γ, declines from 6 to 2. Figures 1.9 to 1.11 show that the sign and the size of the gaps in the models' responses following the neutral technology, the MEI and the monetary policy shocks, respectively, do not change noticeably with a smaller value of γ.

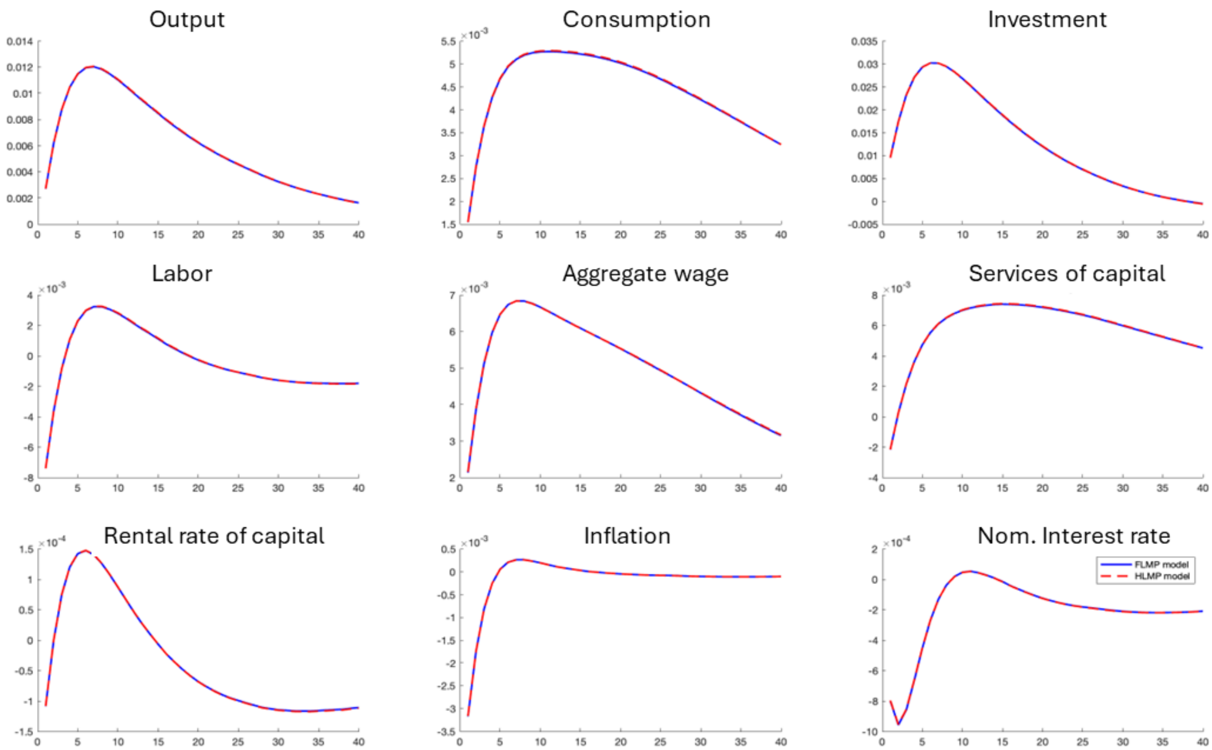

Figure 1.9: Impulse responses of the cyclical components of macroeconomic variables following a neutral technology shock: labor market monopoly versus labor market monopsony, with a smaller value of γ(one period is a quarter).

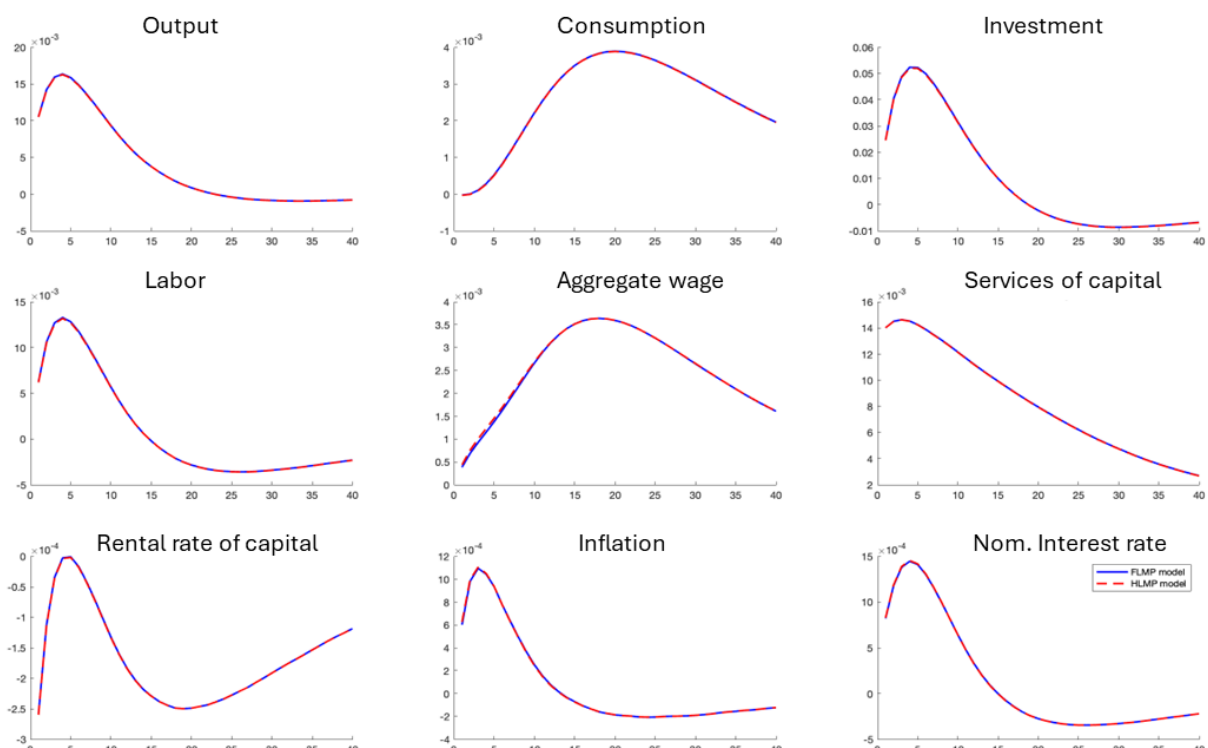

Figure 1.10: Impulse responses of the cyclical components of macroeconomic variables following a MEI shock: labor market monopoly versus labor market monopsony, with a smaller value of γ (one period is a quarter).

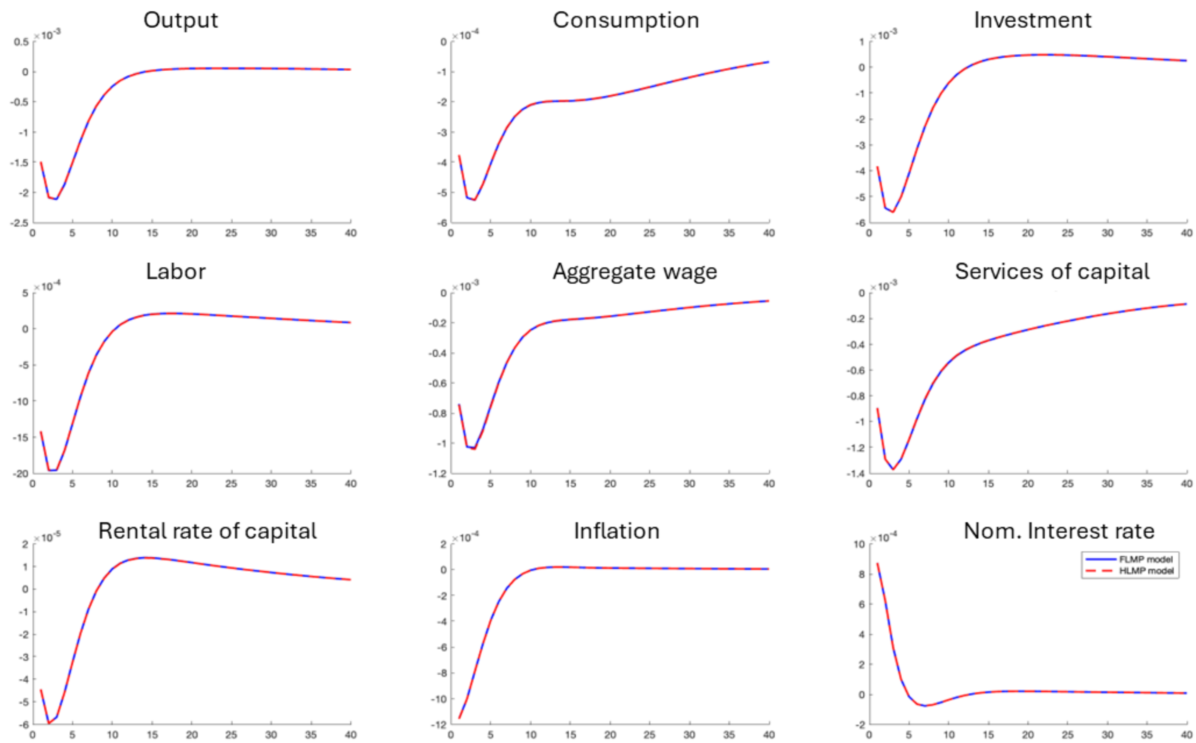

Figure 1.11: Impulse responses of the cyclical components of macroeconomic variables following a monetary policy shock: labor market monopoly versus labor market monopsony, with a smaller value of γ (one period is a quarter).

The value of γ seems to have a greater interaction with the wage shock. Figure 1.12 reports the comparison of the two models under a smaller value of γ and following the wage shock. Two significant observations can be made regarding Figure 1.4. First, the responses at the peak in the FLMP model are lower than that in the HLMP model. Second, the gaps between the two models' cyclical responses are smaller compared to the baseline case. Intuitively, a smaller γ implies that the labor skills are less substituable. In the FLMP model, this somewhat restricts firms' labor market power, thereby cushioning the fall in aggregate wage. Consequently, there is a modest rise in labor and output. Contrastingly, in the HLMP model, a smaller value of γ raises the sensitivity of aggregate wage to the wage shock, which explains its deeper fall. Since households possess a higher monopoly power because of a smaller γ, they are led to increase their labor supply in response to the shock. Consequently, labor and output increase to a greater extent in the HLMP model, especially during the first fifteen quarters.

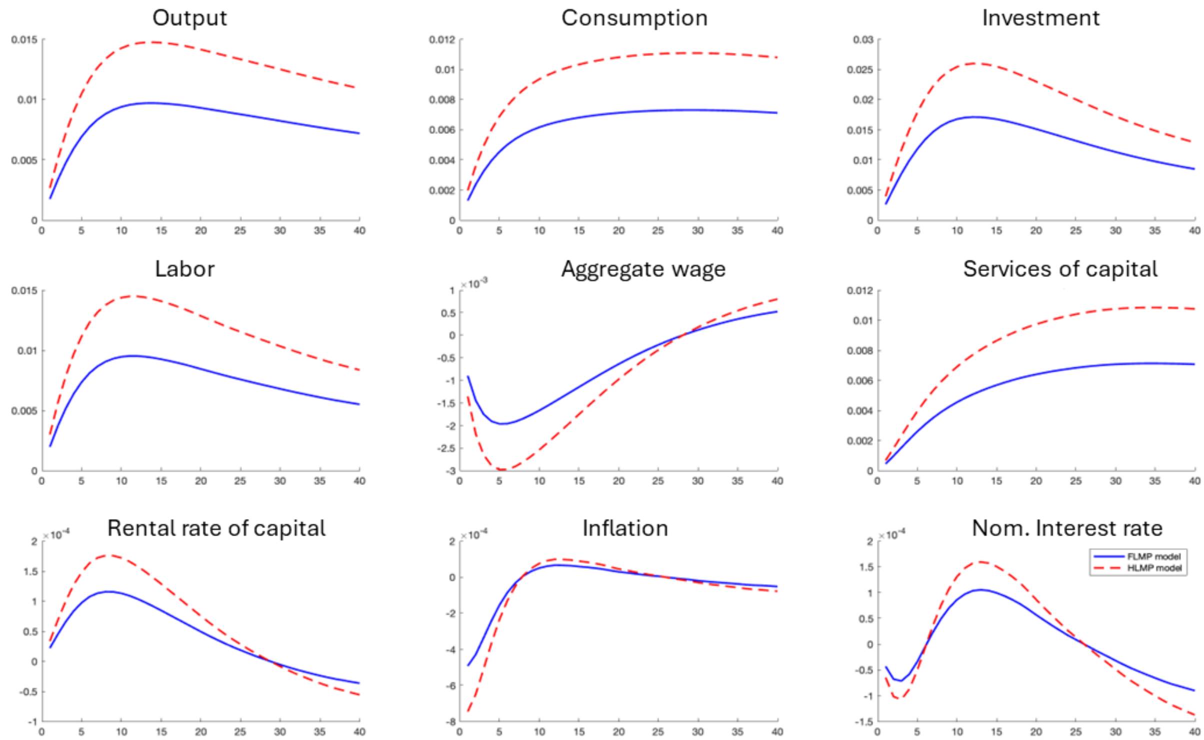

Figure 1.12: Impulse responses of the cyclical components of macroeconomic variables following a wage shock: labor market monopoly versus labor market monopsony, with a smaller value of γ (one period is a quarter).

1.4.2 Matching business cycle moments

This section compares the ability of the FLMP model to that of the HLMP model in matching some key moments in the data. The data used to generate empirical business cycle statistics cover the period from 1948Q1 to 2019Q4. Note that series from the data and from the models have been HP-filtered. Moreover, these moments are based on 4000 replications from which we burn the first 500. We start by looking at the volatility and comovements induced by all four shocks in both models.

Table 1.2 compares the volatility in the data to the unconditional volatility generated by the two models. Panel A shows absolute volatility, while panel B presents relative volatility i.e. the ratio of a variable standard deviation over the standard deviation of output. The two models predict quite well the volatilities of output, of the marginal product of labor (MPL) and of inflation. The FLMP model incorrectly predicts that consumption, investment and the real wage are less volatile than output. The HLMP model provides a better match regarding these variables. One dimension along which the FLMP model does a better job is the volatility of labor. In terms of relative volatility, the two models match quite well the relative volatility of labor. Contrastingly, the HLMP model is better at predicting the relative volatility of investment and of the MPL. Moreover both models predict incorrectly the relative volatility of the real wage, i.e. 0.24 and 0.25 in the HLMP and FLMP models respectively, while it is 0.44 in the data.

Tableau 1.2: Business cycle volatilities

Panel A: Absolute volatility

	$\sigma(Y)$	$\sigma(C)$	$\sigma(I)$	$\sigma(W)$	$\sigma(L)$	$\sigma(MPL)$	$\sigma(\pi)$
Data	0.02	0.008	0.06	0.009	0.01	0.01	0.004
FLMP model	0.03	0.01	0.01	0.03	0.01	0.009	0.004
HLMP model	0.03	0.008	0.11	0.008	0.03	0.01	0.004

Panel B: Relative volatility

	$\frac{\sigma(Y)}{\sigma(Y)}$	$\frac{\sigma(C)}{\sigma(Y)}$	$\frac{\sigma(I)}{\sigma(Y)}$	$\frac{\sigma(W)}{\sigma(Y)}$	$\frac{\sigma(L)}{\sigma(Y)}$	$\frac{\sigma(MPL)}{\sigma(Y)}$	$\frac{\sigma(\pi)}{\sigma(Y)}$
Data	1	0.38	3.03	0.44	0.89	0.49	0.20
FLMP model	1	0.42	2.79	0.25	0.95	0.38	0.12
HLMP model	1	0.24	3.16	0.24	0.91	0.40	0.13

Notes: This table displays the volatility and the relative volatility of the cyclical component of HP filtered empirical or simulated series. "σ" refers to standard deviation. ”FLMP” and ”HLMP” refer to firms’ labor market power and households’ labor market power, respectively, and thus they are simulated series. Empirical series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

Table 1.4 reports contemporaneous cross correlations from the data and from both models. In the discussion, we focus on the discrepancies between the two models’ predictions. The real wage is mildly procyclical in the data given its 0.15 correlation with output. It is mildly countercyclical in the FLMP model (-0.14) and acyclical in the HLMP model (0.004). Looking at the correlation between consumption and the real wage, we find that it is mildly procyclical in the data at 0.25. The HLMP model correctly predicts that correlation at 0.23, while the FLMP model implies that correlation is countercyclical at -0.29. Another discrepancy is the correlation between the real wage and inflation. It is acyclical in the data (-0.01) as it is in the FLMP model (0.03), although it is midly countercyclical in the HLMP model (-0.43).

Tableau 1.3: Business cycle contemporaneous cross correlation.

	$\rho(Y,C)$	$\rho(Y,I)$	$\rho(Y,W)$	$\rho(Y,L)$	$\rho(Y,MPL)$
Data	0.79	0.89	0.15	0.86	0.44
FLMP model	0.63	0.94	-0.14	0.93	0.31
HLMP model	0.51	0.97	0.004	0.91	0.41

	$\rho(Y,\pi)$	$\rho(C,I)$	$\rho(C,W)$	$\rho(C,L)$	$\rho(C,\pi)$
Data	0.32	0.60	0.22	0.73	0.25
FLMP model	0.32	0.39	-0.29	0.62	0.02
HLMP model	0.29	0.44	0.23	0.40	-0.005

	$\rho(L,W)$	$\rho(L,MPL)$	$\rho(L,\pi)$	$\rho(W,MPL)$	$\rho(W,\pi)$
Data	-0.05	-0.05	0.32	0.41	-0.01
FLMP model	-0.39	-0.07	0.50	0.60	0.03
HLMP model	-0.25	0.02	0.51	0.59	-0.43

Notes: This table displays the contemporaneous cross correlation between the cyclical component of HP filtered empirical or simulated series. "ρ" refers to the contemporanous cross correlation. ”FLMP” and ”HLMP” refer to firms’ labor market power and households’ labor market power, respectively, and thus they are simulated series. Empirical series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

We also present the autocorrelation functions up to four quarters in Table 1.4. Overall, the two models perform quite similarly and both exhibit some discrepancies with the data. There are two exceptions. First the autocorrelation of the real wage at one quarter lag is -0.09 in the FLMP model and 0.04 in the HLMP model. It is 0.68 in the data. Second, the autocorrelation of the MPL at one and two quarters are respectively 0.16 and 0.06 in the FLMP model, 0.25 and 0.12 in the HLMP model but 0.70 and 0.46 in the data.

According to the impulse responses that we presented in the previous sections, it seems that wages shocks create the most significant discrepancies between the two models, which reflect on the business cycle statistics we just discussed. Therefore, it is important to assess how the differences in terms of business moments predictions change when there are no wage shocks.[24] Overall, the two models generate volatil-

[24] The results of these simulation are available in A

ities, correlations and autocorrelation coefficients that are almost perfectly identical. Yet, there are some exceptions such as the implied correlation between the real wage and inflation which is 0.44 in the HLMP model but 0.09 in the FLMP model.

Tableau 1.4: Business cycle autocorrelation functions (one to four lags).

	Lag	-1	-2	-3	-4
Output	Empirical	0.84	0.60	0.33	0.09
	FLMP model	0.92	0.76	0.57	0.37
	HLMP model	0.91	0.75	0.55	0.35
Consumption	Empirical	0.84	0.66	0.45	0.22
	FLMP model	0.60	0.53	0.43	0.32
	HLMP model	0.53	0.50	0.45	0.38
Investment	Empirical	0.82	0.46	0.26	-0.004
	FLMP model	0.90	0.77	0.60	0.41
	HLMP model	0.93	0.79	0.61	0.41
Real wage	Empirical	0.68	0.47	0.29	0.12
	FLMP model	-0.09	-0.04	0.005	0.06
	HLMP model	0.04	0.07	0.10	0.14
Labor	Empirical	0.90	0.70	0.45	0.20
	FLMP model	0.90	0.77	0.60	0.40
	HLMP model	0.89	0.77	0.58	0.38
Labor prod.	Empirical	0.70	0.46	0.19	0.009
	FLMP model	0.16	0.06	0.01	-0.007
	HLMP model	0.24	0.12	0.05	0.02
Inflation	Empirical	0.49	0.27	0.11	-0.07
	FLMP model	0.41	0.40	0.34	0.25
	HLMP model	0.39	0.38	0.32	0.24

Notes: This table displays the autocorrelation coefficients of the cyclical component of HP filtered empirical or simulated series. ”FLMP” and ”HLMP” refer to firms’ labor market power and households’ labor market power, respectively, and thus they are simulated series. Empirical series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

1.4.3 The cyclicality of the wage markdown

The cyclical behavior of the wage markup has often been a crucial focus in the macroeconomic literature on business cycles. There is a large literature agreeing that the wage markup is countercyclical.[25] However, little has been said regarding the cyclicality of the wage markdown which is the object of this section. In particular, the cyclicality is assessed using the contemporaneous cross-correlation between output and the wage markdown.

Empirical evidence regarding the unconditional cyclical nature of the aggregate wage markdown is somewhat inconclusive. On one hand, some studies find that the wage markdown is countercyclical. For instance, using linked employee-employer data, Depew and Sørensen (2013) find that the wage mardown, proxied by the elasticity of labor supply, rises during recessions and falls during expansions. Hirsch *et al.* (2018) reach the same conclusion using German linked employee-employer data. On the other hand, Khan and Metaxoglou (2021) use KLEMS data to measure the U.S. aggregate wage markdown and find it to be procyclical, which is consistent with labor productivity being more procyclical than the aggregate real wage. While we do not take a stand on the empirical evidence, our analysis provides some additional insights on factors that influence the cyclicality of a wage markdown (at least in the case of the entire labor market being thought as being characterized with FLMP).

Table 1.5 reports the contemporaneous cross-correlations between aggregate output and the wage markdown. We report five specifications of the FLMP model: the baseline specification, a specification without the wage shock, a specification with only the neutral technology shock, a specification with only the MEI shock and a specification in which there is only the monetary policy shock.

[25] See for example Gali *et al.* (2007) and Shimer (2009) for more details.

Tableau 1.5: Cyclicality of wage markdown, wage markup and labor wedge

	ρ(Y,Wage markdown)	ρ(Y,W)	ρ(Y,MPL)
Baseline	-0.51	0.52	0.55
No wage shock	-0.39	0.52	0.55
Only neutral technology shock	-0.30	0.98	0.71
Only MEI shock	-0.80	-0.07	0.71
Only monet. pol. shock	0.97	0.97	0.87

Notes: This table displays the contemporaneous cross correlation between the cyclical component of HP filtered simulated series. "ρ" refers to the contemporanous cross correlation. Wage markdown is the difference between labor productivity (MPL) and the real aggregate wage (W) in the FLMP model. Wage markup is the difference between aggregate wage and the MRS. The simulated series are based on 4000 replications from which we burn the first 500.

Our findings reveal that, in most cases, the wage markdown is countercyclical, which is consistent with the evidence of Depew and Sørensen (2013) and Hirsch *et al.* (2018). In particular, the wage markdown is rather countercyclical in the baseline model (-0.51), whereas it is either mildly countercyclical as in the ”no wage shock” and the ”only neutral technology shock” specfications (-0.39 and -0.30, respectively) or strongly countercyclical as in the ”only MEI shock” (-0.80) specification. However, in the ”only monetary policy shock” specification, the wage markdown is strongly procyclical at 0.97. Moreover, in that specification, the aggregate real wage is more procyclical than labor productivity, which does not reconcile with the evidence reported in Khan and Metaxoglou (2021). This particular case in which the wage markdown becomes procyclical suggests that demand shocks may affect its cyclicality differently than supply shocks.

1.4.4 A comparison with related papers in the literature

This section is devoted to outlining the potential similarities and differences between our work and the existing literature. To the best of our knowledge, there are two other papers that incorporate firms' labor market power, instead of households' labor market power, within a NK (theoretical) framework.

The first related paper is Dennery (2020) who compares the implications of a monopsony versus monopoly in the labor market on the NK Phillips Curve. He argues that in the traditional monopolistic labor market, the labor market adjustments to an increase in inflation are made on the demand side. As households cannot fully adjust their nominal wages (real wages fall), it gives firms incentives to raise their labor demand, thus inducing an increase in output. However, in a monopsonistic labor market, since firms cannot fully adjust real wages that they set, labor supply declines, hence generating a drop in output. The agents economic problems that we pose and solve in our FLMP model shares the same economic intuition as that of Dennery (2020). However, it is impossible to compare our results not only in terms of impulse responses but also in terms of the models' ability to replicate observed statistical moments.

Alpanda and Zubairy (2021) explores the business cycle implications of an oligopsonistic labor market structure within an estimated NK DSGE model. Their model explicitly considers the influence of industry concentration, through the relative number of firms withing each sector. As that number shrinks, firms get more labor market power and impose higher markdown. In order words, wage markdown varies endogenously because of the number of firms but it is also subject to exogenous variations through a stochastic disturbance inserted in the wage equation. Finally, intermediate goods market is characterized by firms' oligopoly instead of monopoly.

Except for the wage shock, Alpanda and Zubairy (2021) report that there are mainly quantitative differences when comparing the cyclical responses in their model with "oligopsony labor" to those in their model with "oligopoly labor". For instance, they find that a neutral technology shock induces a stronger economic expansion in the model with oligopsonistic labor. In particular, their impulse responses show that the most significant discrepancies between the two types of labor market are related to the responses of labor and of the nominal interest rate, while the path other variables, such as output and consumption, do not display substantial gaps. These findings are broadly consistent with ours. In particular, we find that there is no significant interaction between the neutral technology shock and the labor market structure, so that the models' impulse responses are very similar.

Alpanda and Zubairy (2021) also show that a wage shock produces a cyclical upturn in the model with "oligopsony labor" whereas it generates an economic contraction in the model with "oligopoly labor". While we don't find opposite cyclical effects on the models' variables following a wage shock, we do observe that it induce a stronger economic upturn in the FLMP model. Finally, Alpanda and Zubairy (2021) estimate their model using Bayesian methods and do not provide simulated business cycle moments, thus not enabling us to compare the relative ability of our model to replicate observed statistics.

It is worth noting that the source of the discrepancies between our results and that of Alpanda and Zubairy (2021) is unclear as it might stem from the modeling of the labor market structure is different, the fact that the wage markdown is subject to endogenous and exogenous fluctuations or the modeling of the intermediate goods market structure.

Another interesting paper from an empirical perspective is Khan and Metaxoglou (2021). Using KLEMS data spanning from 1987 to 2018, the assess the evolution over time and the cyclicality of employers' ability to set wages below the marginal revenue product of labor. To do so, they estimate the aggregate wage markdown by considering the output elasticities of inputs and their shares of gross output across U.S. industries, while making sure to disentangle markdown from markup. They find an upward trend in aggregate wage markdown mainly by changes in input shares. This finding further supports our argument that firms' labor market power has increased over time and has become a macroeconomic phenomenon that needs to be embedded in macroeconomic models. Furthermore, they found that wage markdown is procyclical, meaning it increases during economic expansions and decreases during recessions, consistent with a lower procyclicality of the real wage compared to the marginal revenue product of labor. Overall, our simulations do not support this conclusion. Instead, we find that the wage markdown is countercyclical i.e. it rises during recessions and falls during economic expansion.

1.5 Concluding remarks

Typically, conventional New Keynesian DSGE models impose at the outset that households hold a leverage in the labor market that interacts with nominal wage rigidities and which are at the core of the money non-neutrality in the short- and medium-run. Motivated by empirical evidence on the existence and the likely macroeconomic relevance of firms' labor market power, we study how this alternative characterization of the nature of the labor market matters for our understanding of business cycles. In this paper, we therefore contrast two polar views about the imperfect competition in the labor market. In one case, as in typical NK-DSGE models, we assume that households who possess some wage-setting power operates in a monopolistically competitive setup, making intermediate firms wage-takers. Then, alternatively, we consider the case in which firms the labor market is monopsonistic, driven by market power on the demand side, making intermediate firms wage-markers.

First, we find that the propagation of neutral technology, MEI and monetary policy shocks is not qualitatively altered when we assume that monopsonistic competition instead of monopolistic competition prevails in the labor market. However, the models' impulse response functions following wage shocks exhibit substantial quantitative differences despite their qualitative similarity. In particular, because of the responses of aggregate output and inflation, negative wage shocks leads to an increase in the policy rate in our model whereas the standard New Keynesian model implies that there would be an accommodative response of the central bank. Moreover, our findings suggest that the interaction between aggregate shocks and the models' characteristics is not necessarily innocuous. For instance we note a great and significant interaction between investment adjustment costs and monetary policy and wage shocks when assessing the role played by the models' features.

To the extent that the role of the labor market structure was to be solely assessed on a model's capacity to reproduce the volatility, correlation and autocorrelation of key macroeconomic variables, it is unclear which model is superior when evaluating its performance in reproducing the empirical contemporaneous correlations. As a first stop, our analysis allows to assess how distinct polar modeling of the nature of imperfect competition might affect the propagation of various shocks.

One possibility is that we assume the same calibration in both models for shock and non-shock parameters. In particular, the calibration of the inverse Frisch elasticity of labor supply could be model-specific. The calibration of shocks parameters could also be model-specific as their implications could be seen as different within each model.

Other issues may be related to our actual modeling of the labor market. Indeed, we could argue that a more realistic and better performing model would embed the coexistence of three segments in the labor market. A first one might be rather competitive, a second one might show monopolistic power belonging to the households, while a last one might be characterized by firms with monopsonistic power. Furthermore, the relative market power of firms versus households in the overall economy may vary depending on the phase of the business cycle and the nature of the shock affecting the economy. There is a limited existing literature that has collectively investigated these features and their aggregate-level implications. Hence, future work is arguably well be motivated to characterize the macroeconomic implications of the structure of the labor market. That is why this paper was seen as a useful and instructive preliminary step to understand whether and how the customary labor market specification with households detaining market power may be too specific by adopting a polar view.

Another important issue to raise is that the empirical evidence points towards an extensive margin adjustment of labor fluctuations. Hence, another issue could be related to the deliberate omission of frictions inherent in the matching process that underlie the adjustment in the extensive margin. We believe that despite its more restricted scope at this early stage, this paper explored the relevance of extending the set up of the labor market.

Finally, possibly, either polar views may be too strong as not all workers and firms do not necessarily operate in a single type of labor market. There might be instances in which households may dominate firms in the labor market, other where firms exert a dominating position, and even others were neither households nor firms have any market power. Therefore it might be important to rethink the labor market as an aggregation of different segments, each of them being characterized by different types of competition.

CHAPITRE 2

THE CYCLICAL AND WELFARE IMPLICATIONS OF A COMPLETE LABOR MARKET STRUCTURE IN A MACROECONOMIC MODEL

RÉSUMÉ

This study enriches the standard New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) framework by embedding a tripartite labor market structure, delineating in segments respectively characterized by either monopsonistic, perfect competition, or monopolistic competition. This extended model implies a cyclical behavior of macroeconomic variables, that remains comprehensively aligned with the established business cycle literature with regards to the aggregate impact of neutral technology, MEI and monetary policy shocks. Notably, we reveal that the influence of restrictive monetary policy shocks intensifies as firms' labor market power augments vis-à-vis households. A comparative analysis with the traditional NK model demonstrates that our augmented model not only more accurately mirrors key business cycle metrics, like standard deviations, but also delineates a distinct, both quantitative and qualitative, transmission of aggregate shocks. Interestingly, a welfare analysis indicates potential gains from a reduction in the workforce under monopsonistic conditions, highlighting the implications of the labor market structures in macroeconomic modeling. These findings advocate for a more complex understanding of labor market dynamics and their macroeconomic repercussions, challenging the conventional assumption that only households have market power and thus operate in a monopolistically competitive environment in the typical NK-DSGE model.

KEY WORDS: Firms vs Households Labor Market Power; Labor Market Structure; Business Cycles; New Keynesian DSGE Model; Welfare Analysis, Monetary Policy.

JEL classification: E12, O32, J42, E52.

2.1 Introduction

Microeconomic theory distinguishes various forms of labor market power: it can be monopolistically driven by households (supply-side), monopsonistically driven by firms (demand-side) or perfectly competitive driven (with no market power attributed to either side). The choice of a labor market structure, especially within a macroeconomic model, carries both positive implications for business cycle analysis and normative implications for economic policy assessment. For a broad range of reasons, including workers' preferences and skills, the types of institutions in the economy and other legal dispositions, it is reasonable to argue that different segments of the labor market are each characterized by different types of competition. Yet, standard New Keynesian (hereafter NK-DSGE) and real business cycle models, typically employed a simplified, single-structure, typically characterized by either monopolistic or perfect competitions. Thus, these approaches may overlook the complex and varied nature of the actual labor market that may not be innocuous to understand aggregate economic dynamics.

The theoretical underpinnings of our approach are grounded in a rich body of literature that recognizes the diverse nature of distinct segments of the labor market. On one hand, in a perfectly competitive labor market, employers and workers possess equal bargaining power, resulting in both parties being wage takers with no market power. An important implication of this framework is that the wage received by workers equals the marginal productivity of labor.

The description of the labor market as functioning in a perfectly competitive environment is generally the initial and natural first step in modeling. This perspective was also a common feature in many important contributions of the real business cycle literature such as Kydland and Prescott (1982), King *et al.* (1988), and King and Rebelo (1999). In any case, as a first-order approximation, perfect competition adequately represents situations pertaining for some workers evolving in sectors or regions where neither workers nor firms possess clear or significant leverage in the labor market. While there is no clear empirical evidence confirming the existence of a completely competitive labor market, one can make the case that middle-skilled workers, whether we use educational attainment or occupations as proxies, can be thought as evolving in a perfectly competitive environment.[1] Given that middle-skilled workers constitute approximately 40% of the U.S. employment share, their significance at the aggregate level must not be overlooked.[2]

[1] Yang and Shim (2019) show that education and occupation, as proxies, are highly correlated.

[2] Jaimovich and Siu (2020) report that the employment share of middle-skilled workers was 42% in 2017.

On the other hand, the standard NK DSGE models suggest that due to the specific skills possessed by workers, households can be considered as holding some market power, leading them to being wage makers, albeit in economies with wage contracts and nominal rigidities.[3] Therefore, by maximizing their utility, the wage chosen by workers is a markup over their marginal rate of substitution between consumption and leisure.

The role and impact of labor unions provide empirical evidence supporting the idea of households possessing monopoly power in the labor market. Unions, which aim to maximize workers' well-being, legally exercise bargaining power on behalf of workers in their negotiations with firms. Consequently, they exert a significant influence on the labor income of unionized workers and their working conditions, as extensively documented in the literature. For instance, Stansbury and Summers (2020) find that 50% of the decline in workers' labor rent is attributed to the fall in unionization rates, and Farber *et al.* (2021) report that unionized workers' income is between 10% and 20% higher than non-unionized workers' income.

Lastly, impulsed by the labor economics literature such as Manning (2003b), there is a body of theoretical and empirical literature that adopts the concept of monopsony as a labor market structure. Due to labor market concentration and frictions such as regulatory barriers to worker mobility, employers have incentives to exert some market power, making them wage makers. In their pursuit of profit maximization, which entails minimizing wage bills, employers pay workers a wage that represents a markdown on their marginal revenue product.

There is substantial empirical evidence supporting the presence of firms' monopsony in the labor market. Various factors, such as the use of no-poaching agreements by firms (Krueger and Ashenfelter (2022)), the finding of small empirical estimates of the labor supply elasticity (Azar *et al.* (2022b), Kroft *et al.* (2021), Sokolova and Sorensen (2021)) and the rise in labor market concentration (Benmelech *et al.* (2022), Qiu and Sojourner (2023), Rinz (2022)), indicate that a significant portion of labor market power is held by firms. Noncompete clauses (NCs) have also recently gained attention as a key element in this context. These clauses prevent employees from joining or starting competing firms within specific geographic boundaries or time frames. Not only are NCs prevalent at the aggregate level (see Starr *et al.* (2021) and Colvin and Shierholz (2019)) but they also depress wages (see Starr (2018) and Balasubramanian *et al.* (2022)). These detrimental effects on workers' welfare prompted the Federal Trade Comission to propose a rule banning

[3] See, for example, seminal papers such as Smets and Wouters (2007) Christiano *et al.* (2005).

them. Hence, this recent evidence has led some reseachers to consider a monopsonistic labor market structure (e.g. Dennery (2020), Alpanda and Zubairy (2021) and Atsiga (2023)).

While these different types of labor market competition can be seen as alternative depiction, treating them as mutually exclusive may well provide an incomplete picture of the overall labor market. It is rather most likely that none of them alone can or should be generalized to the entire economy. Therefore, we propose to simultaneously encompass all three types of competition, with each characterizing one of three segments of the labor market.

In this paper, we want to address two research questions. First, what are the macroeconomic implications of a richer labor market structure? In particular, can it alter the business cycle properties of NK-DSGE models in non trivial ways, and if so, through which mechanisms and following which shocks? Second, what are the welfare gains of a shift in the relative proportion of workers in a given labor market segment? More specifically, does a decline in the share of workers in the monopsonistic segment of the labor market improves households' welfare?

By simultaneously capturing different level of leverage between employers and employees, the first question opens the door for a deeper understanding of both the cyclicality of the labor market and its impact on the aggregate economy. The second question is timely given the recent proposal by the Federal Trade Commission to ban NCs, a source of monopsony power, from workers' contracts despite polar views on the topic.[4] While we do not claim to be able to settle this debate, we derive, at least from a theoretical point of view, the potential welfare implications of such proposal.

To address these questions, we extend the traditionnal NK DSGE model with a richer labor market structure that includes three segments, namely monopsonistic, monopolistic and perfect competitions, respectively. The model also embeds features of the standard framework such as a monopolistic intermediate firms in the goods market, nominal wage and price rigidities and aggregate fluctuations driven by a neutral productivity shock, a shock to the marginal efficiency of investment and a monetary policy shock.

Our main results are as follows. First, the cyclical paths of macroeconomic variables following the neutral technology, the MEI and the monetary policy shocks in our model are qualitatively in line with works such

[4] On one hand, there is a view advocating that NCs protect firms' investments in training which has a positive impact on human capital, and thus, firms' productivity and workers' wage. On the other hand, there is another view arguing that NCs restrict workers' mobility, suppressing wages and reducing well-being.

as Gali (1999) and Justiniano *et al.* (2010). Second, our analysis shows, for instance, that the contractionay effects of a restrictive monetary policy shock are stronger when firms possess more labor market power compared to when household have more monopolistic labor market power. In fact, an increase in households' labor market power reduces the monopsonistic rent captured by firms, hence raising the negative wealth effect on labor supply. Therefore, the decline in aggregate labor and output is mitigated compared to the case in which firms' labor market power has risen.

Third, we find that the cyclical effects induced by neutral technology, MEI and monetary policy shocks are weaker in our model than in the standard NK-DSGE model. In addition, our model has a better ability to reproduce the observed volatility of output, investment, wages, labor, marginal labor productivity and inflation, compared to the traditional NK-DSGE model. Fourth, our welfare analysis reveals that a reduction in the share of workers in the monopsonistic segment of the labor market leads to an improvement in household' welfare. This last result is consistent with the view that firms' monopsony harms workers.

The next section describes the model's structure, the economic agents' problems, and their respective optimal solution. Section 3 discusses the model's parameter values. Sections 4 and 5 delve into the business cycle and welfare implications of our labor market structure, respectively. Finally, concluding remarks are exposed in section 6.

2.2 The model

The model features typical characteristics of a standard NK model.[5] Specifically, the economy consists of the following agents: households, labor intermediaries (comprising unions and employer agencies), the final good producer, intermediate good producers and a monetary authority. Households derive utility from consumption and leisure while supplying firms specific labor to the labor intermediaries. Intermediate goods producers create differentiated goods using the services of physical capital and labor. They operate in a monopolistically competitive setup that allows them to be price makers. Operating in a perfectly competitive market, the final good producer transforms differentiated intermediate goods into output. The monetary authority sets the nominal interest rate according to a Taylor rule. Common features in both models also include the following frictions: nominal rigidities in the form of Calvo wage and price contracts, habits formation in consumption, investment adjustment costs and variable utilization of physical capital.

[5] See, for example, Christiano *et al.* (2005).

Our model departs from the standard NK model with respect to the labor market structure. In particular, each household comprises three types of members (or workers), each evolving within a different labor market segment. To elaborate, workers from a first segment are considered non-unionized and face restrictions to their mobility like noncompete clauses. We refer to this individuals as f-workers because they are subject to firms's labor market power (or monopsonistic power), rendering them wage-takers. Operating in a monopsonistically competititve labor market, employer agencies exert the wage-setting and hiring decisions on the behalf of firms. They do so by aggregating the labor supplied by f-workers into an homogeneous labor, and by applying markdown on their wage rate.

A second segment regroups workers who can also be considered non-unionized but do not face restrictions akin to f-workers. This group is denoted c-workers because they evolve in a competitive labor market segment. They supply labor to intermediate firms without the involvement of a labor intermediary, in exchange of a competitive wage rate.

Lastly, workers in a third segment are considered unionized, thus granting them some labor market power over their wage rate. We refer to them as h-workers since the power belongs to households within this labor market segment. Labor unions, acting on behalf of h-workers, not only combine the specific labor supply of h-workers into a homogeneous labor, but also set their wage rate as a markup over their marginal rate of substitution between consumption and leisure.[6]

We make the assumption that there is no movement across labor market segments because of the existence of high mobility costs such that switching from one segment to another is prohibitively costly. In fact, we can argue that there are some high fixed costs associated to a (geographical) change in job that are not negligible in practice.[7]

The next sections provide an in-depth overview of the baseline model, delving into the characteristics, the problems and the equilibrium conditions associated to each economic agent and the aggregate equilibrium conditions.

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[6] It is worth noting that the classification between f-, c- and h-workers that we aim to establish is not rigid. For example, h-workers can be non-unionized but still hold some significant market power relative to employers, because of their skills, their experience or the position they occupy within the firm. In addition, f-workers can have a lot of skills but still be constrained by noncompete clauses, implicit collusion between employers or a somewhat dominant position of firms in the activity sector in which they belong.

[7] An example could be the cost of moving to another city or country or the money and time costs of getting additional training.

2.2.1 Households

The economy is populated by a large number of identical households that we normalize to a unit measure. Each household comprises three members (or workers) that participate in the labor force: f-, c- and h-workers. Decisions regarding consumption, C_t, investment in physical capital, X_t, the intensity of utilization of physical capital, u_t, the holding of physical capital in the next period, K_{t+1}, and the holding of bonds, b_{t+1}, are made at the household level and and are independent of the specific member. However, decisions related to hours worked and wages depend on the member, and as a result, these variables carry the subscript $j \in \{f, c, h\}$, reflecting the influence of the worker's environment. Furthermore, since labor supplied by workers is specific to firm, we introduce an additional index, i, for hours worked and wages variables.[8] [9]

A household i's intertemporal preferences over consumption and labor are described by the following expected utility function over an infinite horizon:

$$E_t \sum_{t=0}^{\infty} \beta^t \left(\ln(C_t - bC_{t-1}) - \eta_f \frac{L_{f,t}(i)^{1+\psi_f}}{1+\psi_f} - \eta_c \frac{L_{c,t}(i)^{1+\psi_c}}{1+\psi_c} - \eta_h \frac{L_{h,t}(i)^{1+\psi_h}}{1+\psi_h} \right), \tag{2.1}$$

where E_t is the expectation operator conditional on all the information available and known as of period t, $0 < \beta < 1$ is the subjective discount factor, $0 < b < 1$ is a parameter governing internal habit formation. η_j and ψ_j are respectively the weight on labor disutility and the inverse Frisch elasticity of labor supply of each household's type j-worker, with $j \in \{f, c, h\}$.

Each period, a j-worker allocates its time between hours of work, $L_{j,t}(i)$, and leisure, $l_{j,t}(i)$, with he total time at its disposal being normalized to one. Accordingly, this defines the following time constraint

$$L_{j,t}(i) + l_{j,t}(i) = 1, \tag{2.2}$$

$\forall j \in \{f, c, h\}$. The household's time t real budget constraint equates one's amount of resources to its expenses, according to:[10]

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[8] In subsequent sections, we use index i to refer to intermediate firms.

[9] This formulation aligns with the approach taken by Erceg *et al.* (2000), which assumes implicit insurance contracts (except for labor), ensuring that households are identical across all dimensions except for labor supply and wages. Therefore, we can omit index i from all the households' variables except for their labor supply and wage.

[10] Real variables are simply nominal variables divided by the price P_t.

$$C_t + X_t + b_{t+1} + a(u_t)K_t = w_{f,t}(i)L_{f,t}(i) + w_{c,t}(i)L_{c,t}(i) + w_{h,t}(i)L_{h,t}(i) + q_t u_t K_t + \frac{(1+R_{t-1,t})}{(1+\pi_{t,t+1})}b_t + d_t \quad (2.3)$$

In period t, a j-worker supplies labor to an intermediate firm i, either directly or through labor intermediaries, and receive the real wage rate, $w_{jt}(i)$. The household rents the services of physical capital, $u_t K_t$ (or $\hat{K}_t$) to intermediate firms at a competitive real rate, q_t. Physical capital utilization rate, $0 \leq u_t \leq 1$, allows households to adjust the intensity and the quantity of physical capital rented each period. In addition, the household receives an income from its purchase of one-period bonds, b_t, in the previous period with a gross real interest rate, $\frac{(1+R_{t-1,t})}{(1+\pi_{t,t+1})}$, where $\pi_{t,t+1}$ is net inflation.[11] Furthermore, since the representative household owns firms (i.e. the final good producer, intermediate firms and the labor intermediaries), its income includes real dividends which consist of two components. First, real economic profits, $\pi_t(i)$, stem from the market power of intermediate firms operating in a monopolistically competitive intermediate goods market. Second, the exercise of monopsony power by intermediate firms carries a rent given by $\pi_{EA,t}(i)$.[12] Therefore, $d_t \equiv \pi_t(i) + pi_{EA,t}(i)$

The household's current income is allocated to various uses including real consumption of the final good, C_t, the cost of real investment in capital goods, X_t, the purchases (or sales) of one-period bonds, b_{t+1}, and the real cost of adjusting physical capital, $a(u_t)K_t$. The resource cost of variable utilization of physical capital is proportional to the to the capital stock, with $a(u_t)$ being given by the following convex function:

$$a(u_t) = \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{1}{Z_t}, \quad (2.4)$$

with $\chi_1 \geq 0$ and $\chi_2 \geq 0$, two parameters governing the cost. Z_t is a common stochastic investment shock that affects the efficiency of transforming units of investment into new units of capital and is defined as:

$$lnZ_t = \rho_Z lnZ_{t-1} + \epsilon_{Z,t}. \quad (2.5)$$

[11] b_t can be either negative or positive depending on the household being creditor or debtor. However, as this is a closed economy, the aggregate equilibrium condition is b_t=0.

[12] The rent generated by monopolists h-workers is already built-in the wage rate paid with a markup. However, in the monopsonistic segment of the labor market, the rent captured by firms is reversed to f-workers in the form of dividends, as they are also owners of intermediate firms.

Furthermore, we assume that the transformation of today's investment into tomorrow capital is costly because of some investment adjustment costs, and that it also depends on a marginal efficiency of investment shock (hereafter MEI shock), so that the law of capital accumulation is written as

$$K_{t+1} = Z_t \left(1 - \tau/2 \left(\frac{X_t}{X_{t-1}} - 1\right)^2\right) X_t + (1-\delta)K_t, \tag{2.6}$$

where is $0 < \delta < 1$ is the depreciation rate and $\tau \geq 0$ governs the magnitude of the cost.

The household's objective is to maximize its expected utility over an infinite horizon (equation 2.1), subject to the sequence of budget constraints (equation 2.3), the time constraint (equation 2.2), the law of physical capital accumulation (equation 2.6) and the appropriate transversality conditions. Finally, Υ_t and μ_t are the Lagrange multipliers associated with the household' budget constraint and the law of physical capital accumulation, respectively.

2.2.2 The labor intermediaries and the labor market

The labor intermediaries ensure the match between households and intermediate firms in the labor market. However, the type of competition they face, the decisions they make as well as the constraints they face differ depending on which segment of the labor market in which they work.

2.2.2.1 The monopsonistic segment of the labor market

In the monopsonistic segment of the labor market, the labor intermediaries operate within a monopsonistically competitive environment. Hence, we can think of a representative employment agency (EA) that acts on behalf of intermediate firms, managing hiring and wage-setting decisions.

The hiring decision of the EA

The EA combines labor supplied by f-workers using an aggregation function:

$$L_{f,t} = \left(\int_0^1 L_{f,t}(i)^{\frac{\gamma_f - 1}{\gamma_f}} di\right)^{\frac{\gamma_f}{\gamma_f - 1}} , \tag{2.7}$$

where γ_f represents the elasticity of substitution between the labor supplied by f-workers.

The EA chooses the quantity of f-labor along the upward-sloping labor supply curve by solving the following real profit maximization problem:

$$\max_{L_{f,t}(i)} \pi_{EA,t} = w_{f,t} L_{f,t} - \int_0^1 w_{f,t}(i) L_{f,t}(i) di, \tag{2.8}$$

subject to the labor aggregation function:

$$L_{f,t} = \left(\int_0^1 L_{f,t}(i)^{\frac{\gamma_f - 1}{\gamma_f}} di \right)^{\frac{\gamma_f}{\gamma_f - 1}}, \tag{2.9}$$

and f-worker's labor supply:[13]

$$\eta_f L_{f,t}(i)^{\psi_f} = \Upsilon_t w_{f,t}(i). \tag{2.10}$$

Solving this problem yields the demand for f-labor:

$$L_{f,t}(i) = \left((1 + \psi_f) \frac{w_{f,t}(i)}{w_{f,t}} \right)^{-\gamma_f} L_{f,t}. \tag{2.11}$$

The wage-setting decision of the EA

We assume the existence of nominal wage rigidities, making the EA unable to adjust all the individual wages each period. In a given period, it can only adjust a constant fraction, $(1 - \theta_{f,w})$, of wages while the other fraction, $\theta_{f,w}$, is the same as in the previous period. Thus, the EA chooses the real wage, $w_{f,t}(i)$, that maximizes its constrained expected discounted real profits weighted by the probability of not being able to make a wage adjustment in a given period according to[14]

$$\max_{w_{f,t}(i)} \pi_{EA,t} = E_t \sum_{s=0}^{\infty} \left(\theta_{f,w} \Lambda_{t+s} \right)^s \left\{ w_{f,t+s} L_{f,t+s} - \int_0^1 w_{f,t}(i)(1 + \pi_{t,t+s})^{-1} L_{f,t+s}(i) di \right\}, \tag{2.12}$$

subject to the labor supply

[13] The labor supply curve comes from a household i's FOC with respect to f-labor. In fact, since intermediate firms possess some monopsony power, they take into account the fact that they have to raise wages along the labor supply curve to attract more workers.

[14] The probability of not being able to adjust wages for s periods is $\theta_{f,w}^s$, with s=1, 2, ...

$$L_{f,t+s}(i) = \left(w_{jt}(i)\Upsilon_{t+s}(1+\pi_{t,t+s})^{-1}\eta_l^{-1}\right)^{1/\psi_l}, \tag{2.13}$$

and the aggregation function for type f labor

$$L_{f,t+s} = \left(\int_0^1 L_{f,t+s}(i)^{\frac{\gamma_f - 1}{\gamma_f}}\, di\right)^{\frac{\gamma_f}{\gamma_f - 1}}, \tag{2.14}$$

where $\Lambda_{t+s} = \beta^s \left(\frac{\Upsilon_{t+s}}{\Upsilon_t}\right)$ is the stochastic discount factor and Υ_t is the marginal utility of an extra unit of real total income received by the household.

The solution of this problem yields the optimal reset wage or monopsonistic wage for f-workers, which is implicitly defined by the equation:

$$a_{1,t} = a_{2,t}, \tag{2.15}$$

with auxiliary variables:

$$a_{1,t} = \eta_f^{\frac{1}{\gamma_f \psi_f}} w_{f,t} L_{f,t}^{\frac{1}{\gamma_f}} \Upsilon_t^{\frac{\gamma_f - 1 + \gamma_f \psi_f}{\gamma_f \psi_f}} + \theta_{f,w}\beta E_t(1+\pi_{t+1})^{\frac{-\gamma_f + 1}{\gamma_f \psi_f}} a_{1,t+1}, \tag{2.16}$$

$$a_{2,t} = (1+\psi_f) w_{f,t}^{\#^{\frac{1+\gamma_f \psi_f}{\gamma_f \psi_f}}} \Upsilon_t^{\frac{\psi_f + 1}{\psi_f}} + \theta_{f,w}\beta E_t(1+\pi_{t+1})^{\frac{-\psi_f - 1}{\psi_f}} a_{2,t+1}. \tag{2.17}$$

where $\Lambda_{t+s} = \beta^s \left(\frac{\Upsilon_{t+s}}{\Upsilon_t}\right)$ is the stochastic discount factor and Υ_t is the marginal utility of an extra unit of real total income received by the household. According to equations (2.15) to (2.17), the optimal reset wage mainly depends on the marginal utility of consumption, hours worked by f-workers as well as their wage index and the constant wage markdown. The latter is given by $(\frac{1}{1+\psi_f})$.

The wage index for f-workers

In a given period t, f-labor is composed of a proportion of workers, $(1-\theta_{f,w})$, that receive the monopsonistic wage set at t, a proportion of workers, $\theta_{f,w}(1-\theta_{f,w})$, that receive the monopsonistic wage set at $t-1$, a proportion of workers, $\theta_{f,w}^2(1-\theta_{f,w})$, that receive the monopsonistic wage set at $t-2$, an so on.

Therefore, we can write aggregate labor as:

$$L_{f,t} = (1-\theta_{f,w})L^{\#}_{f,t} + \theta_{f,w}(1-\theta_{f,w})L^{\#}_{f,t-1} + \theta^2_{f,w}(1-\theta_{f,w})L^{\#}_{f,t-2} + ... \tag{2.18}$$

Substituting $L^{\#}_{f,t} = \left((1+\psi_f)\frac{w^{\#}_t}{w_{f,t}}\right)^{-\gamma_f} L_{f,t}$, $L^{\#}_{f,t-1} = \left((1+\psi_f)\frac{w^{\#}_{f,t-1}}{w_{f,t}}(1+\pi_t)^{-1}\right)^{-\gamma_f} L_t$, ..., in $L_{f,t}$, yields the real wage index for f-workers

$$w^{-\gamma_f}_{f,t} = (1-\theta_{f,w})(1+\psi_f)^{-\gamma_f} b_{1,t}, \tag{2.19}$$

with the auxiliary variable:

$$b_{1,t} = w^{\#^{-\gamma_f}}_{f,t} + \theta_{f,w}(1+\pi_t)^{\gamma_f} b_{1,t-1}. \tag{2.20}$$

The EA's profits

The EA' profit calculaton accounts for the fact that at time t, there is a fraction $(1-\theta_{f,w})$ of reoptimized monopsonistic wages paid by the EA and set at t, and a fraction $\theta_{f,w}(1-\theta_{f,w})$ of reoptimized monopsonistic wages paid by the EA and set at $t-1$, a fraction $\theta^2_{f,w}(1-\theta_{f,w})$ of reoptimized monopsonistic wages paid by the EA and set at $t-2$, and so on. Moreover, nominal wages rigidities also imply that in each period, $L_{f,t}$ might be different than $L^{\#}_{f,t}$. Hence, taking these specifities into account, we have the real EA's profit:

$$\begin{aligned}\pi_{EA,t} = (1-\theta_{f,w})w_{f,t}L_{f,t}\left(1+\theta_{f,w}+\theta^2_{f,w}+...\right) - (1-\theta_{f,w})\left(w^{\#}_{f,t}L^{\#}_{f,t}(1+\pi_t)^{-1}\right) \\ -\theta_{f,w}(1-\theta_{f,w})\left(w^{\#}_{f,t-1}L^{\#}_{f,t-1}\right) - \theta^2_{f,w}(1-\theta_{f,w})\left(w^{\#}_{f,t-2}L^{\#}_{f,t-2}(1+\pi_t)^{-1}(1+\pi_{t-1})^{-1}\right) - ....\end{aligned} \tag{2.21}$$

Substituting $L^{\#}_{f,t} = \left((1+\psi_f)\frac{w^{\#}_t}{w_{f,t}}\right)^{-\gamma_f} L_{f,t}$, $L^{\#}_{f,t-1} = \left((1+\psi_f)\frac{w^{\#}_{f,t-1}}{w_{f,t}}(1+\pi_t)^{-1}\right)^{-\gamma_f} L_t$, ..., in $L_{f,t}$, we obtain an expression for the EA's profit:

$$\pi_{EA,t} = w_{f,t}L_{f,t} - (1-\theta_{f,w})(1+\psi_f)^{-\gamma_f} w^{\gamma_f}_t L_{f,t} b_{2,t}, \tag{2.22}$$

with the auxiliary variable

$$b_{2,t} = w^{\#^{1-\gamma_f}}_{f,t} + \theta_{f,w}(1+\pi_t)^{\gamma_f-1} b_{2,t-1}. \tag{2.23}$$

2.2.2.2 The competitive segment of the labor market

In the competitive labor market segment, labor intermediaries are absent, and c-workers directly supply labor to intermediate firms. Both intermediate firms and c-workers are considered wage takers. In equilibrium, the wage received by c-workers equals their marginal rate of substitution between consumption and leisure, which, in turn, equals the marginal productivity of c-labor, i.e. the firm's real marginal product of labor. Moreover, it is assumed that wages are flexible in this labor market segment.

The functioning of the competitive labor market segment can be summarized by the labor supply equation of c-workers,

$$\eta_c L_{c,t}(i)^{\psi_c} = \Upsilon_t w_{c,t}(i), \tag{2.24}$$

This equation represents the wage determination for c-workers, where η_c represents the weight on labor disutility, ψ_c is the inverse Frisch elasticity of labor supply for c-workers, $L_{c,t}(i)$ is the labor supplied by c-workers to intermediate firm i, Υ_t is the Lagrangian multiplier on the budget constraint, and $w_{c,t}(i)$ is the wage rate received by c-workers. In equilibrium, this wage rate equals the marginal revenue product of c-labor, a condition we will further explore in the intermediate firms' section.

2.2.2.3 The monopolistic segment of the labor market

In the monopolistic segment of the labor market, h-workers possess the market power that is delegated to a labor intermediary that, we assume, is operating under perfect competition. We can think of this employment agency as a representative labor union (LU) that aggregates households' labor supply, $L_{h,t}(i)$, and turns it into a combined labor input, $L_{h,t}$, which is subsequently employed by intermediate firms. This aggregation process is governed by the following production function:

$$L_{h,t} = \left(\int_0^1 L_{h,t}(i)^{\frac{\gamma_h - 1}{\gamma_h}} di \right)^{\frac{\gamma_h}{\gamma_h - 1}}, \tag{2.25}$$

where γ_h is the elasticity of substitution between labor supplied by h-workers.

The hiring decision of the labor union

The LU chooses the optimal level of h-labor desired by intermediate firms by solving a corresponding real profit maximization problem:

$$\max_{L_{h,t}(i)} \pi^{h}_{LU,t} = w_{h,t}L_{h,t} - \int_0^1 w_{h,t}(i)L_{h,t}(i)di, \tag{2.26}$$

subject to the labor aggregation function:

$$L_{h,t} = \left(\int_0^1 L_{h,t}(i)^{\frac{\gamma_h-1}{\gamma_h}} di\right)^{\frac{\gamma_h}{\gamma_h-1}}. \tag{2.27}$$

Solving this problem yields the demand for h-labor:

$$L_{h,t}(i) = \left(\frac{w_{h,t}(i)}{w_{h,t}}\right)^{-\gamma_h} L_{ht}. \tag{2.28}$$

The wage-setting decision of the labor union

Next, we can consider the wage-setting decision undertaken by the LU on behalf of households. In particular, the LU does not have complete freedom to adjust individual wages every period due to the presence of nominal wage rigidities modeled as Calvo wage contracts. In a given period, it can renegotiate only a constant fraction, (1-$\theta_{h,w}$), of individual wages while the remaining fraction, $\theta_{h,w}$, stays the same as in the previous period. The LU faces the same problem each time it renegotiates individual wages. Specifically, the LU chooses the current value of the real wage, $w_{h,t}(i)$, that maximizes household i's expected utility weighed by the probability $\theta_{h,w}$ of not being allowed to renegotiate that wage, subject to the downward-sloping labor demand function. Formally:

$$\max_{w_{h,t}(i)} E_t \sum_{t=0}^{\infty} \theta^s_{h,w}\beta^s \left(-\eta_h \frac{L_{h,t+s}(i)^{1+\psi_h}}{1+\psi_h} + \Upsilon_{t+s} w_{h,t}(i)(1+\pi_{t,t+s})^{-1} L_{h,t+s}(i)\right), \tag{2.29}$$

subject to the h-labor demand function:

$$L_{h,t+s}(i) = \left(\frac{w_{h,t}(i)(1+\pi_{t,t+s})^{-1}}{w_{h,t+s}}\right)^{-\gamma_h} L_{h,t+s}. \tag{2.30}$$

Solving this problem yields the optimal reset wage for h-workers:

$$w^{\#}_{h,t} = \frac{\gamma_h}{\gamma_h - 1}\frac{c_{1,t}}{c_{1,t}}, \tag{2.31}$$

with auxiliary variables

$$c_{1,t} = \eta_h \left(\frac{w_{ht}}{w^{\#}_{h,t}}\right)^{\gamma_h(1+\psi_h)} L^{1+\psi_h}_{h,t} + \theta_{h,w}\beta E_t(1+\pi_{t+1})^{\gamma_h(1+\psi_h)}\left(\frac{w^{\#}_{h,t+1}}{w^{\#}_{h,t}}\right)^{\gamma_h(1+\psi_h)} c_{1,t+1}, \tag{2.32}$$

$$c_{2,t} = \Upsilon_t \left(\frac{w_{h,t}}{w^{\#}_{h,t}}\right)^{\gamma_h} L_{h,t} + \theta_{w,h}\beta E_t(1+\pi_{t+1})^{\gamma_h - 1}\left(\frac{w^{\#}_{h,t+1}}{w^{\#}_{h,t}}\right)^{\gamma_t} c_{2,t+1}. \tag{2.33}$$

Equations (2.31) to (2.33) define the reset optimal wage which is a constant markup over the marginal rate of substitution between consumption and h-workers' leisure, $\frac{\gamma_h}{\gamma_h - 1}$.

The wage index for the h-workers

From the zero-profit condition of the LU under perfect competition, we obtain a relationship between the real total wage bill and the sum of the real wage bill per h-worker

$$w_{h,t}L_{h,t} = \int_0^1 w_{h,t}(i)L_{h,t}(i)di, \tag{2.34}$$

which using equation (2.28), defines the aggregate wage index

$$w^{1-\gamma_h}_{h,t} = \int_0^1 w_{h,t}(i)^{1-\gamma_h}di. \tag{2.35}$$

Exploiting the fact that in period t, the economy is divided into two types of h-wages, with a fraction $\theta_{h,w}$ of wages that cannot be adjusted and the remaining share, $(1-\theta_{h,w})$, that are allowed to be adjusted by the LU, the wage index for h-workers can be written as

$$w^{1-\gamma_h}_{h,t} = \theta_{h,w} w^{1-\gamma_h}_{h,t-1}(1+\pi_{t,t-1})^{\gamma_h - 1} + (1-\theta_{h,w}) w^{\# 1-\gamma_h}_{h,t}. \tag{2.36}$$

2.2.3 The final good producer

A representative final good producer aggregates the production of all i intermediate firms in order to produce a final consumption good, Y_t, according to the following technology:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{2.37}$$

where Y_t is the total output of the economy, and ϵ is the elasticity of substitution among intermediate goods, $Y_t(i)$.

The final good producer evolves in a perfectly competitive environment, taking as given the price of aggregate output, P_t, and the prices charged by intermediate goods producers, $P_t(i)$. It thus solves the following nominal profit maximization problem:

$$\max_{Y_t(i)} P_t Y_t - \int_0^1 P_t(i) Y_t(i) di. \tag{2.38}$$

The solution of this problem yields the conditional demand for each intermediate good i, which depends negatively on its relative price and positively on the total output of the economy:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t. \tag{2.39}$$

The zero-profit condition of the final good producer under perfect competition, implies a relationship between the total nominal output and the sum of the nominal value of intermediate goods

$$P_t Y_t = \int_0^1 P_t(i) Y_t(i) di, \tag{2.40}$$

which, using (2.39), defines the aggregate price index

$$P_t = \left(\int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}. \tag{2.41}$$

2.2.4 The intermediate goods producers

The economy is populated by a continuum of intermediate firms indexed by $i \in [0, 1]$, where i denotes a particular type of good. Intermediate firms possess some monopoly power in the goods market which allows them to set the price of their production. They take as given the rental rate of capital and the wage rate of c- and h-workers, while indirectly choosing the wage rate of f-workers as the EA acts on their behalf. The typical intermediate goods producer i combines physical capital services, $\hat{K}_t(i)$, and labor, $L_t(i)$, according to the following production function:

$$Y_t(i) = A_t \hat{K}_t(i)^{\alpha} L_t(i)^{1-\alpha} - \Gamma_t, \tag{2.42}$$

where

$$L_t(i) = L_{f,t}^{\alpha_l}(i) L_{c,t}^{\alpha_c}(i) L_{h,t}^{\alpha_h}(i), \tag{2.43}$$

with α_j, the labor shares of income of j-workers, $\forall j \in \{f, c, h\}$. A_t is the common level of technology that follows a first-order autoregressive process so that we have

$$lnA_t = \rho_A lnA_{t-1} + \epsilon_{A,t}, \tag{2.44}$$

with $\epsilon_{A,t}$ the productivity shock. With the production of good i required to be non-negative. Moreover, since intermediate firms operate in monopolistic competition in their intermediate good market, they typically generate positive economic profit. From a modelling's perspective, one way to ensure that each firm i makes zero profit in the long-run is to impose a cost variable, Γ_t, built in with the production function.[15]

The optimization problem

To solve the optimization problem of a typical intermediate good producer i, it can be thought as a two-stage optimization. First it minimizes its costs by choosing the quantity of each type of labor, $L_{f,t}(i)$, $L_{c,t}(i)$, and $L_{h,t}(i)$, and the quantity of physical capital services, $\hat{K}_t(i)$, needed to produce intermediate output:

[15] Some questions related to dividends and their distribution across households or some other questions related to entry and exit of firms in the long-run might be interesting in their own right, but these are beyond the scope of our study.

$$\min_{\hat{K}_t(i), L_{f,t}(i), L_{c,t}(i), L_{ht}(i)} w_{f,t}(i) L_{f,t}(i) + w_{c,t}(i) L_{c,t}(i) + w_{ht}(i) L_{ht}(i) + q_t(i) \hat{K}_t(i), \tag{2.45}$$

subject to the intermediate good production function

$$Y_t(i) = A_t \hat{K}_t(i)^{\alpha} \left(L_{f,t}^{\alpha_l}(i) L_{c,t}^{\alpha_c}(i) L_{ht}^{\alpha_h}(i) \right)^{1-\alpha} - \Gamma_t, \tag{2.46}$$

and the demand for intermediate goods

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t. \tag{2.47}$$

Solving this constrained minimization problem yields the following first-order conditions which are similar across intermediate firms:

the first order condition with respect to j-labor, with $\forall j \in \{f, c, h\}$, is given by

$$w_{j,t} = (1 - \alpha) \alpha_j A_t \left(\frac{\hat{K}_t(i)}{L_t(i)} \right)^{\alpha} \frac{L_t(i)}{L_{j,t}(i)} mc_t, \tag{2.48}$$

and the first-order condition with respect to the services of physical capital

$$q_t = \alpha A_t \left(\frac{\hat{K}_t(i)}{L_t(i)} \right)^{\alpha - 1} mc_t, \tag{2.49}$$

where mc_t is the real marginal cost of production.[16]

In the second step, taking into account the costs of inputs, an intermediate firm i chooses the price that it charges. However, the pricing decision cannot be undertaken each period by all intermediate firms because of nominal price rigidities. Consequently, all intermediate firms face a constant probability, $(1 - \theta_p)$, that they can adjust their prices. This also means that the probability for a firm to be stuck with a price for one period is θ_p, for two periods is θ_p^2, and so on.

[16] Marginal cost is equal to the Lagrange multiplier of the intermediate goods demand constraint.

An intermediate firm that can reset its price will discount its real profits s periods into the future by the stochastic discount factor $\Lambda_{t,t+s} = \beta^s \left(\frac{C_{t+s}}{C_t}\right)^{-\sigma}$.[17] Therefore, it maximizes its real expected profits according to:

$$\max_{P_t(i)} E_t \sum_{s=0}^{\infty} \theta_p^s \Lambda_{t,t+s} \left\{ \frac{P_t(i)}{P_{t+s}} Y_{t,t+s}(i) - \frac{MC_{t+s}}{P_{t+s}} Y_{t,t+s}(i) \right\}, \tag{2.50}$$

subject to the goods demand

$$Y_{t+s}(i) = \left(\frac{P_t(i)}{P_{t+s}}\right)^{-\epsilon} Y_{t+s}. \tag{2.51}$$

Solving this problem yields the optimal reset price,

$$P_t(i)^{\#} = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \theta_p^s \Lambda_{t,t+s} \left\{ mc_{t+s} P_{t+s}^{\epsilon} Y_{t+s} \right\}}{E_t \sum_{s=0}^{\infty} \theta_p^s \Lambda_{t,t+s} \left\{ P_{t+s}^{\epsilon-1} Y_{t+s} \right\}}. \tag{2.52}$$

Since all intermediate firms have the same markup and the same marginal cost, they will choose the same optimal price. Hence, $P_t(i)^{\#} = P_t^{\#}$. We can rewrite equation (2.52) as

$$P_t^{\#} = \frac{\epsilon}{\epsilon - 1} \frac{d_{1,t}}{d_{2,t}}, \tag{2.53}$$

with auxiliary variables:

$$d_{1,t} = P_t^{\epsilon} mc_t Y_t + \theta_p \beta E_t d_{1,t+1}, \tag{2.54}$$

$$d_{2,t} = P_t^{\epsilon-1} Y_t + \theta_p \beta E_t d_{2,t+1}. \tag{2.55}$$

Dividing both sides by P_t, we can rewrite equation (2.52) to represent the dynamics of inflation:

$$1 + \pi_t^{\#} = \frac{\epsilon}{\epsilon - 1} (1 + \pi_t) \frac{d_{1,t}}{d_{2,t}}, \tag{2.56}$$

with auxiliary variables:

[17] Given that households are the owners of intermediate firms, real profits are discounted by the stochastic factor stemming from the households' Euler equation associated with the trade-off between current and future consumption.

$$d_{1,t} = mc_t Y_t + \theta_p E_t (1+\pi_{t+1})^{\epsilon} \beta d_{1,t+1} \tag{2.57}$$

$$d_{2,t} = Y_t + \theta_p E_t (1+\pi_{t+1})^{\epsilon-1} \beta d_{2,t+1} \tag{2.58}$$

2.2.5 The monetary authority

We assume that the central bank's monetary policy follows a Taylor-type feedback rule up to a stochastic component:

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R}\right)^{\rho_R} \left[\left(\frac{1+\pi_t}{1+\pi}\right)^{\alpha_\pi} \left(\frac{Y_t}{Y_{t-1}} g^{-1}\right)^{\alpha_Y}\right]^{1-\rho_R} \mu_{M,t}, \tag{2.59}$$

with $\mu_{M,t}$ that follows the process

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t}. \tag{2.60}$$

The nominal interest rate responds to deviations of net inflation, π_t, from its target, π=0, as well as deviations of output growth from its trend growth, g^{-1}. $\epsilon_{M,t}$ is a monetary policy shock. α_π is the control parameter for inflation gap and α_Y is the control parameter with respect to the output growth gap. Finally, ρ_R accommodates the smoothing effect of the nominal interest rate.

2.2.6 Aggregation and equilibrium conditions

This section is devoted to the aggregate economy and the other equilibrium conditions pertaining to the model.

2.2.6.1 Aggregate production

Using equations (2.39) and (2.42), as well as the capital-labor ratio and integrating over all the i intermediate firms yields

$$Y_t = \frac{A_t \hat{K}_t^{\alpha} L_t^{1-\alpha} - \Gamma_t}{v_t^p} = \frac{A_t \hat{K}_t^{\alpha} \left(L_{f,t}^{\alpha_f} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h}\right)^{1-\alpha} - \Gamma_t}{v_t^p}, \tag{2.61}$$

where v_t^p captures the price dispersion across intermediate firms and is defined as

$$v_t^p = \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} di. \tag{2.62}$$

2.2.6.2 The aggregate price index

From equation (2.41) and exploiting the fact that in period t the economy is divided into two types of firms, where a fraction θ_p of firms cannot adjust their prices and the remaining share, $(1-\theta_p)$, is allowed to set the optimal price, the aggregate price index can be written as:

$$P_t^{1-\epsilon} = (1-\theta_p)P_t^{\#1-\epsilon} + \theta_p P_{t-1}^{1-\epsilon}. \tag{2.63}$$

2.2.6.3 The aggregate wage index

Since the labor market is composed of three segments, the aggregate wage index is a weighted sum of the wage rates received by each type of workers. Accordingly, we have

$$w_t = w_{f,t}^{\alpha_l} w_{c,t}^{\alpha_c} w_{h,t}^{\alpha_h}. \tag{2.64}$$

2.2.6.4 The aggregate resource constraint

From equation (2.3), and by aggregating over all firms and households, the aggregate resource constraint is expressed as

$$Y_t = C_t + X_t + \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{K_t}{Z_t}, \tag{2.65}$$

meaning that, each period, the economy's aggregate output is shared between the consumption of final good, private investment in capital good and the resources devoted to adjust the utilization rate of capital.

2.2.6.5 Other equilibrium conditions

In addition, the general equilibrium in this economy requires simultaneous equilibria in the labor market, the bonds market, the final good market, the intermediate goods market, the physical capital market, the market of investment in physical capital, while being consistent with the Euler equations associated with each agent's optimization problems.

2.3 The calibration

The calibration of the parameters is based on U.S. quarterly empirical studies and the DSGE macroeconomic literature. Table 2.1 reports the choice of the parameter values. While some parameter values are standard in the calibration commonly employed in the literature of NK-DSGE models, the richer labor market structure that we assume requires some adjustments regarding non standard parameters.[18]

2.3.1 Standard parameter values from the literature

The calibration of standard parameters is set as follows. We fix the inverse Frisch-elasticity of labor supply for all the three types of workers to 1, which is a usual value in NK DSGE models.[19] We set the elasticity of substitution between goods, ϵ, at 6. This value is fairly standard in the literature and implies a 20% steady state price markup over the marginal cost. We fix the elasticity of substitution between each type of h-labor, γ_h, at 6, as typically assumed in NK models. That calibration implies a 20% steady state wage markup over the MRS of h-workers. Therefore, γ_h is determining the extent of unions' wage-setting power. We also choose a value of 6 for γ_f, the elasticity of substitution between each type of f-labor. Nevertheless, it does not play as much a critical role as γ_h since non-unionized workers do not have wage-setting power.

The values assigned to the subjective discount rate, β=0.99, to the capital's share of income, α=0.33, and to the depreciation rate of physical capital, δ=0.025, are also fairly standard in the DSGE macroeconomic literature. The parameter of habits formation in consumption, b, is set to 0.8, which is consistent with estimates by Christiano *et al.* (2005), Justiniano *et al.* (2010) and Justiniano *et al.* (2011). The Calvo parameter for price rigidity, θ_p, at a 0.66 value corresponds to a median waiting time between price changes of 5.1 months.[20] This value is consistent with the empirical estimate in Bils and Klenow (2004).

Furthermore, we set $\chi_1 = 1/\beta - 1 - \delta$, which is one of the parameters that governs the cost of the variable utilization of physical capital, so that the steady state utilization is one. We fix the second parameter that governs the cost of variable utilization of physical capital, χ_2, to 0.05. These two values in the calibration are consistent with Ascari *et al.* (2018). With respect to the Taylor rule parameters, we use the estimates

[18] The calibration we adopt implies that the great ratios in both models are similar. Moreover, we also check the sensitivity of the results to some variations in parameter values. As far as shocks' parameters are concerned, it can be argued their values should related to the specific structure of the model. This will be considered for future research.

[19] See for example Christiano *et al.* (2005) and Ascari *et al.* (2018).

[20] Cogley and Sbordone (2008) show that the relationship between the value of the θ_p and the median waiting time between a price change can be approximated by $-\frac{\ln(2)}{\ln(\theta_p)}$.

Tableau 2.1: Calibration values

Parameter	Value	Description
		Non-shock parameters
β	0.99	Subjective discount rate
ψ_f	1	Inverse Frisch-elasticity of labor supply, f-workers
ψ_c	1	Inverse Frisch-elasticity of labor supply, c-workers
ψ_h	1	Inverse Frisch-elasticity of labor supply, h-workers
δ	0.025	Physical capital depreciation rate
γ_f	6	Elasticity of substitution between labor f-labor
γ_c	6	Elasticity of substitution between c-labor
γ_h	6	Elasticity of substitution between labor h-labor
ϵ	2.9	Elasticity of substitution between goods
α	0.33	Capital's share of income
α_f	0.20	Share of f-workers in the labor input
α_c	0.45	Share of c-workers in the labor input
α_h	0.35	Share of h-workers in the labor input
$\theta_{f,w}$	0.75	Calvo parameter for f-wages
$\theta_{h,w}$	0.75	Calvo parameter for h-wages
θ_p	0.66	Calvo price
ρ_R	0.8	Smoothing effect of the nominal interest rate
α_π	1.3	Inflation control parameter
α_Y	0.3	Output control parameter
b	0.8	Consumption habits formation
τ	2	Investment adjustment costs parameter
χ_1	0.0351	Parameter that governs the cost of the variable utilization of physical capital
χ_2	0.05	Parameter that governs the cost of the variable utilization of physical capital
		Shock parameters
ρ_A	0.95	Neutral technology shock persistence
ρ_M	0.2	Monetary shock persistence
ρ_Z	0.9	Investment shock persistence
σ_A	0.008	Neutral technology shock standard deviation
σ_M	0.0013	Monetary shock standard deviation
σ_Z	0.01	MEI shock standard deviation

from Justiniano *et al.* (2010) and Justiniano *et al.* (2011), i.e., a value of 0.8 for the interest rate smoothing parameter, ρ_R, a value of 1.3 for the inflation gap coefficient, α_π, and a value of 0.3 for the output growth gap parameter, α_Y.

2.3.2 Adjusted calibration conformable to the model

The calibration of the labor share of income for each segment of the labor market (i.e. α_f, α_c and α_h) is quite challenging for many reasons. First, there is no empirical study that directly measures these shares. To the best of our knowledges, there is no macroeconomic model that takes simultaneously into account the coexistence of three types of competition in the labor market. Second, from an empirical perspective, there is no obvious partition between these three segments. Depending on the criterion that is employed, some of the workers assigned to one segment might in fact belong to another one. For instance, even though the unionization rate might be a good proxy for calibrating α_h, certain workers that are not covered by unions may possess significant market power akin to monopolistic competition. For example, that might be the case of some CEOs or highly specialized or skilled workers. In the same vein, the share of workers with noncompete clauses may be an imperfect proxy for calibrating α_f since some workers are compensated for signing noncompete clauses. Consequently, these workers do not really evolve in the monopsonistic segment of the labor market.

Despite these limitations, some empirical evidence can guide our calibration. Starr *et al.* (2021) find that 20% of the U.S. labor force had signed labor contracts with noncompete clauses. In the same vein, Colvin and Shierholz (2019) find that between 27.8% and 46.5% of U.S. private sector workers are subject to non-compete in 2014. While these estimates do not distinguish between workers that are compensated and workers that are not, they provide an insight for our calibration. Accordingly, we set α_f=0.20. For the remaining workers, based on the quite low U.S. unionization rate, we can argue that more of them are in the competitive segment of the labor market than in the monopolistic one. Moreover, amongst workers that face noncompete clauses, some of them are high-skilled workers that are compensated, hence they are presumed to belong to the monopolistic segment. Accordingly, we set α_c=0.45 and α_h=0.35.

We fix the Calvo parameter for wage rigidity for f- and h-workers, $\theta_{f,w}$ and $\theta_{h,w}$, respectively, to 0.75. This choice is broadly consistent with the range of values (between 0.760 and 0.83) that Justiniano *et al.* (2010) and Justiniano *et al.* (2011) find using their Bayesian estimation. Since c-workers evolve in a competitive labor market, we choose not to make them subject to nominal wage rigidities.

2.3.3 The calibration of the stochastic processes associated with the shocks

We now turn to the calibrations of shocks parameters. Following the estimates of Gomme and Lkhagvasuren (2013) for the persistence of the neutral technology shock and its standard deviation, we choose ρ_A=0.95 and σ_A=0.008. We set the persistence of the monetary policy shock, ρ_M, and the MEI shock, ρ_Z, respectively to 0.2 and 0.8 as suggested by Justiniano *et al.* (2010)'s estimates. The monetary policy shock standard deviation, σ_M, is equal to 0.0013, also in accordance with Justiniano *et al.* (2010). As far as the MEI shock is concerned, we fix its standard deviation, σ_Z, to 0.01. This value is broadly consistent with the result in Ascari *et al.* (2018) who calculate the variance of the MEI shock by using estimates of the contribution of each types of shocks (neutral technology, MEI, and monetary shocks) to aggregate output fluctuations.

While this calibration serves as a benchmark, some sensitivity analysis are carried out in subsequent sections, especially regarding the values of parameters introduced because of the special labor market structure.

2.4 The business cycle implications

This section discusses the business cycles implications of the baseline model that simultaneously embeds a monopsonistic segment, a monopolistic segment and a competitive segment. We begin by presenting the cyclical paths of key variables in the model following different aggregate shocks. Subsequently, we investigate how changes in the extent and nature of the labor market power affect the business cycle. Finally, we compare our model to the standard NK model along two dimensions: the cyclical paths of key macroeconomic variables and the ability to match some key empirical business cycle moments.

2.4.1 A comparison with the standard New Keynesian model

In this section, we undertake a comprehensive comparison between our model, referred to as the "Extended NK model," and the standard New Keynesian (NK) model, henceforth called the "Standard NK model". We assess both models along two dimensions: the impulse response functions they generate following exogenous shocks and their ability to replicate key statistical moments observed in empirical data.

The models feature three types of shocks: a neutral technology shock (as described by equation 2.44 with ρ_A=0.95 and σ_A=0.008), a MEI shock (as described by equation 1.5 with ρ_Z=0.8 and σ_Z=0.01), and a monetary policy shock (as described by equation 1.65 with ρ_M=0.2 and σ_M=0.0013). We set the parameters in the models according to Table 2.1. To provide a comprehensive discussion, the impulse responses are discussed at various horizons, including at the impact, at the peak, in the short-run (four quarters or less), in the medium-run (from five to fifteen quarters), and eventually in the longer-run (beyond fifteen quarters).

2.4.1.1 Impulse responses

We start by analyzing the differences in the impulse response functions generated by both models, with a particular focus on the cyclical paths of labor market variables, namely labor and aggregate wage.

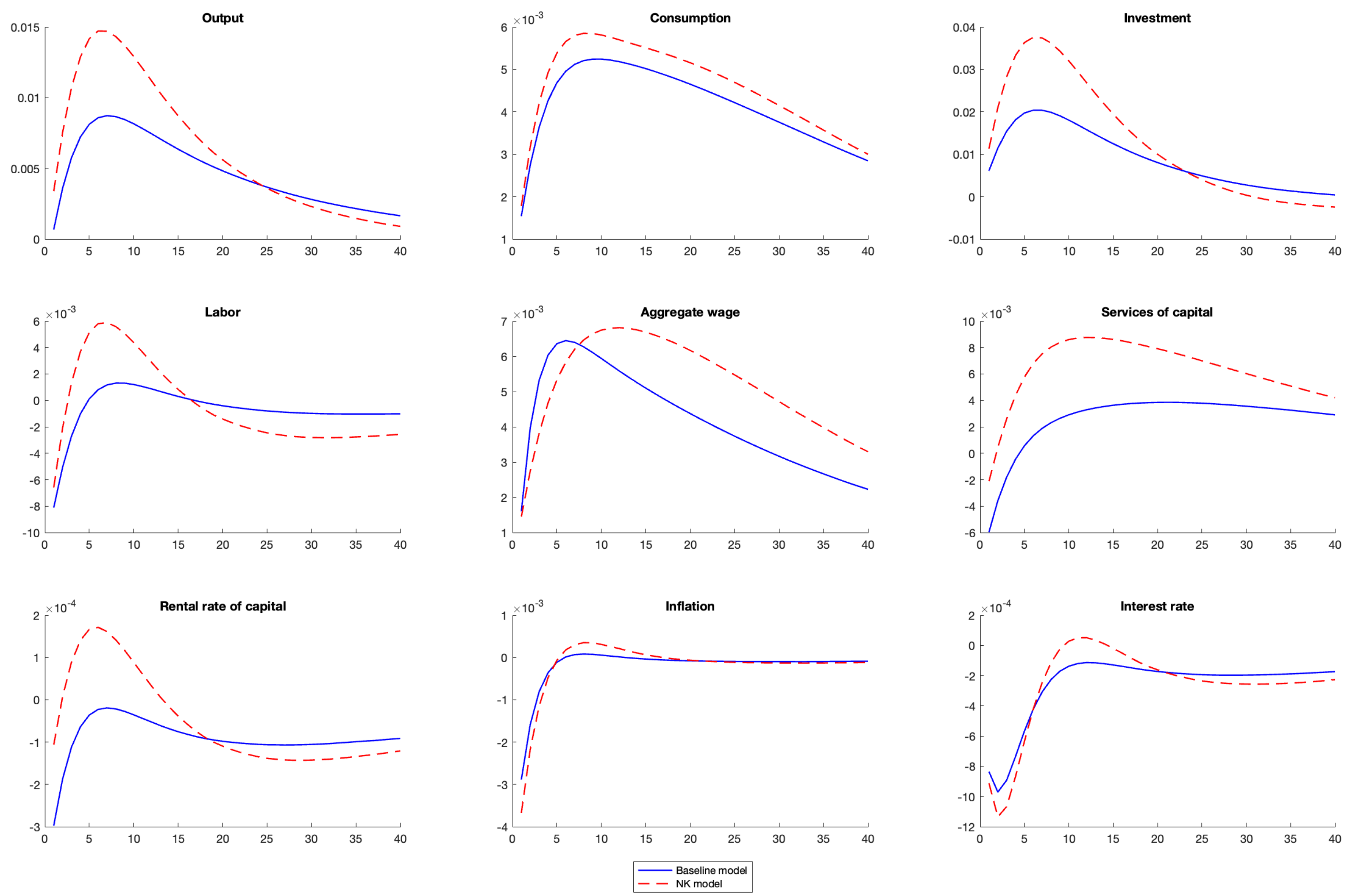
A positive neutral technology shock

Figure 2.1 compares the impulse responses from our model ("Extended NK model") to those from the standard NK model ("Standard NK model"), following a neutral technology shock. Overall, the impulse responses are qualitatively similar in both models, supporting the fact that the transmission mechanisms of a positive technology shock in our model are in line with the literature. However, we note that the shock produces a weaker economic expansion in our model compared to the standard NK model. The differences between the models are highlighted especially at the peak responses of variables. For example, the peak response of output is only half as substantial in our model compared to the NK model.

Notably, aggregate wage reaches a lower peak but does so more rapidly in our model relative to the standard NK model. In our model, two forces contribute to these differences. The quicker rise in aggregate wage is primarily attributed to the wage rate of c-workers. These workers operate in a competitive segment and are not subject to nominal wage rigidities, resulting in a faster translation of the MPL increase into aggregate wage. However, the presence of the monopsonistic segment helps dampening the rise in aggregate wage because firms apply a markdown on the wage rate of f-workers. In contrast, in the standard NK model, there is only one force driving aggregate wage fluctuations. In particular, monopolistic households apply markup on their marginal rate of substitution between consumption and leisure (MRS), while being subject to nominal wage rigidities.

Another key difference between our model and the standard NK model is the presence of EA' positive profits, which rise following the technology shock. This creates a stronger wealth effect which has more depressing effects on labor supply in our model, thus mitigating the positive responses of output and consumption. Contrastingly, in the standard NK model, where there is only one source of profits, the wealth effect is relatively weaker, leading to a stronger response of labor.

Figure 2.1: Impulse responses functions of the cyclical components of macroeconomic variables following a positive neutral technology shock (one period is a quarter)



Note: The solid blue lines show responses in the baseline calibrated model. The red dashed lines shows responses in the baseline calibrated standard New Keynesian model.

2.4.1.2 A positive MEI shock

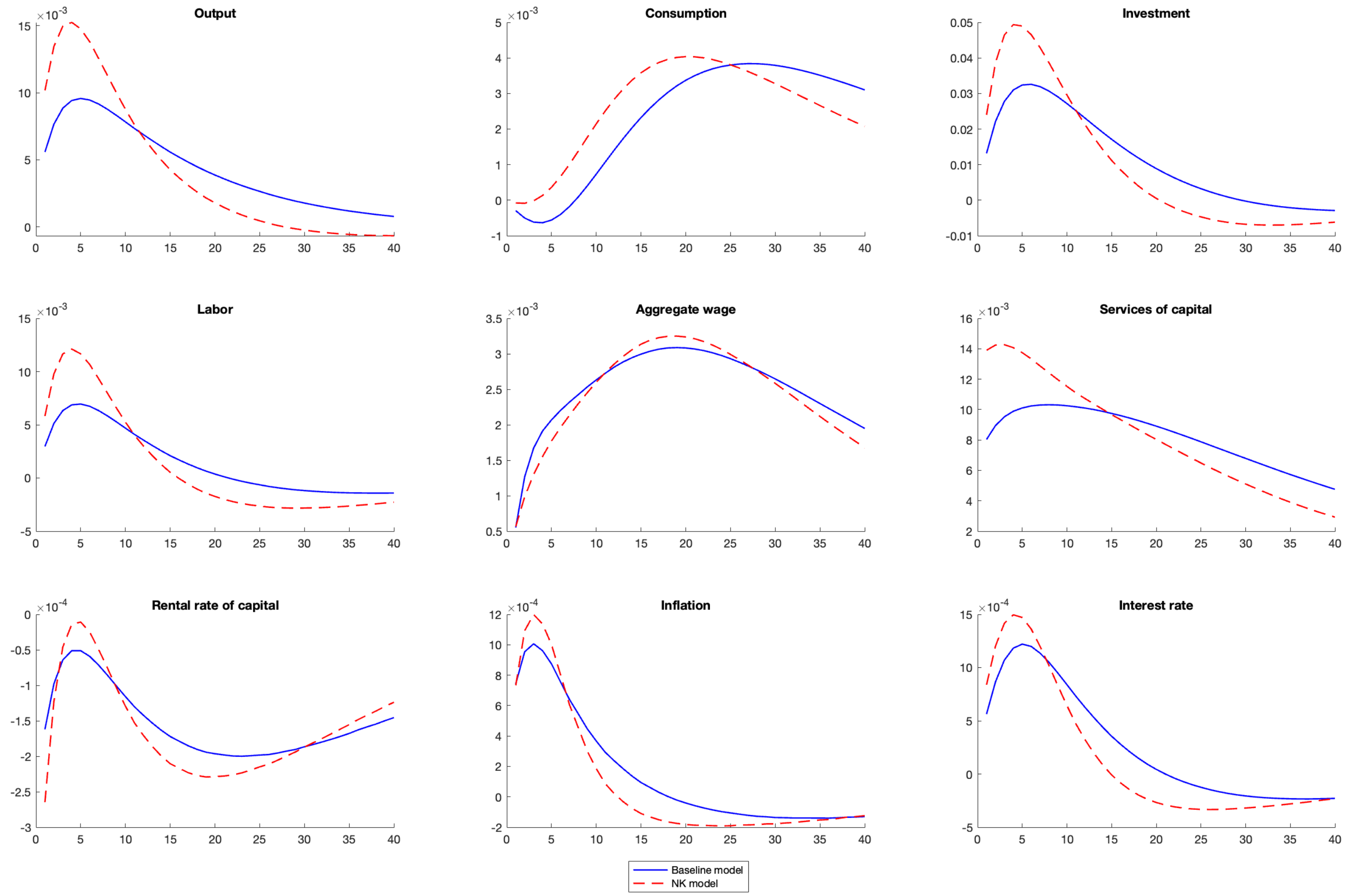
As shown in Figure 2.2, the transmission mechanisms of a positive MEI shock in the model are broadly consistent with that of the literature given the qualitative similarities between the model and the standard NK model. In particular, the MEI shock induces a more substancial cyclical upturn in the standard NK model. For example, the labor' response at the peak is almost twice as small, while the short-run response of aggregate wage is slightly stronger in our model compared to the standard NK model.

In our model, the rise in labor demand affects workers in different ways due to the presence of different worker types, which has implications for their wage rates. Specifically, the wage rate of c-workers rises the most since their labor market segment is competitive and without nominal wage rigidities. However, the wage of monopolistic households (h-workers) is subject to dampened increases because of the fall in consumption which negatively impacts the MRS. For f-workers, despite facing firms' wage markdowns, the increase in labor demand means that firms need to raise their wage rate to attract them.

In the standard NK model, instead, the fall in consumption has a slightly more pronounced impact on aggregate wage, as it depends solely on the MRS and there are no additional sources of mitigation for its fluctuations. Consequently, the aggregate wage response in the standard NK model is smaller compared to our model.

The fall in the MRS and the rise in f-workers wage rate, respectively gives h- and f-workers more incentives to supply more hours worked. However, the substitution effect induced by a bigger rise in the wage rate of c-workers leads them to supply less hours worked than the other two types of workers. This additional effect, that is not present in the standard NK model, makes aggregate labor increase more in that model compared to our model. This more modest response of labor translates into more modest booms in output and inflation in the short-run in our model.

Figure 2.2: Impulse responses functions of the cyclical components of macroeconomic variables following a positive MEI shock (one period is a quarter)



Note: The solid blue lines show responses in the baseline calibrated model. The red dashed lines shows responses in the baseline calibrated standard New Keynesian model.

It is worth noting that, at it is often reported in the literature, the impulse response functions following the MEI shock in the baseline models and alternative specifications suffer from Barro and King (1984)'s curse i.e. a non-positive comovement between output and consumption. Ascari *et al.* (2016) demonstrate that features such as roundabout production and long-run real per capita output growth generate consistent comovements between consumption and output following a MEI shock.

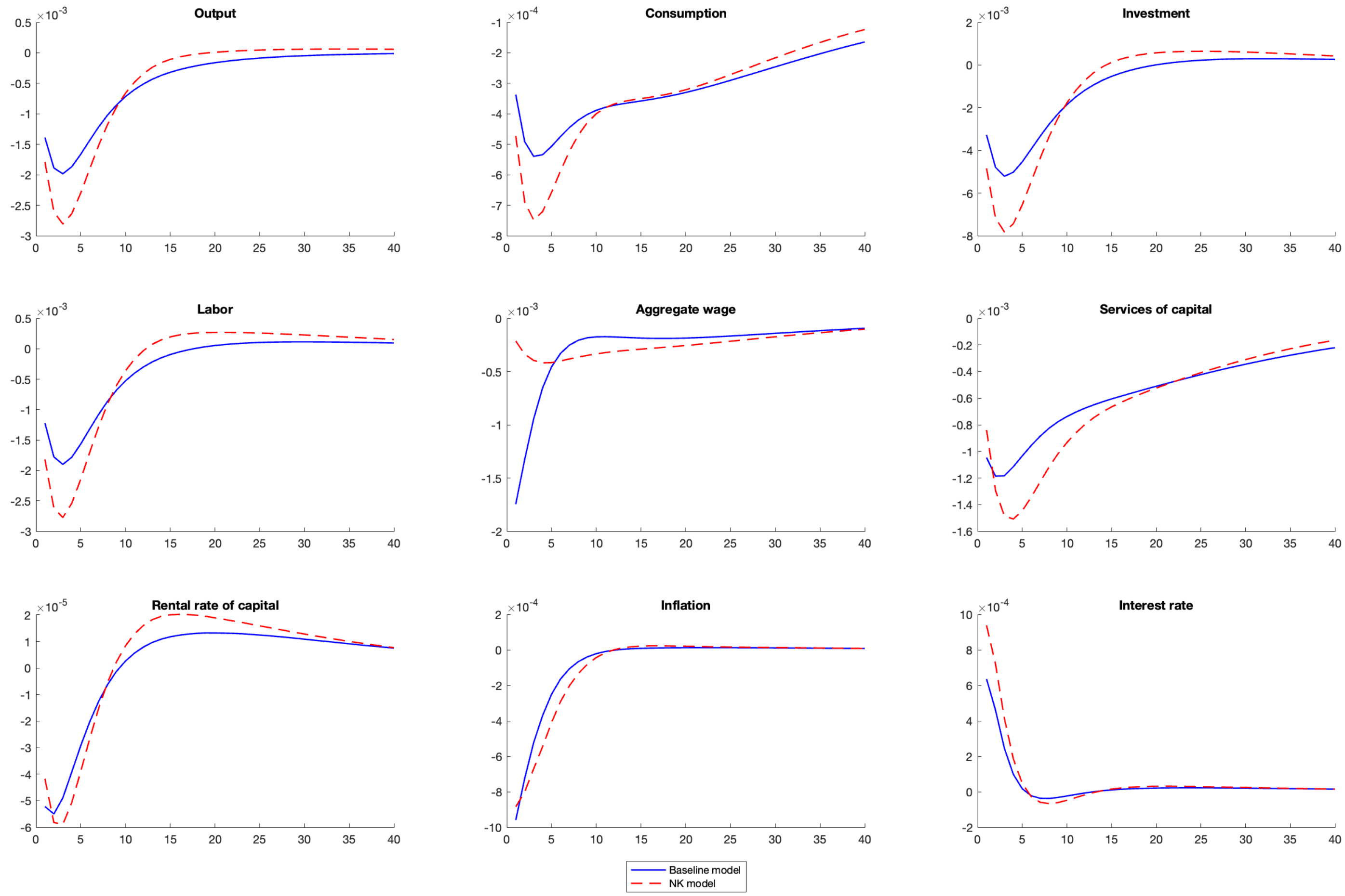
2.4.1.3 A restrictive monetary policy shock

Finally, Figure 2.3 compares the models' impulse responses following a restrictive monetary policy shock. In general, the shock induces a less severe cyclical downturn in our model, especially in the short-run. However, the response of aggregate wage at the impact of the shock is seven times smaller in our model compared to the Standard NK model.

The existence of EA' profits in our model amplifies the contractionary effects of the monetary policy shock, creating a stronger wealth effect on labor. Hence, the decline in labor is dampened compared to the standard NK model. Consequently, the decline in labor is less pronounced compared to the Standard NK model, leading to more moderate declines in output, consumption, investment, and the services of capital in the short run.

The intuition behind the difference in the response of aggregate wage is also straightforward to explain. In the standard NK model, the wage markup depends solely on the MRS, implying that the responses of consumption and labor are its main drivers. However, in our model, only the wage rate of h-workers, a fraction of aggregate wage, depends directly on the MRS. Furthermore, aggregate wage depends on the wage rate of c-workers, which falls more sharply, and of f-workers which does not change following the shock. Because of these additional forces that exert a downward pressure, aggregate wage in our model experiences a deeper decline in comparison to the standard NK model.

Figure 2.3: Impulse responses functions of the cyclical components of macroeconomic variables following a contractionary monetary policy shock (one period is a quarter)



Note: The solid blue lines show responses in the baseline calibrated model. The red dashed lines shows responses in the baseline calibrated standard New Keynesian model.

2.4.1.4 Matching the data

Next, we assess the empirical relevance of our model and the standard NK model in terms of their capacity to reproduce some key moments of the HP cyclical components of simulated and empirical data covering the period from 1948Q1 to 2019Q4. These moments are based on 4000 replications from which we burn the first 500. We start by looking at the volatility and comovements induced by all four shocks in both models.

Table 2.2 reports volatilities (panel A) and the volatilities relative to output standard deviation (panel B) of key macroeconomic variables. Panel A shows that both models correctly predict that consumption, investment, aggregate wage and inflation are more volatile than output, whereas labor and labor productivity are less volatile than output. Our model performs better than the standard NK model in matching the volatility of all selected variables, except consumption for which the models predict a value of 0.006 while it is 0.008 in the data.

Panel B reveals that our model provides a better match for the empirical relative volatility of consumption (0.38 in the data, 0.36 in our model and 0.23 in the standard model), aggregate wage (0.44 in the data, 0.50 in our model and 0.22 in the standard model) and labor (0.89 in the data, 0.88 in our model and 0.80 in the standard model). However, one noteworthy difference is observed in the prediction of the relative volatility of the MPL. Our model overestimates that value at 0.75 while it is 0.49 in the data and 0.48 in the standard NK model.[21]

[21] It can be argued that the introduction of c- and f-workers add additional sources of labor fluctuations, especially in labor supply, inducing more movement in aggregate labor, and thus in the MPL.

Tableau 2.2: Volatility

Panel A: Absolute volatility

	$\sigma(Y)$	$\sigma(C)$	$\sigma(I)$	$\sigma(W)$	$\sigma(L)$	$\sigma(MPL)$	$\sigma(\pi)$
Data	0.02	0.008	0.06	0.009	0.01	0.01	0.004
Extended NK model	0.02	0.006	0.05	0.008	0.01	0.01	0.004
Standard NK model	0.03	0.006	0.09	0.006	0.02	0.02	0.005

Panel B: Relative volatility

	$\frac{\sigma_Y}{\sigma_Y}$	$\frac{\sigma_C}{\sigma_Y}$	$\frac{\sigma_I}{\sigma_Y}$	$\frac{\sigma_W}{\sigma_Y}$	$\frac{\sigma_L}{\sigma_Y}$	$\frac{\sigma_{MPL}}{\sigma_Y}$	$\frac{\sigma_\pi}{\sigma_Y}$
Data	1	0.38	3.03	0.44	0.89	0.49	0.20
Extended NK model	1	0.36	3.15	0.50	0.88	0.75	0.23
Standard NK model	1	0.23	3.23	0.22	0.80	0.48	0.17

Notes: This table displays the volatility and the relative volatility of the cyclical component of HP filtered empirical and simulated data series. "σ" refers to standard deviation. Empirical data series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

Table 2.3 provides the contemporaneous cross-correlations in the data and in both models. Both models tend to significantly underestimate the correlations between output and consumption, between consumption and investment and between consumption and inflation. Both models also tend to significantly overestimate the correlations between output and aggregate wage, between consumption and aggregate wage, between labor and aggregate wage, between labor and inflation, between aggregate wage and the MPL and between aggregate wage and inflation.

Tableau 2.3: Contemporaneous cross correlation

	$\rho(Y,C)$	$\rho(Y,I)$	$\rho(Y,W)$	$\rho(Y,L)$	$\rho(Y,MPL)$
Data	0.79	0.89	0.15	0.86	0.44
Extended NK model	0.30	0.96	0.75	0.68	0.53
Standard NK model	0.40	0.98	0.66	0.89	0.63
	$\rho(Y,\pi)$	$\rho(C,I)$	$\rho(C,W)$	$\rho(C,L)$	$\rho(C,\pi)$
Data	0.32	0.60	0.22	0.73	0.25
Extended NK model	0.46	0.14	0.79	-0.16	-0.09
Standard NK model	0.38	0.31	0.89	0.14	-0.03
	$\rho(L,W)$	$\rho(L,MPL)$	$\rho(L,\pi)$	$\rho(W,MPL)$	$\rho(W,\pi)$
Data	-0.05	-0.05	0.32	0.41	-0.01
Extended NK model	0.21	-0.26	0.90	0.74	0.15
Standard NK model	0.47	0.21	0.71	0.63	0.21

Notes: This table displays the contemporaneous cross correlation between the cyclical component of HP filtered empirical and simulated data series. "ρ" refers to the contemporaneous cross correlation. Empirical data series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

The standard NK model better matches the correlation between output and labor (0.89), which is 0.86 in the data but only 0.68 in our model. Our model is closer to the data when predicting the correlation between output and the MPL (0.44 in the data and 0.53 in our model), which is 0.63 in the standard model. However, there are discrepancies, such as the correlation between consumption and labor, which is strongly procyclical at 0.73 in the data. Both models incorrectly predict that correlation, with a value of -0.16 in our model and 0.14 in the standard NK model. Similarly, the correlation between labor and the MPL is weakly countercyclical (-0.005). Our model predicts it to be mildly countercyclical (with a -0.26 correlation), whereas it is mildly procyclical in the data (with a 0.26 correlation).

Finally, Table 2.4 illustrates the autocorrelation functions up to four quarters. Both models predict autocorrelation functions for output, investment and inflation that are quite similar but more persistent than their empirical counterparts. Both models underestimate the autocorrelations of consumption at the one to three quarters. Our model does a better job in replicating the autocorrelations function of real wage, while the standard model tend to overestimate it. The autocorrelation of consumption at the one quarter lag is 0.90 in the data. The standard model matches that value quite well at 0.89, while our model somewhat underestimates it at 0.75. The autocorrelations of labor productivity at the one and two quarters lags are underestimated in our model (0.32 and 0.15, respectively) and in the standard model (0.43 and 0.29, respectively), whereas it is 0.70 and 0.46, respectively, in the data.

Tableau 2.4: Autocorrelation function (one to four lags).

	Lag	-1	-2	-3	-4
Output	Empirical	0.84	0.60	0.33	0.09
	Extended NK model	0.90	0.72	0.40	0.28
	Standard NK model	0.90	0.74	0.66	0.34
Consumption	Empirical	0.84	0.66	0.45	0.22
	Extended NK model	0.26	0.20	0.15	0.10
	Standard NK model	0.40	0.38	0.34	0.31
Investment	Empirical	0.82	0.46	0.26	-0.004
	Extended NK model	0.90	0.75	0.55	0.34
	Standard NK model	0.93	0.79	0.60	0.40
Real wage	Empirical	0.68	0.47	0.29	0.12
	Extended NK model	0.65	0.50	0.33	0.17
	Standard NK model	0.70	0.68	0.63	0.55
Labor	Empirical	0.90	0.70	0.45	0.20
	Extended NK model	0.75	0.68	0.54	0.37
	Standard NK model	0.89	0.77	0.58	0.37
Labor prod.	Empirical	0.70	0.46	0.19	0.009
	Extended NK model	0.32	0.15	0.03	-0.07
	Standard NK model	0.43	0.29	0.19	0.1
Inflation	Empirical	0.49	0.27	0.11	-0.07
	Extended NK model	0.48	0.41	0.30	0.18
	Standard NK model	0.46	0.43	0.35	0.25

Notes: This table displays the autocorrelation coefficients of the cyclical component of HP filtered empirical and simulated data series. Empirical data series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

2.4.2 A sensitivity analysis of the model's responses

This section aims at assessing how deviations in the benchmark calibration of some parameters affect the cyclical responses of key variables in the model. We primarily focus on the transmission of monetary policy shocks when assessing the effects induced by these alternative specifications. This is because the transmission of other aggregate shocks seems to remain relatively unaffected by these alternative parameter values.[22]

2.4.2.1 Monetary policy shocks and changes in the labor market power

We start by assessing whether a restrictive monetary policy shock has the same effects in an economy in which firms have greater monopsony power in the labor market (indicated by higher values for ψ_f and γ_h) compared to an economy in which households have greater monopoly power in the labor market (indicated by smaller values of ψ_f and γ_h).[23]

Figure 2.4 compares the cyclical responses of macroeconomic variables following a restrictive monetary policy shock. The solid blue lines present the responses in the baseline model. The red dashed lines display the responses when there is an increase in firms' labor market power (”more FLMP”). The dashed black lines with ”+” markers show the responses when there is a rise in households' labor market power (”more HLMP”).

Overall, changes in the degree of firms' or households' labor market power do not change the sign but have mixed effects on the size of the model' responses. While some variables such as aggregate wage, the rental rate of capital, inflation and interest rates are barely affected, others like output, consumption, investment, labor and capital are more significantly impacted. Notably, the responses of variables in the ”more HLMP” model specification exceed those in the baseline model whereas the responses of variables in the ”more FLMP” specification are smaller than those in the baseline specification.

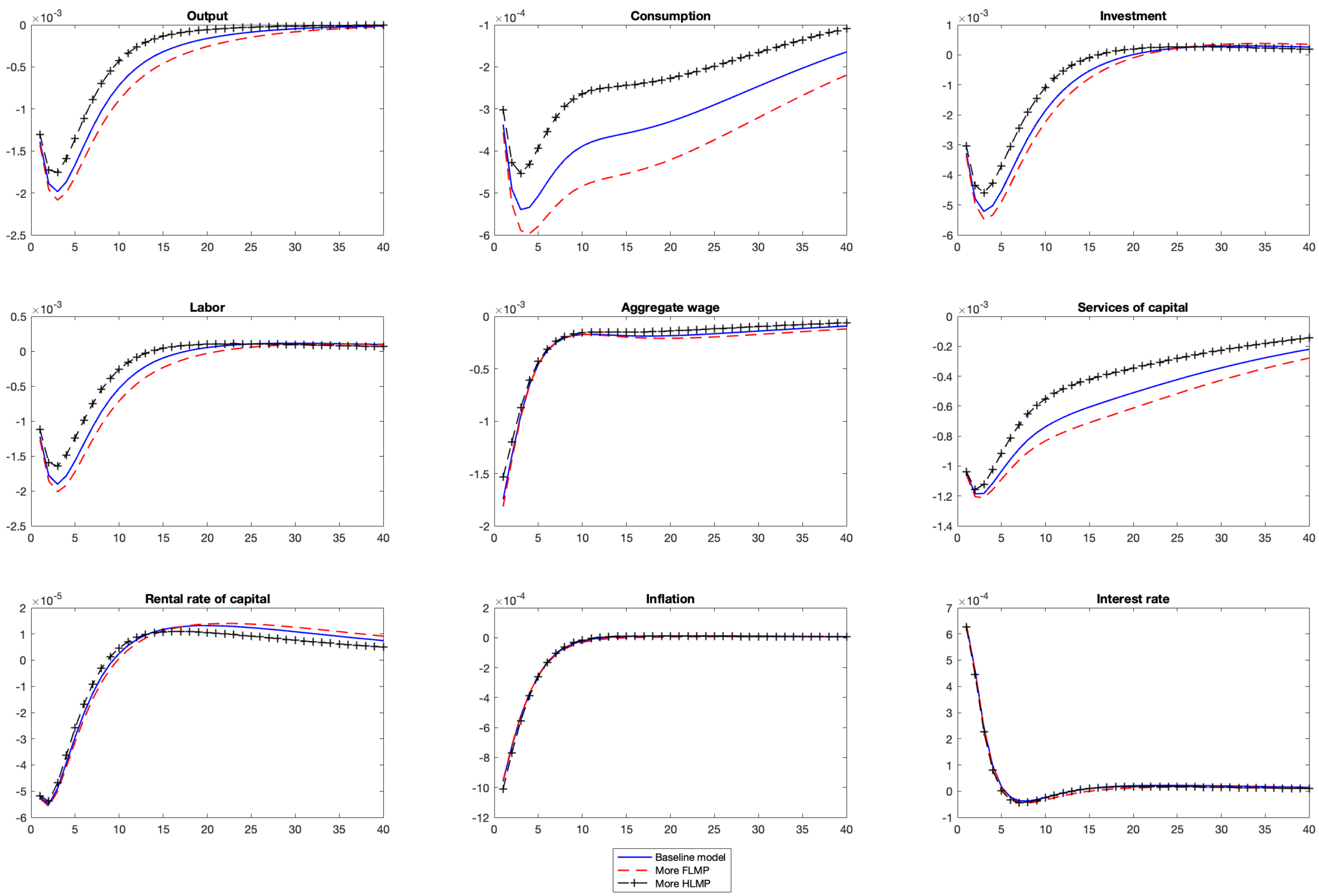
Recall that aggregate wage in this economy is a weighted sum of the wage rate specific to each segment, the wage rate of c-workers, having the biggest weight (α_c). In other words, fluctuations in c-workers wage rate dictate most of the fluctuations in aggregate wage. Given that c-workers are not directly affected by changes in the labor market power, their wage rate is barely impacted. Consequently, aggregate wage merely changes following shifts in the labor market power, as displayed in Figure 2.4.Furthermore, a restrictive monetary policy shock induces a negative wealth effect and reduces firms' profits. Therefore, when households possess more labor market power, the EA's profits are more negatively impacted by the shock.

[22] The impulse response functions following the neutral technology and the MEI shocks are available upon request.

[23] In particular, we set ψ_f=1.7 and γ_h=10 when firms have more labor market power. In contrast, we set ψ_f=0.3 and γ_h=2 when households have more labor market power.

Accordingly, the negative aggregate wealth effect is stronger, thus mitigating the fall in labor that we observe in the ”more HLMP” specification. Instead, in the ”more FLMP” specification, the drop in the EA’s profits is dampened, as well as the negative wealth effect since firms possess more labor market power. In this context, labor rises less since households have less incentives to increase their labor supply. Consequently, the responses of labor, output, consumption, the services of physical capital and investment, in the ”more HLMP” specification exceed that of the baseline model, which in turn also exceed that of the ”more FLMP” specification.

Figure 2.4: Impulse responses functions of the cyclical components of macroeconomic variables following contractionary monetary policy shock (one period is a quarter)



Note: The solid blue lines show responses in the baseline calibrated model. The red dashed lines shows responses when there is more firms' labor marker power ("FLMP"). The black dashed line with "+" markers show responses when there more households labor market power ("HLMP").

2.4.2.2 Monetary policy shocks and changes in the composition of the labor market

Here, we assess the cyclical implications of changes in the values of the labor shares of income of f-workers, α_f, of c-workers, α_c, and of h-workers, α_h. We focus especially on two cases in which α_f is smaller and we either have a bigger α_m or a bigger α_h relative to the benchmark calibration. In fact, the intuition regarding the other possible combinations is analogous to these two cases. Figure 2.5 compares the cyclical responses of key variables in the baseline model (solid blue lines), when we decrease α_f and increase either α_c (red dashed lines) or α_h (black dashed line with "+" markers).[24]

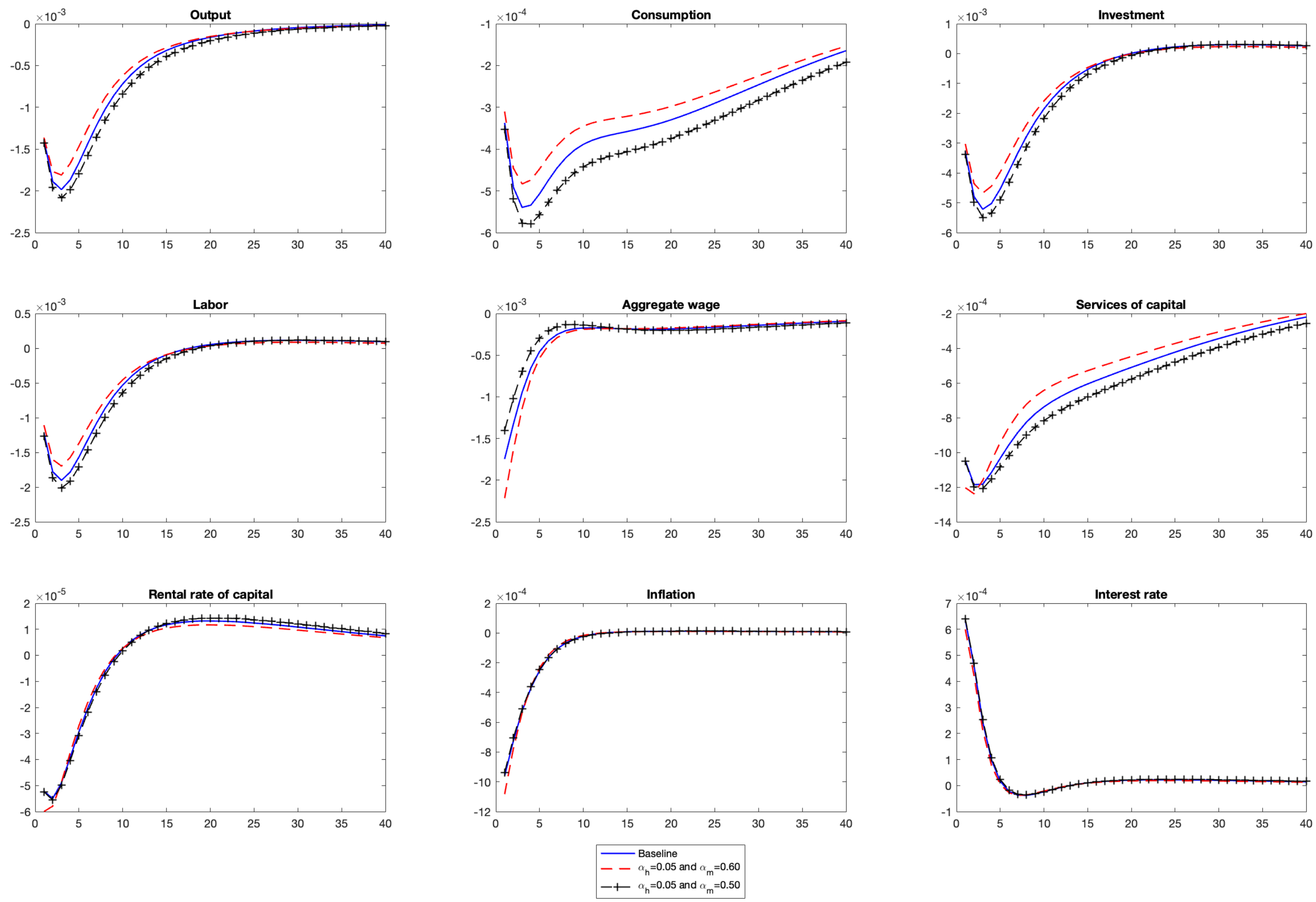
In general, a restrictive monetary policy shock associated with changes in the composition of the labor market has mixed effects on the size of the cyclical paths of variables. Except for output, consumption, investment, labor, aggregate wage and the services of capital, the other variables are left almost unaffected. For the impacted variables, increasing the proportion of workers in the perfectly competitive segment helps mitigating the contractionary effects of the monetary policy shock. Contrastingly, raising the proportion of workers in the monopolistic segment accentuate the cyclical downturn induced by the shock. Moreover, we observe differences between the variables' responses in the short- and medium-run.

Explanations and intuition follow. The wage rate of c-workers is more negatively impacted by the restrictive monetary policy shock than the two other types of workers because h-workers are wage makers and firms need a wage rate higher than the competitive case to attract f-workers. Since aggregate wage is the a weighted sum of the wage rate specific to each segment, and c-workers has the bigger weight, the deeper fall experienced by the wage rate of c-workers drives down aggregate wage, especially in the short-run. That also means that the impact of the substitution effect on labor supply is larger. Consequently, aggregate labor and output are raised more than in the baseline case.

On the contrary, with a larger α_h, the overall negative effects of the monetary policy shocks are amplified relative to the baseline model, except for aggregate wage. On one hand, the decline in the wage rate of h-workers is mitigated because of their monopoly power, thus alleviating the drop in aggregate wage relative to the baseline case. On the other hand, the fall in h-workers' labor supply is stronger, which in equilibrium causes h-labor to decline more sharply compared to the baseline model. Since α_h is higher, it enhances these two effects, leading to a more pronounced drop in macroeconomic variables such as output.

[24] In particular, we fix α_f=0.05 (from 0.20 in the benchmark calibration) and either fix α_c=0.60 (from 0.45 in the benchmark calibration) or fix α_h=0.50 (from 0.35) in the benchmark calibration.

Figure 2.5: Impulse responses functions of the cyclical components of macroeconomic variables following a contractionary monetary policy shock (one period is a quarter)



Note: The solid blue lines show responses in the baseline calibrated model. The red dashed lines shows responses when we decrease α_f and increase α_c, while α_h is kept constant. The black dashed line with "+" markers show responses when we decrease α_f and increase α_h, while α_c is kept constant

2.4.2.3 Monetary policy shocks and changes in nominal wage rigidities

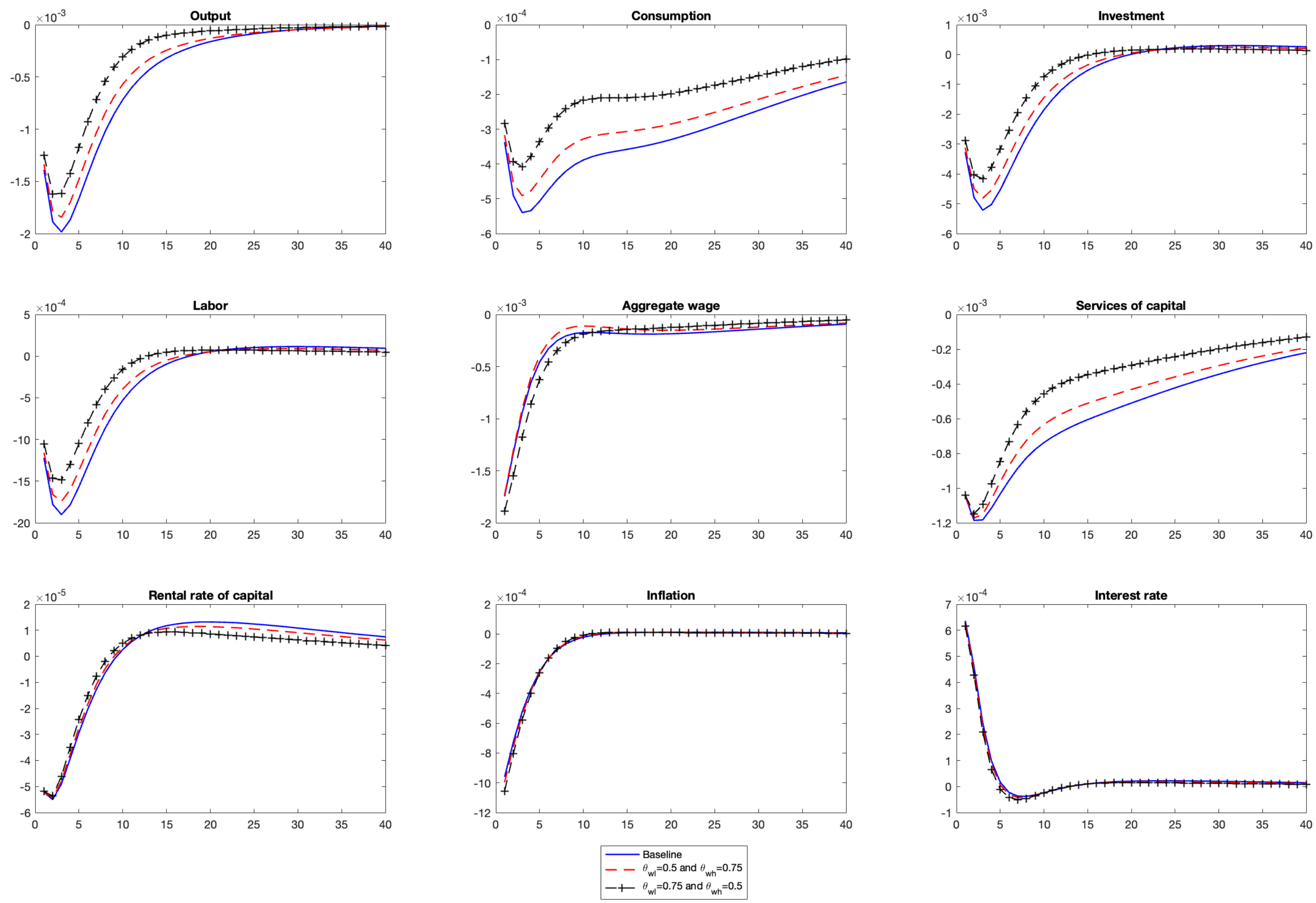
In our benchmark calibration, we assume that the wage rate of f-workers is as much rigid as the wage rate of h-workers. However, an important question arises: what are the cyclical implications of altering the relative rigidity of nominal wages? This inquiry is explored in Figure 2.6, where we present the cyclical responses following a contractionary monetary policy shock for different levels of nominal wage rigidities among f- and h-workers.

The solid blue lines show our baseline model in which f-workers and h-workers have the same degree of nominal wage stickiness i.e ($\theta_{h,w} = \theta_{f,w} = 0.75$). The red dashed lines present a specification in which the wage rate of f-workers is more flexible ($\theta_{h,w}$=0.75 and $\theta_{f,w}$=0.5). And the black dashed lines with ”+” markers show a specification in which the wage rate of h-workers is more flexible ($\theta_{h,w}$=0.5 and $\theta_{f,w}$=0.75).

Two key observations merit attention. First, it is apparent that the interaction between the monetary shock and the nominal wage rigidities is weaker than its interaction with parameters governing the labor market power or the composition of the labor market. Second, the cyclical downturn induced by a restrictive monetary policy shock is mitigated when the wage rate of h-workers is more flexible, in contrast to the scenario in which the wage rate of f-workers is more flexible. When the wage rate of f-workers becomes more flexible, the response of aggregate wage is slightly above that of the baseline model, especially from the fourth to the twelfth quarter. This occurs because, despite facing firms' monopsony power, f-workers' wages have a modest but positive influence on aggregate wage due to more frequent upward wage reoptimization by firms. However, the more attenuated negative wealth effect on f-workers' labor supply exacerbates the drop in the responses of labor, output and consumption compared to the baseline model.

Conversely, Figure 2.6 shows that a higher flexibility of the wage rate of h-workers mitigates the contractionary effects of the monetary policy shock. Notably, except for aggregate wage, the black dashed lines with ”+” markers lie above not only the blue solid lines but also the red dashed lines. When the wage rate of h-workers is more flexible, the short-run response of aggregate wage is smaller in comparison to the baseline model. Intuitively, the fall in labor demand in general, and for h-workers in particular, refrain them to raise their wage rate as they would if their nominal wage were more rigid because they are able to reoptimize more quickly. Since there is a limited rise in their wage rate relative to the baseline case, h-workers have more incentives to increase their labor supply. Accordingly, labor, output and consumption drop less than in the baseline model.

Figure 2.6: Impulse responses functions of the cyclical components of macroeconomic variables following a contractionary monetary policy shock (one period is a quarter)



Note: The solid blue lines show responses in the baseline calibrated model. The red dashed lines shows responses when we decrease θ_{wl}, while θ_{wh} is kept at its baseline value. The black dashed line with "+" markers show responses when we decrease θ_{wh}, while θ_{wl} is kept its baseline value.

2.5 The welfare implications of changes in the composition of the labor market structure

On January 19 2023, the U.S. Federal Trade Commission (FTC) proposed a rule to ban noncompete clauses from workers' contracts. This decision has been influenced by empirical findings suggesting that such clauses harm workers by reducing their wage rates and overall welfare. We do not pretend that our model has the ability to take into account all the issues at stake related to this important question. Nevertheless, from a cyclical point of view it can serve as a starting point to assess possible aggregate welfare implications of changes in the composition of the labor market.

In particular, we measure consumption equivalent welfare losses implied by a labor market in which there are less workers under monopsonistic competition, a scenario that the FTC is trying to achieve through its proposal. Our recursive measure of aggregate welfare is the infinite-horizon sum of the present discounted value of flow utilities across households that can be expressed as:[25]

$$\Psi_t = U(C_t, L_{f,t}, L_{c,t}, L_{h,t}) + \beta\Psi_{t+1}. \tag{2.66}$$

Accordingly, the consumption equivalent, Ξ, is defined as the percentage fraction of consumption that would have to be sacrificed each period in an alternative scenario (with subscript A) to reach the same welfare level as in a benchmark scenario (with no subscript). The benchmark scenario corresponds to a certain labor market composition in which we set the labor share of workers in the monopsonistic segment, α_f, of the labor share of workers in the competitive segment, α_c, and the labor share of workers in the monopolistic segment, α_h, at certain values. In the alternative scenario, we decrease the value of α_f, which is the will of the FTC, in favor of either a bigger α_c or a bigger α_h. For each computations of the welfare impact, we reduce α_f by two percentage points. We explore two measures of consumption equivalent welfare losses. The first one is based on stochastic means and use the subscript "m", while the second one is based on non-stochastic steady states and use the subscript "ss". The equations for the stochastic means measure and the steady state measure, are respectively:

$$\Xi_m = 1 - \exp((1-\beta)(\Psi_m - \Psi_{A,m})), \tag{2.67}$$

$$\Xi_{ss} = 1 - \exp((1-\beta)(\Psi_{ss} - \Psi_{A,ss})). \tag{2.68}$$

[25] After solving the model via a second order approximation, the mean value of the aggregate welfare is computed following different scenarios of the labor market structure. See Schmitt-Grohé and Uribe (2004) for more details about the methodology.

The results of the consumption equivalent welfare losses from decreasing α_f to increase either α_c or α_h are shown in Tables 2.5 and 2.6, respectively. Moreover, for each Table, panels (a) and (b) report the stochastic means metric and the non-stochastic steady state metric of the consumption equivalent welfare losses, respectively. Finally, it is worth noting that while computing the equivalent welfare losses, when we change the labor share, we adjust the labor disutility parameter for each type of workers accordingly, to match the steady state hours worked value of 1/3.[26]

Overall, there are three important observations regarding the reported results on the welfare analysis. First, decreasing the labor share of workers in the monopsonistic segment improves households' welfare, regardless of whether we increase the labor share of workers in the competitive segment or workers in the monopolistic segment.[27] For example, if α_f falls from 0.22 to 0.20, while α_c increases from 0.43 to 0.45, welfare improves by 0.29% based on either stochastic means or non-stochastic steady state measurements. Moreover, if α_f falls from 0.22 to 0.20, while α_h increases from 0.35 to 0.37, the welfare rises by 0.19% based on stochastic means and by 0.18% based on non-stochastic steady state.

Second, the results from the stochastic means metric and the non-stochastic steady state metric are quite similar. For instance, as displayed in Table 2.5, the stochastic mean metric shows that a decline in α_f from 0.20 to 0.16 and the rise in α_f from 0.45 to 0.47 raises the welfare by 0.65% and 0.64% based on stochastic means and non-stochastic steady state, respectively. The same observation can be made from the results reported in Table 2.6.

Third, the increase in welfare resulting from the rise in the labor share of workers in the competitive segment is higher than that of workers in the monopolistic segment, regardless of the metric considered. Following a decline in α_f (from 0.16 to 0.14), an increase in α_c (from 0.49 to 0.51) raises the welfare by 0.36%. However, following the same decrease in α_f, while α_h rises from 0.41 to 0.43, causes aggregate welfare to improve 0.26%.

[26] We obtain the same results without this adjustment.

[27] The minus sign in the Tables means an improvement in aggregate welfare.

Tableau 2.5: Welfare implications of a fall in the share of workers in the monopsonistic segment and a rise in the share of workers in the competitive segment

	α_f	0.22→	0.20→	0.18→	0.16→
(a) Means					
	0.22	0			
	0.20	-0.0029	0		
	0.18	-0.0061	-0.0031	0	
	0.16	-0.0094	-0.0065	-0.0034	0
	0.14	-0.0131	-0.0101	-0.0070	-0.0036
(b) Steady state					
	0.22	0			
	0.20	-0.0029	0		
	0.18	-0.0060	-0.0031	0	
	0.16	-0.0093	-0.0064	-0.0033	0
	0.14	-0.0129	-0.010	-0.0069	-0.0035

Tableau 2.6: Welfare implications of a fall in the share of workers in the monopsonistic segment and a rise in the share of workers in monopolistic segment

	α_f	0.22→	0.20→	0.18→	0.16→
(a) Means					
	0.22	0			
	0.20	-0.0019	0		
	0.18	-0.0040	-0.0021	0	
	0.16	-0.0063	-0.0044	-0.0023	0
	0.14	-0.0089	-0.0070	-0.0049	-0.0026
(b) Steady state					
	0.22	0			
	0.20	-0.0018	0		
	0.18	-0.0038	-0.0020	0	
	0.16	-0.0061	-0.0043	-0.0023	0
	0.14	-0.0086	-0.0068	-0.0048	-0.0025

The economic intuition regarding the welfare results is the following and is valid for both the stochastic means metric and the steady state metric. Let's consider the case in which α_f falls while α_c rises. When α_f falls, aggregate wage rises. In fact, since there is, simultaneously, a smaller proportion of workers in the monopsonistic segment and a bigger proportion of workers in the competitive segment, aggregate markdown drops. Accordingly, aggregate consumption shifts up, increasing consumption utility and welfare. This intuition is also valid for the case in which we decrease α_f and raises α_h instead of α_c. However, the fact that households possess some monopoly power is synonym to a market inefficiency, thus leading to an inefficient outcome, in comparison to a competitive labor market. This explains the higher welfare gains when increasing the labor share of competitive workers relative to that of monopolistic workers.

2.6 Concluding remarks

This chapter's contribution stems from a novel integration of a multifaceted labor market structure into the standard New Keynesian DSGE (NK-DSGE) model. This richer labor market structure illustrates the complex interplay between diverse employment relationships and macroeconomic dynamics. By incorporating three distinct labor market segments-where firms, workers wield varying degrees of market power, this study challenges and refines the traditional assumptions in NK-DSGE models regarding wage setting.

Our analysis yields several interesting findings. First, the cyclical behavior of key macroeconomic variables in our extended model exhibits an overall consistency with established business cycle literature. This alignment underscores the robustness of our model in capturing the fundamental dynamics of the economy despite the incorporation of more complex labor market structures. Second, we observed that the contractionary effects of restrictive monetary policy shocks are more pronounced when firms exert greater labor market power, highlighting the critical role of market power distribution in determining policy effectiveness.

A pivotal aspect of our research was the comparative analysis with the standard NK-DSGE model. Our findings indicate that, generally, our extended model provides a better fit for the volatility of several key macroeconomic variables. Moreover, the impulse response functions reveal that the effects of aggregate shocks are more dampened in our model. Two forces change the traditional transmission mechanisms. First, the introduction of a flexible competitive segment increase the flexibility of the aggregate nominal wage. Second, real wage is not solely driven by markup but also by markdown.

One significant insights pertains to the welfare implications of labor market structures. For instance, in an economy with 20% of workers in the monopsonistic segment of the labor market instead of 22%, when dynamic interactions are considered, results in 0.24% aggregate welfare improvement, on average. This finding aligns with the potential welfare improvements that could result from policy interventions aimed at reducing the number of workers in monopsonistic competition, such as those bound by noncompete clauses. These findings not only contribute to the theoretical discourse but also have practical implications, suggesting that policies promoting more competitive labor markets could lead to broader societal benefits.

While this paper considers a relevant advancement in integrating different types of competition within a singular labor market structure, it also highlights several avenues for future research. Paramount among these is the need for more refined data to calibrate new parameter arising because of the enriched labor market structure. This includes, for example, the labor share parameters. Furthermore, our model makes an implicit assumption of uniform incentives across different worker types regarding consumption, investment and bold holding, for instance. Future studies could explore these aspect in greater detail, examining how distinct incentives across labor market segments might further influence macroeconomic outcomes.

One limitation of the model is the fact that we do not distinguish between the extensive and the intensive margins of aggregate labor, especially given that empirical evidence from the labor economics literature points towards the relative importance of extensive margin adjustments of labor movements. By considering overall hours-person worked, it abstracts explicitly from taking into account frictions inherent to the matching process associated with the number of workers between households and firms and that may likely differ in the distinctive labor market segments.

Another possible limitation that may arise from having assumed that the inverse Frisch elasticity of labor supply and the degree of wage rigidity are both constant over time and similar in each labor market segment. Recently, Khan and Metaxoglou (2021) find empirical evidence that the wage markdown is strongly procyclical, thus a potentially promising avenue to better capture labor market dynamics following various shocks might be to embed this cyclicality.

CHAPITRE 3

AN ESTIMATED DSGE MODEL WITH MULTIPLE TYPES OF COMPETITION IN THE LABOR MARKET

RÉSUMÉ

Expanding upon the tripartite labor market framework initially proposed by Atsiga (2023), this study innovatively estimates a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) model utilizing Bayesian likelihood methods. Employing a mix of standard and non-informative prior distributions, we successfully estimate not only conventional parameters but also those unique to our augmented labor market structure. Our estimation captures pivotal shifts in the U.S. economy around the first half of the 1980s, coinciding notably with a decrease in the volatility of output and inflation and with the ascendance of firms' market power. Furthermore, our analysis revisits and critically reassesses the drivers of business cycle fluctuations, revealing findings that contrast and extend beyond seminal works in the field. These results underscore the significance of incorporating diverse labor market segments into macroeconomic models, highlighting the possibly non trivial impact on understanding economic dynamics.

KEY WORDS: New Keynesian DSGE Models; Bayesian Estimation, Labor Market Structure; Business Cycles.

JEL classification: E12, O32, E17, J42, E52.

3.1 Introduction

The estimation and use of Dynamic Stochastic General Equilibrium (DSGE) models have become a central pillar in modern business cycle analysis, providing a rigorous framework for understanding the intricate dynamics of macroeconomic variables and assessing the empirical relevance of the models. These models, particularly when calibrated or estimated with real data, offer invaluable insights into the structural and shocks parameters that shape the economy's response to various policies and external changes, making them indispensable tools for policymakers. This chapter builds on the pioneering works such as of Christiano *et al.* (2005) and Smets and Wouters (2007), who have significantly advanced macroeconomic modeling, by proposing to enrich the nature of the labor market and to empirically assess its relevance.

In the evolving landscape of macroeconomic analysis, two predominant techniques for estimating DSGE models have emerged: frequentist methods, and Bayesian estimation. Each approach offers unique insights and methodological advantages that are extensively discussed in Fernández-Villaverde *et al.* (2016). This paper particularly focuses on Bayesian likelihood methods, following Smets and Wouters (2007), Justiniano *et al.* (2010) and Justiniano *et al.* (2011). Bayesian estimation not only aids in updating our beliefs about the model's parameters through data but also provides a coherent framework for dealing with model uncertainty and incorporating various sources of information.

Building upon the novel three-segment labor market structure developed in Atsiga (2023), this study enhances the standard New Keynesian model by incorporating more realistic labor market dynamics by including the coexistence of monopsonistic, competitive, and monopolistic segments in the labor market. Moreover, in accordance with the requirement of the Bayesian approach that is used for estimation, it also introduces additional shocks, including those affecting intertemporal (preference shock) and intratemporal (wage markdown, wage markup and price markup shocks) trade-offs as well as policy-induced changes (the government spending shock).

The estimation of the model with Bayesian likelihood methods provides a few challenges. In particular, a strict correspondance of the labor market variables for each segment of the labor market and the data does not exist since there is no obvious partition between the three segments. Depending on the criterion that is employed, some of the workers assigned to one segment might in fact belong to another one. For instance, even though the unionization rate might be a good proxy for calibrating the share of workers in the monopolistic segment, some workers that are not covered by unions may possess significant market power akin to monopolistic competition. For example, that might be the case of some CEOs or highly specialized or skilled workers. In the same vein, the share of workers with noncompete clauses may be an imperfect proxy for calibrating the share of workers in the monopsonistic segment. However, since some workers are compensated for signing noncompete clauses, we can argue that they do not really evolve in the monopsonistic segment of the labor market.

A direct consequence of the first challenge is that there is also little to no evidence regarding the prior values of the new parameters we wish to estimate. In fact, empirical evidence regarding parameters values are usually at the macroeconomic or at the microeconomic level. However, given our labor market structure, the level of aggregation of some labor market variables is more of an intermediate level, between the microeconomic and the macroeconomic levels. Finally, the estimation maybe challenging because we want to consistently estimate, not only traditional parameters but also new parameters arising from the new labor market structure.

The mid-1980s marked two significant shifts in the U.S. economy. The first is known as the Great Moderation, characterized by a notable decrease in the volatility of macroeconomic variables like output and inflation. Although some authors, including Blanchard and Simon (2001), suggest that the decline in output volatility began in the 1950s, the consensus in the literature identifies the first quarter of 1984 as the onset of the Great Moderation.[1] The degree of the decline in output and inflation volatilities varies with the period considered. For instance, Blanchard and Simon (2001) observe that from 1982 to 2000, the standard deviations of output and inflation halved and reduced by two-thirds, respectively. McConnell and Perez-Quiros (2000) show that the variance of output growth was over four times smaller from 1984:Q1 to 1997:Q2 than between 1952:Q2 and 1983:Q4. With our data sample, we find a roughly 30% and 68% reduction in the volatilities of output growth and inflation growth, respectively, from 1984:Q1 to 2019:Q4. The Great Moderation has been attributed to three main factors: structural changes (such as changes in economic institutions and technology), improved macroeconomic policies (particularly more effective monetary policies), and good luck (a decrease in the frequency and size of economic shocks).

A second notable shift around the mid-1980s was an increase in firms' market power. Analysis by De Loecker *et al.* (2020) using data covering 1950 to 2016 show a significant rise in aggregate markup, from 21% above marginal cost in 1980 to 61% in 2016. This increase in product market power among firms has contributed

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[1] See, for example, Kim and Nelson (1999), McConnell and Perez-Quiros (2000), Stock and Watson (2002)

to a decline in the labor share and labor market dynamism, which, as argued by Barkai (2020), is the result of markets concentration, including labor markets.

Smets and Wouters (2007) and Justiniano *et al*. (2011) have investigated the Great Moderation within the framework of a standard New Keynesian model. By estimating our model for the subperiods before (1948:Q1 to 1983:Q4) and after 1984 (1984:Q1 to 2019:Q4), we expand on their analysis using a richer and more complex framework. Additionally, our three-segment labor market structure allows us to explore the rise in firms' market power, especially in the labor market. Our primary goal is to evaluate our model's ability to capture and offer alternative explanations for these two significant shifts in the U.S. economy that started in the 1980s.

In section 2, we summarily present the model developed in Atsiga (2023) with a particular emphasis on the less conventional features of the labor market. Section 3 lays out the estimation procedure as well as well the data used for that purpose. Section 4 is dedicated to the estimation results. In that section we first discuss the results of our identification analysis. Then, we compare the estimates of the two subperiods and their implications for the cyclical paths of variables, before delving into the discussion of business cycle driving forces. Finally, we conclude in section 5.

3.2 The model

The model is based on the extended version of the New Keynesian framework developed in Atsiga (2023). In that model, the labor market is segmented in three parts, each of them characterized by a distinct types of competition. A first segment of the labor market is perfectly competitive, a second segment is monopolistically competitive with households holding some market power, and a third segment is monopsonistically competitive with firms exercising market power. The model also includes typical characteristics of standard New Keynesian (NK) models: nominal rigidities in the form of Calvo wage and price contracts, habits formation in consumption, investment adjustment costs and variable utilization of physical capital. Typical shocks such as the neutral technology, the MEI and the monetary policy are included but the introduction of several additional shocks leads to a higher number of observables at the estimation stage to potentially fit the data better. In this section, we succinctly discuss the extended model.[2]

[2] The different constrained optimization problems faced by the economic agents in this chapter are to similar to those in 2, in which they are presented in more details.

3.2.1 Households

The economy is populated by a large number of identical households that we normalize to a unit measure. Each household comprises three members (or workers) that participate in the labor force: f-, c- and h-workers. Decisions regarding consumption, C_t, the holding of physical capital in the next period, K_{t+1} (thus investment in physical capital, X_t), the intensity of utilization of physical capital, u_t, and the holding of bonds, b_{t+1}, are made at the household level and and are independent of the specific member. However, decisions related to hours worked and wages depend on the member, and as a result, these variables carry the subscript $j \in \{f, c, h\}$, reflecting the influence of the worker's environment. Furthermore, since labor supplied by workers is specific to firm, we introduce an additional index, i, for hours worked and wages variables.[3, 4]

A household i's intertemporal preferences over consumption and labor are described by the following expected utility function over an infinite horizon:

$$E_t \sum_{t=0}^{\infty} \beta^t \omega_t \left(\ln(C_t - bC_{t-1}) - \eta_f \frac{L_{f,t}(i)^{1+\psi_{f,t}}}{1+\psi_{f,t}} - \eta_c \frac{L_{c,t}(i)^{1+\psi_c}}{1+\psi_c} - \eta_h \frac{L_{h,t}(i)^{1+\psi_h}}{1+\psi_h} \right), \tag{3.1}$$

where E_t is the expectation operator conditional on all the information available and known as of period t, $0 < \beta < 1$ is the subjective discount factor, ω_t is an exogenous intertemporal preference shock following an AR(1) process:

$$ln\omega_t = \rho_\omega ln\omega_{t-1} + \epsilon_{\omega,t}. \tag{3.2}$$

$0 < b < 1$ is a parameter governing internal habit formation. η_j and ψ_j are respectively the weight on labor disutility and the inverse Frisch elasticity of labor supply of each household's type j-worker, with $j \in \{c, h\}$. $\psi_{f,t}$ is the time-varying inverse Frisch elasticity of labor supply of f-workers by which we introduce a shock to the wage markdown as will be defined in a subsequent section. It evolves according to the following stochastic process:

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[3] In subsequent sections, we use index i to refer to intermediate firms.

[4] This formulation aligns with the approach taken by Erceg *et al.* (2000), which assumes implicit insurance contracts (except for labor), ensuring that households are identical across all dimensions except for labor supply and wages. Therefore, we can omit index i from all the households' variables except for their labor supply and wage.

$$\psi_{f,t} = (1-\rho_\psi)\psi^*_{f,t} + \rho_\psi \psi_{f,t-1} + \epsilon_{\psi,t}. \tag{3.3}$$

where ρ_ψ is the shock's persistence parameter and ψ^*_f is the steady state value of the inverse Frisch elasticity of labor supply.

Each period, a j-worker allocates its time between hours of work, $L_{j,t}(i)$, and leisure, $l_{j,t}(i)$, with total time at its disposal being normalized to one. According we define the following time constraint:

$$L_{j,t}(i) + l_{j,t}(i) = 1, \tag{3.4}$$

$\forall j \in \{f, c, h\}$. The household's time t real budget constraint equates one's amount of resources to its expenses, according to:[5]

$$\begin{aligned} C_t + X_t + b_{t+1} + a(u_t)K_t = w_{f,t}(i)L_{f,t}(i) + w_{c,t}(i)L_{c,t}(i) + w_{h,t}(i)L_{h,t}(i) \\ + q_t u_t K_t + \frac{(1+R_{t-1,t})}{(1+\pi_{t,t+1})} b_t + d_t + T_t \end{aligned} \tag{3.5}$$

In period t, a j-worker supplies labor to an intermediate firm i, either directly or through labor intermediaries, and receive the real wage rate, $w_{jt}(i)$. The household rents the services of physical capital, $u_t K_t$ (or $\hat{K}_t$) to intermediate firms at a competitive real rate, q_t. Physical capital utilization rate, $0 \leq u_t \leq 1$, allows households to adjust the intensity and the quantity of physical capital rented each period. In addition, the household receives an income from its purchase of one-period bonds, b_t, in the previous period with a gross real interest rate, $\frac{(1+R_{t-1,t})}{(1+\pi_{t,t+1})}$, where $\pi_{t,t+1}$ is net inflation.[6] Furthermore, since the representative household owns firms (i.e. the final good producer, intermediate firms and the labor intermediaries), its income includes real dividends which consist of two components. First, real economic profits, $\pi_t(i)$, stem from the market power of intermediate firms operating in a monopolistically competitive interme-

[5] Real variables are simply nominal variables divided by the price P_t.

[6] b_t can be either negative or positive depending on the household being creditor or debtor. However, as this is a closed economy, the aggregate equilibrium condition is b_t=0.

diate goods market. Second, the exercise of monopsony power by intermediate firms carries a rent given by $\pi_{EA,t}(i)$. At the same time, for a type-h worker who exercises monopolistic market power, the markup rent that he extracts is built-in the wage rate he receives. Lastly, T_t represents lump-sum taxes collected by the government to finance its expenditures that are exogenous.[7]

The household's current income is allocated to various uses including real consumption of the final good, C_t, the cost of real investment in capital goods, X_t, the purchases (or sales) of one-period bonds, b_{t+1}, and the real cost of adjusting physical capital, $a(u_t)K_t$. The resource cost of variable utilization of physical capital, $a(u_t)$, is given by the following convex function:

$$a(u_t) = \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{1}{Z_t}, \tag{3.6}$$

with $\chi_1 \geq 0$ and $\chi_2 \geq 0$, two parameters governing the cost and proportional to the stock of physical capital. Z_t is a common stochastic investment shock that affects the efficiency of transforming units of investment into new units of capital and is defined as:

$$lnZ_t = \rho_Z lnZ_{t-1} + \epsilon_{Z,t}. \tag{3.7}$$

Furthermore, we assume that the transformation of today's investment into tomorrow capital is costly because of some investment adjustment costs and that it also depends on a marginal efficiency of investment shock (hereafter MEI shock), so that the law of capital accumulation is

$$K_{t+1} = Z_t\left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2\right)X_t + (1-\delta)K_t, \tag{3.8}$$

where is $0 < \delta < 1$ is the depreciation rate and $\tau \geq 0$ governs the magnitude of the cost.

The household's objective is to maximize its expected utility over an infinite horizon (equation 3.1), subject to the sequence of budget constraints (equation 3.5), the time constraint (equation 3.4), the law of physical capital accumulation (equation 3.8) and appropriate transversality conditions. Finally, Υ_t and μ_t are respectively the Lagrange multiplier for the household' budget constraint and the law of physical capital

[7] Strictly speaking, in this context, we could make the household' utility function dependent on the level of government expenditures in a separable way because they positively affect the household' welfare. However, since they do not have distorting effects on households decisions, this simplified way of writing and posing the problem is also appropriate.

accumulation.

3.2.2 The labor intermediaries and the labor market

The labor intermediaries ensure the match between households and intermediate firms in the labor market. However, the type of competition they face, the decisions they make as well as the constraints they are subject to differ depending on which segment of the labor market they operate.

3.2.2.1 The monopsonistic segment of the labor market

In the monopsonistic segment of the labor market, the labor intermediaries operate within a monopsonistically competitive environment. We can think of a representative employment agency (EA) that acts on behalf of intermediate firms, managing hiring and wage-setting decisions.

The hiring decision of the EA

The EA combines labor supplied by f-workers using an aggregation function:

$$L_{f,t} = \left(\int_0^1 L_{f,t}(i)^{\frac{\gamma_f - 1}{\gamma_f}} di \right)^{\frac{\gamma_f}{\gamma_f - 1}}, \tag{3.9}$$

where γ_f represents the elasticity of substitution between the labor supplied by f-workers.

The EA chooses the quantity of f-labor along the upward-sloping labor supply curve by solving its constrained real profit maximization problem which yields the demand for f-labor:

$$L_{f,t}(i) = \left((1 + \psi_{f,t}) \frac{w_{f,t}(i)}{w_{f,t}} \right)^{-\gamma_f} L_{f,t}. \tag{3.10}$$

The wage-setting decision of the EA

We assume the existence of nominal wage rigidities for f-workers nominal wages, making the EA unable to adjust all the individual wages each period. In a given period, it can only adjust a constant fraction, $(1 - \theta_{f,w})$, of wages while the other fraction, $\theta_{f,w}$, is the same as in the previous period. Thus, the EA chooses the real wage, $w_{f,t}(i)$, that maximizes its constrained expected discounted real profits weighted by the probability of not being able to make a wage adjustment in a given period.[8] The solution of its problem yields the optimal reset wage or monopsonistic wage for f-workers, which is implicitly defined by the equation:

$$a_{1,t} = a_{2,t}, \tag{3.11}$$

such that:

$$a_{1,t} = \eta_f^{\frac{1}{\gamma_f \psi_{f,t}}} w_{f,t} L_{f,t}^{\frac{1}{\gamma_f}} \Upsilon_t^{\frac{\gamma_f - 1 + \gamma_f \psi_{f,t}}{\gamma_f \psi_{f,t}}} + \theta_{f,w} \beta E_t (1 + \pi_{t+1})^{\frac{-\gamma_f + 1}{\gamma_f \psi_{f,t}}} a_{1,t+1}, \tag{3.12}$$

$$a_{2,t} = (1 + \psi_{f,t}) w_{f,t}^{\# \frac{1 + \gamma_f \psi_{f,t}}{\gamma_f \psi_{f,t}}} \Upsilon_t^{\frac{\psi_{f,t+1}}{\psi_{f,t}}} + \theta_{f,w} \beta E_t (1 + \pi_{t+1})^{\frac{-\psi_{f,t} - 1}{\psi_{f,t}}} a_{2,t+1}, \tag{3.13}$$

where $\Lambda_{t+s} = \beta^s \left(\frac{\Upsilon_{t+s}}{\Upsilon_t} \right)$ is the stochastic discount factor and Υ_t is the marginal utility of an extra unit of real total income received by the household. According to equations (3.11) to (3.13), the optimal reset wage depends on the marginal utility of consumption, hours worked by f-workers as well as their wage index and the time-varying wage markdown. The latter is given by $(\frac{1}{1+\psi_{f,t}})$. Since $\psi_{f,t}$ is a stochastic process, $(1 + \psi_{f,t})$ takes the interpretation of the desired of wage markdown of firms on the marginal revenue product of f-labor. We refer to it as the *wage markdown shock*.

The wage index for f-workers

In a given period t, f-labor is composed of a proportion of workers, $(1 - \theta_{f,w})$, that receive the monopsonistic wage set at t, a proportion of workers, $\theta_{f,w}(1 - \theta_{f,w})$, that receive the monopsonistic wage set at $t - 1$, a proportion of workers, $\theta_{f,w}^2 (1 - \theta_{f,w})$, that receive the monopsonistic wage set at $t - 2$, an so on. Combining this definition of aggregate labor with the definition of labor demand (3.10) at different dates of wage optimization gives the real wage index for f-workers

$$w_{f,t}^{-\gamma_f} = (1 - \theta_{f,w})(1 + \psi_{f,t})^{-\gamma_f} b_{1,t}, \tag{3.14}$$

with the auxiliary variable:

$$b_{1,t} = w_{f,t}^{\# -\gamma_f} + \theta_{f,w} (1 + \pi_t)^{\gamma_f} b_{1,t-1}. \tag{3.15}$$

[8] The probability of not being able to adjust wages for s periods is $\theta_{f,w}^s$, with s=1, 2, ...

The EA's profits

The EA' profit calculaton accounts for the fact that at time t, there is a fraction $(1-\theta_{f,w})$ of reoptimized monopsonistic wages paid by the EA and set at t, and a fraction $\theta_{f,w}(1-\theta_{f,w})$ of reoptimized monopsonistic wages paid by the EA and set at $t-1$, a fraction $\theta^2_{f,w}(1-\theta_{f,w})$ of reoptimized monopsonistic wages paid by the EA and set at $t-2$, and so on. Moreover, nominal wages rigidities also imply that in each period, $L_{f,t}$ might be different than $L^{\#}_{f,t}$. Hence, taking these specifities into account, we obtain an expression for the EA's profit:

$$\pi_{EA,t} = w_{f,t}L_{f,t} - (1-\theta_{f,w})(1+\psi_{f,t})^{-\gamma_f} w_t^{\gamma_f} L_{f,t} b_{2,t}, \tag{3.16}$$

with the auxiliary variable

$$b_{2,t} = {w^{\#}_{f,t}}^{1-\gamma_f} + \theta_{f,w}(1+\pi_t)^{\gamma_f - 1} b_{2,t-1}. \tag{3.17}$$

3.2.2.2 The competitive segment of the labor market

In the competitive labor market segment, labor intermediaries are absent, and c-workers directly supply labor to intermediate firms. Both intermediate firms and c-workers are considered wage takers. In equilibrium, the wage received by c-workers equals their marginal rate of substitution between consumption and leisure, which, in turn, equals the marginal revenue product of c-labor.

The functioning of the competitive labor market segment can be summarized by the labor supply equation of c-workers,

$$\eta_c L_{c,t}(i)^{\psi_c} = \Upsilon_t w_{c,t}(i), \tag{3.18}$$

This equation represents the wage determination for c-workers, where η_c represents the weight on labor disutility. ψ_c is the inverse Frisch elasticity of labor supply for c-workers which is assumed to be constant over time. However, productivity shocks will have an impact on the marginal revenue product of c-labor. $L_{c,t}(i)$ is the labor supplied by c-workers to intermediate firm i, Υ_t is the Lagrangian multiplier on the budget constraint, and $w_{c,t}(i)$ is the wage rate received by c-workers. In equilibrium, this wage rate equals the marginal revenue product of c-labor, a condition we will further explore in the intermediate firms' section.

3.2.2.3 The monopolistic segment of the labor market

In the monopolistic segment of the labor market, h-workers possess the market power, and the labor intermediary operates under perfect competition. Here, we can think of a representative labor union (LU) that aggregates households' labor supply, $L_{h,t}(i)$, and turns it into a combined labor input, $L_{h,t}$, which is subsequently employed by intermediate firms. This aggregation process is governed by the following production function:

$$L_{h,t} = \left(\int_0^1 L_{h,t}(i)^{\frac{\gamma_{h,t}-1}{\gamma_{h,t}}} di \right)^{\frac{\gamma_{h,t}}{\gamma_{h,t}-1}}, \tag{3.19}$$

where $\gamma_{h,t}$ is the time-varying elasticity of substitution between labor supplied by h-workers by which we introduce a shock to the wage markup as will be defined in a subsequent section. $\gamma_{h,t}$ evolves according to

$$\gamma_{h,t} = (1-\rho_\gamma)\gamma_h^* + \rho_\gamma \gamma_{h,t-1} + \epsilon_{\gamma,t}, \tag{3.20}$$

where ρ_γ is the shock's persistence parameter and γ_h^* is the steady state value of the elasticity of substitution between h-labor.

The hiring decision of the labor union

The LU chooses the optimal level of h-labor desired by intermediate firms by solving a corresponding real profit maximization problem, thus yielding the demand for h-labor:

$$L_{h,t}(i) = \left(\frac{w_{h,t}(i)}{w_{h,t}} \right)^{-\gamma_{h,t}} L_{ht}. \tag{3.21}$$

The wage-setting decision of the labor union

Now, let's consider the wage-setting decision undertaken by the LU on behalf of households. The LU doesn't have complete freedom to adjust individual wages every period due to the presence of nominal wage rigidities modeled as Calvo wage contracts. In a given period, it can renegotiate only a constant fraction, (1-$\theta_{h,w}$), of individual wages while the remaining fraction, $\theta_{h,w}$, stays the same as in the previous period. The LU faces the same problem each time it renegotiates individual wages. Specifically, the LU chooses the current value of the real wage, $w_{h,t}(i)$, that maximizes household i's expected utility weighed by the probability

$\theta_{h,w}$ of not being allowed to renegotiate that wage, subject to the downward-sloping labor demand function. The solution of this constrained problem provides the optimal reset wage for h-workers implicitly defined by:

$$c_{1,t} = c_{2,t}, \tag{3.22}$$

with auxiliary variables

$$c_{1,t} = \eta_h \gamma_{h,t} w_{h,t}^{\gamma_{h,t}(1+\psi_h)} L_{h,t}^{1+\psi_h} + \theta_{h,w} \beta E_t (1+\pi_{t+1})^{\gamma_{h,t}(1+\psi_h)} c_{1,t+1}, \tag{3.23}$$

$$c_{2,t} = (\gamma_{h,t} - 1) w_{h,t}^{\#^{1+\gamma_{h,t}\psi_h}} w_{h,t}^{\gamma_{h,t}} \omega_t \Upsilon_t L_{h,t} + \theta_{h,w} \beta (1+\pi_{t+1})^{\gamma_{h,t}-1} c_{2,t+1}. \tag{3.24}$$

Equations (3.22) to (3.24) define the reset optimal wage which depends on the marginal utility of consumption, the labor and wage indexes of h-labor, and a markup over the marginal rate of substitution between consumption and leisure. The latter is defined by $\frac{\gamma_{h,t}}{\gamma_{h,t}-1}$, which, as customary in the literature, takes the interpretation of the stochastic desired markup of wage over the marginal rate of substitution between consumption and leisure of h-labor. We refer to $\gamma_{h,t}$ as the *wage markup shock*.

The wage index for the h-workers

From the zero-profit condition of the LU under perfect competition, we obtain a relationship between the real total wage bill and the sum of the real wage bill per h-worker. Combining that relationship with equation (2.28), and exploiting the fact that the economy is divided into two types of h-wages, with a fraction $\theta_{h,w}$ of wages that cannot be adjusted and the remaining share, $(1-\theta_{h,w})$, we obtain the wage index for h-workers

$$w_{h,t}^{1-\gamma_{h,t}} = \theta_{h,w} w_{h,t-1}^{1-\gamma_{h,t}} (1+\pi_{t,t-1})^{\gamma_{h,t}-1} + (1-\theta_{h,w}) w_{h,t}^{\#^{1-\gamma_{h,t}}}. \tag{3.25}$$

3.2.3 The final good producer

A representative final good producer aggregates the production of all i intermediate firms in order to produce a final consumption good, Y_t, according to the following technology:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{3.26}$$

where Y_t is the total output of the economy, and ϵ is the elasticity of substitution among intermediate goods, $Y_t(i)$.

The final good producer evolves in a perfectly competitive environment, taking as given the price of aggregate output, P_t, and the prices charged by intermediate goods producers, $P_t(i)$. Solving its constrained profit maximization problem we obtain the conditional demand for each intermediate good i, which depends negatively on its relative price and positively on the total output of the economy:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t. \tag{3.27}$$

The zero-profit condition of the final good producer under perfect competition implies a relationship between the total nominal output and the sum of the nominal value of intermediate goods, from which we can derive the aggregate price index

$$P_t = \left(\int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}. \tag{3.28}$$

3.2.4 The intermediate goods producers

The economy is populated by a continuum of intermediate firms indexed by $i \in$ [0, 1], where i denotes a particular type of good. Intermediate firms possess some monopoly power in the goods market which allows them to set the price of their production. They take as given the rental rate of capital and the wage rate of c- and h-workers, while indirectly choosing the wage rate of f-workers as the EA acts on their behalf. The typical intermediate goods producer i combines physical capital services, $\hat{K}_t(i)$, and labor, $L_t(i)$, according to the following production function:

$$Y_t(i) = A_t \hat{K}_t(i)^{\alpha} L_t(i)^{1-\alpha} - \Gamma_t, \tag{3.29}$$

where

$$L_t(i) = L_{f,t}^{\alpha_l}(i) L_{c,t}^{\alpha_c}(i) L_{h,t}^{\alpha_h}(i), \tag{3.30}$$

with α_j, the labor shares of income of j-workers, $\forall j \in \{f, c, h\}$. A_t is the common level of technology that follows a first-order autoregressive process so that we have

$$lnA_t = \rho_A lnA_{t-1} + \epsilon_{A,t}, \tag{3.31}$$

with $\epsilon_{A,t}$ the productivity shock. With the production of good i required to be non-negative. Moreover, since intermediate firms operate in monopolistic competition in their intermediate good market, they typically generate positive economic profit. From a modelling's perspective, one way to ensure that each firm i makes zero profit in the long-run is to impose a cost variable, Γ_t, built in with the production function.[9]

The optimization problem

To solve the optimization problem of a typical intermediate good producer i, it can be thought as a two-stage optimization. First it minimizes its costs by choosing the quantity of each type of labor, $L_{f,t}(i)$, $L_{c,t}(i)$, and $L_{h,t}(i)$, and the quantity of physical capital services, $\hat{K}_t(i)$, needed to produce intermediate output. Solving this constrained minimization problem provides the labor demand for each j-types of workers, $\forall j \in \{f, c, h\}$,

$$w_{j,t} = (1-\alpha)\alpha_j A_t \left(\frac{\hat{K}_t(i)}{L_t(i)} \right)^{\alpha} \frac{L_t(i)}{L_{j,t}(i)} mc_t, \tag{3.32}$$

and the demand for physical capital

$$q_t = \alpha A_t \left(\frac{\hat{K}_t(i)}{L_t(i)} \right)^{\alpha-1} mc_t, \tag{3.33}$$

where mc_t is the real marginal cost of production.[10]

[9] Some questions related to dividends and their distribution across households or some other questions related to entry and exit of firms in the long-run might be interesting in their own right, but these are beyond the scope of our study.

[10] Marginal cost is equal to the Lagrange multiplier of the intermediate goods demand constraint.

In the second step, taking into account the costs of inputs, an intermediate firm i chooses the price that it charges. However, the pricing decision cannot be undertaken each period by all intermediate firms because of nominal price rigidities. Consequently, all intermediate firms face a constant probability, $(1-\theta_p)$, that they can adjust their prices. This also means that the probability for a firm to be stuck with a price for one period is θ_p, for two periods is θ_p^2, and so on.

An intermediate firm that can reset its price will discount its real profits s periods into the future by the stochastic discount factor $\Lambda_{t,t+s} = \beta^s \left(\frac{C_{t+s}}{C_t}\right)^{-\sigma}$.[11] Therefore, by maximizing its real discounted expected profits yields the optimal reset price

$$P_t^{\#} = \frac{\epsilon}{\epsilon - 1} \frac{d_{1,t}}{d_{2,t}}, \tag{3.34}$$

with auxiliary variables:

$$d_{1,t} = P_t^{\epsilon} mc_t Y_t + \theta_p \beta E_t d_{1,t+1}, \tag{3.35}$$

$$d_{2,t} = P_t^{\epsilon-1} Y_t + \theta_p \beta E_t d_{2,t+1}. \tag{3.36}$$

Equations (3.34) to (3.36) define the reset optimal price i.e. a markup over the marginal cost that depends on $\frac{\epsilon}{\epsilon-1}$. Moreover, we make the elasticity of substitution between goods, ϵ, time-varying:

$$\epsilon \equiv \epsilon_t = (1-\rho_\epsilon)\epsilon^* + \rho_\epsilon \epsilon_{t-1} + \epsilon_{\epsilon,t}, \tag{3.37}$$

where ϵ_t corresponds to the stochastic desired firms' markup of price over marginal cost. We refer to ϵ_t as the *price markup shock*. ρ_ϵ is the shock's persistence parameter and ϵ^* is the steady state value of the elasticity of substitution between goods.

3.2.5 The government

The government conducts the monetary and the fiscal policies. We assume that the central bank's monetary policy follows a Taylor type feedback rule but is subject to a stochastic component:

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[11] Given that households are the owners of intermediate firms, real profits are discounted by the stochastic factor stemming from the households' Euler equation associated with the trade-off between current and future consumption.

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R}\right)^{\rho_R} \left[\left(\frac{1+\pi_t}{1+\pi}\right)^{\alpha_\pi} \left(\frac{Y_t}{Y_{t-1}} g^{-1}\right)^{\alpha_Y}\right]^{1-\rho_R} \mu_{M,t}, \tag{3.38}$$

with $\mu_{M,t}$ such that

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t}. \tag{3.39}$$

The nominal interest rate responds to deviations of net inflation, π_t, from its target, π=0, as well as deviations of output growth from its trend growth, g^{-1}. $\epsilon_{M,t}$ is a monetary policy shock. α_π is the control parameter for inflation gap and α_Y is the control parameter with respect to the output growth gap. Finally, ρ_R accommodates the smoothing effect of the nominal interest rate.

We assume that the fiscal policy is fully Ricardian and the government finances its budget by lump-sum taxes. Public expenditure, G_t, which also enters the household's utility function separately, is a time-varying fraction of output, according to:

$$G_t = (1 - \frac{1}{g_t})Y_t, \tag{3.40}$$

where g_t, the government spending shock, follows and AR(1) process:

$$lng_t = (1-\rho_g)lng + \rho_g lng_{t-1} + \epsilon_{g,t}, \tag{3.41}$$

with g the share of government spending in GDP.

3.2.6 Aggregation and equilibrium conditions

This section is devoted to the aggregate economy and the other equilibrium conditions pertaining to the model.

3.2.6.1 Aggregate production

Using equations (3.27) and (3.29), as well as the capital-labor ratio and integrating over all the i intermediate firms yields

$$Y_t = \frac{A_t \hat{K}_t^{\alpha} L_t^{1-\alpha} - \Gamma_t}{v_t^p} = \frac{A_t \hat{K}_t^{\alpha} \left(L_{f,t}^{\alpha_f} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h} \right)^{1-\alpha} - \Gamma_t}{v_t^p}, \tag{3.42}$$

where v_t^p captures the price dispersion across intermediate firms and is defined as

$$v_t^p = \int_0^1 \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} di. \tag{3.43}$$

3.2.6.2 The aggregate price index

From equation (3.28) and exploiting the fact that in period t the economy is divided into two types of firms, where a fraction θ_p of firms cannot adjust their prices and the remaining share, $(1 - \theta_p)$, is allowed to set the optimal price, the aggregate price index can be written as:

$$P_t^{1-\epsilon} = (1 - \theta_p) P_t^{\#1-\epsilon} + \theta_p P_{t-1}^{1-\epsilon}. \tag{3.44}$$

3.2.6.3 The aggregate wage index

Since the labor market is composed of three segments, the aggregate wage index is a weighted sum of the wage rates received by each type of workers. Accordingly, we have

$$w_t = w_{f,t}^{\alpha_l} w_{c,t}^{\alpha_c} w_{h,t}^{\alpha_h}. \tag{3.45}$$

3.2.6.4 The aggregate resource constraint

From equation (3.5), and by aggregating over all firms and households, the aggregate resource constraint is expressed as

$$Y_t = C_t + X_t + \left(\chi_1 (u_t - 1) + \frac{\chi_2}{2} (u_t - 1)^2 \right) \frac{K_t}{Z_t} + G_t, \tag{3.46}$$

meaning that, each period, the economy's aggregate output is shared between consumption of final good, private investment in capital good, resources devoted to adjust the utilization rate of capital and government spending.

3.2.6.5 Other equilibrium conditions

In addition, the general equilibrium in this economy requires simultaneous equilibria in the labor market, the bonds market, the final good market, the intermediate goods market, the physical capital market, the market of investment in physical capital, while being consistent with the Euler equations associated with each agent's optimization problems.

3.3 Model estimation

This section starts with the description of the estimation methodology. Then, we present the data and how they are linked to the model. Lastly, we discuss parameters calibration and prior distributions.

3.3.1 Bayesian estimation

We estimate the model using Bayesian maximum likelihood methods as explained in An and Schorfheide (2007). We estimate the model's parameters by combining prior information or beliefs and observed data. This implies the need for careful selection of the appropriate data and specification of their relation to the model, as discussed in subsequent sections. The outcome of the estimation is a posterior distribution of the model's parameters that reflects the update of prior beliefs after considering the data.

As a requirement of a DSGE Bayesian estimation, in addition to commonly used structural shocks (i.e. neutral technology, MEI and monetary policy shocks), we have introduced non-structural shocks to improve the quality and the accuracy of the estimation. These shocks include the following: government spending, preference, wage markdown, wage markup, and price markup. This practice is motivated by two main reasons.[12] First, having more shocks is essential for capturing the effects of various unpredictable economic and policy events on the economy. Second, increasing the number of shocks allows us to use more observables, which is expected to improve the general fit of the model with the dynamics of the data we want to capture, as it is customary in the literature on business cycle models estimated with Bayesian methods.

However, it is necessary to have as many shocks as observables to avoid identification issues. These issues arise when it is not possible to uniquely determine the model parameters based on the information available, including both the structure of the model and the observed data. For instance, in the case of

[12] See, for example, Smets and Wouters (2007), Justiniano *et al.* (2010) and Justiniano *et al.* (2011).

under-identification, the model cannot distinguish between the effects of different economic forces on the observables.

Appendix C delves further into the discussion of DSGE models' Bayesian estimation and other important considerations related to that topic.

3.3.2 Data

We utilize two distinct subsamples for the estimation: the pre-1984 period (1948:Q1 to 1983:Q4) and the post-1984 period (1984:Q1 to 2019:Q4). The choice of 1984 as the dividing point is not arbitrary as it marks the onset of the Great Moderation, a period characterized by reduced volatility in output and inflation. This date also aligns with significant economic shifts, including a notable decrease in the labor share of income and an increase in the average price markup, often attributed to a rise in firms' market power.[13]

The data we consider come from various sources, namely the Bureau of Economic Analysis (BEA), the Bureau of Labor Statistics (BLS) and the database of the Federal Reserve of the Bank of St. Louis (FRED). From these data sources, we extract seven variables for the model estimation: inflation (π_t), the nominal interest rate (R_t), hours worked (L_t), GDP (Y_t), consumption (C_t), investment (X_t) and wage (W_t).

Inflation is defined as the log difference of the quarterly GDP deflator. The nominal interest rate is the log of the quarterly effective Federal Funds Rate.[14] Hours worked correspond to the total number of hours worked in the nonfarm business sector. For GDP, we use the total nominal output of the economy. Consumption includes nondurable goods and services, while investment is the addition of durable goods and total private investment. Wage is the average nominal hourly compensation in the nonfarm business sector.

All relevant variables are transformed into per-capita variables by dividing by the civilian non institutional population (16 years old and older.) Additionally, we adjust for price changes by deflating all nominal variables with the GDP deflator. Lastly, to remove trend components and focus on cyclical fluctuations, we

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[13] For discussions on the impact of increasing market power, see Barkai (2020), and De Loecker *et al.* (2020).

[14] Since our sample cover the period spanning from 2008:Q4 to 2015:Q3, it could be argued that Wu and Xia (2016)'s shadow fed funds rate is a better measure of the monetary policy stance reflecting unconventional monetary policies (UMP). However, some works like Mouabbi and Sahuc (2019), Sims and Wu (2020) and Hohberger *et al.* (2023) show that using either the shadow fed funds rate or the effective fed funds rate, does not change the outcomes of a Bayesian estimation of a standard NK-DSGE model when the sample covers the period from 2008:Q4 to 2015:Q3. Intuitively, since conventional and UMP are substitutes, the transmission mechanisms of the latter are similar to that of the traditional policy rate, thus leading to the same posterior estimates.

apply a one-sided HP-filter to the data series. By using only current and previous values of the input series at each time point, the one-sided HP-filter avoids the end effects associated with the two-sided filter which relies also on future values of the input series.[15]

Table 3.1 displays empirical evidence about the volatility of the cyclical component (Panel A) and the growth rates (Panel B) of output, inflation, labor and consumption. We consider 3 subperiods: before the Great Moderation (1948:Q1 to 1983:Q4), from the start of the Great Moderation until the financial crisis (1984:Q1 to 2006:Q4), and from the start of Great Moderation until the start of the COVID-19 recession (1984:Q1 to 2019:Q4).

Overall, regardless of the definition of the variables measured, there is a decline in volatility during the Great Moderation compared to the subperiod before the Great Moderation. This shift is more apparent with output and inflation in comparison to labor and consumption. For instance, the volatilities of output and inflation fall by around 30% and by around 68%, respectively, and regardless of whether we consider the cyclical component or the growth rate.

Tableau 3.1: Standard deviation of macroeconomic variables

Panel A: Level

	1948:Q1-1983:Q4	1984:Q1-2006:Q4	1984:Q1-2019:Q4
Output	0.0084	0.0058	0.0056
Inflation	0.0019	0.0006	0.0007
Labor	0.0085	0.0078	0.0082
Consumption	0.0039	0.0034	0.0035

Panel B: Growth rate

	1948:Q1-1983:Q4	1984:Q1-2006:Q4	1984:Q1-2019:Q4
Output	0.0051	0.0023	0.0025
Inflation	0.0023	0.0007	0.0009
Labor	0.0046	0.0027	0.0030
Consumption	0.0025	0.0016	0.0017

Notes: This table presents the standard deviation of some macroeconomic variables. The level refers to the one-sided HP-filtered variable, while the growth rate is the log-difference of the variable.

[15] For an in-depth discussion of the methodology of the one-sided HP-filter, see Stock and Watson (1999).

The extent of the decrease in the volatility of labor depends on the definition of the variable. The growth rate of labor falls by around 40%, while its cyclical component falls by only 7%. Finally, the volatility of the growth rate of consumption falls by 36%, where the volatility of its cyclical component merely changes across the subperiods.

3.3.3 Measurement equations

In our model, measurement equations play a crucial role in bridging the gap between observed data (observables) and the theoretical variables of the model. These equations are essential for maintaining consistency between empirical data and our model's framework. The mapping from observables to the model's variables is established through the following measurement equations:

$$\pi_t^{obs} = \pi_t - \pi^{ss} \tag{3.47}$$

$$R_t^{obs} = R_t - R^{ss} \tag{3.48}$$

$$L_t^{obs} = lnL_t - lnL^{ss} \tag{3.49}$$

$$Y_t^{obs} = lnY_t - lnY^{ss} \tag{3.50}$$

$$C_t^{obs} = lnC_t - lnC^{ss} \tag{3.51}$$

$$X_t^{obs} = lnX_t - lnX^{ss} \tag{3.52}$$

$$W_t^{obs} = lnW_t - lnW^{ss}. \tag{3.53}$$

On the left-hand side of each equation, the obs superscript indicates the observable, i.e., the cyclical component of the variable that has been transformed as described earlier. The right-hand side of each equation is the model's representation of the observable i.e., the log level of the variable minus its steady state denoted with superscript ss.

3.3.4 Calibrated parameters and prior distributions of parameters

Given the limited number of relevant observables we cannot estimate all the parameters of the model. To address this, we adopt a two-pronged approach: First, we carefully calibrate certain structural parameters that are critical for defining the model's steady state. This calibration is grounded in existing literature and empirical evidence, ensuring that the model accurately reflects underlying economic realities. Following this, we turn our focus to the remaining parameters, which are estimated using Bayesian likelihood methods. This allows us to leverage prior knowledge and existing data effectively. In what follows, we first discuss the rationale behind our calibration choices for the structural parameters, followed by a detailed discussion on the prior distributions selected for the Bayesian estimation of the remaining parameters.

3.3.4.1 Calibrated parameters

Table 3.2 presents the set of calibrated parameters which is based on U.S. quarterly empirical studies and the macroeconomic literature on DSGE models. In particular, we set the subjective discount rate, β, to 0.99 to match a 4% steady state real interest rate. We fix the capital's share of income, α, at 0.33 and the depreciation rate of physical capital, δ, at 0.025, corresponding a 10% depreciation rate in annualized terms. These values are fairly standard and well-known in the literature. Furthermore, we set $\chi_1 = 1/\beta - 1 - \delta$, one of the parameters that governs the cost of the variable utilization of physical capital so that its steady state utilization is one. We fix the second parameter that governs the cost of variable utilization of physical capital, χ_2, to 0.05. The calibration of these two parameters is consistent with Ascari *et al.* (2018). Finally, we fix the steady-state level of government spending, g, in accordance with the average government spending to GDP ratio in each subsamples, i.e. 0.22 from 1948:Q1 to 1983:Q4 and 0.19 from 1984:Q1 to 2019:Q4. All these choices of parameter values are quite common and consensual in the literature.

Tableau 3.2: Calibrated parameters

Parameter	Value	Description
		Non-shock parameters
β	0.99	Subjective discount rate
δ	0.025	Physical capital depreciation rate
α	0.33	Capital's share of income
χ_1	0.0351	Parameter that governs the cost of the variable utilization of physical capital
χ_2	0.05	Parameter that governs the cost of the variable utilization of physical capital

3.3.4.2 Prior distributions of parameters

In this section, we elucidate the composition of coefficients to be estimated, which can be divided into three distinct subsets. The initial subset encompasses structural parameters conventionally found in NK-

DSGE models, the subsequent subset incorporates parameters emergent from the augmentation of the labor market structure, and the final subset comprises parameters featuring shock processes.

The list of standard structural estimated parameters and their respective prior distribution are presented in more detail in Table 3.3. Specifically, we employ Beta distributions for parameters bounded by a unit interval, such as habit formation (b), Calvo price (θ_p), and Taylor rule smoothing (ρ_R). For parameters like the investment adjustment cost (τ), which are unbounded within the positive domain, Gamma distributions are utilized. Normal distributions are designated for parameters determining the steady-state price markup (ϵ^*) and the Taylor rule response coefficients on output (α_Y) and inflation (α_π). In alignment with the established norms in the Bayesian estimation of NK models, as exemplified by Justiniano *et al.* (2010), Justiniano *et al.* (2011), and Alpanda and Zubairy (2021), we meticulously select the prior means for these parameters, as delineated in Table 3.3.

Table 3.4 displays the parameters pertaining to the expanded labor market structure. These parameters are particularly challenging due to insufficient theoretical and empirical guidance available for their appropriate values, especially within our novel framework's context. Nevertheless, leveraging indirect evidence and guided by a reasonable economic intuition, we parameterize their prior distribution. We specifically utilize Normal distributions for the elasticity of substitution between f-labor (γ_f) and h-labor (γ_h^*), setting the mean at 6 and the standard error at 1 for both parameters. This assumption is conventional in standard NK models typified by households' monopoly in the labor market, as it implies a reasonable steady-state markup of 20% over wage, a rationale particularly cogent for h-workers who possess the monopoly power measured by γ_h^*. However, γ_f does not play that role in influencing the wage rate of f-workers as they evolve in the monopsonistic segment of the labor market. Still, the standard value of 6 is the starting point of the estimation.

The Calvo wage parameters for f-workers ($\theta_{f,w}$) and h-workers (θ_h, w) are assumed to follow Beta distributions with means of 0.66 and standard errors of 0.1, in concordance with macro estimates like those reported by Christiano *et al.* (2005), which suggest a median wage duration of five months at the aggregate level. Conversely, the parameters governing the inverse Frisch elasticities of h labor supply (ψ_h) and c labor supply (ψ_c) are presumed to follow Gamma distributions with means set at 2 and standard errors at 0.75, following Justiniano *et al.* (2011). A different approach is taken for the steady-state inverse Frisch elasticity of f-labor supply (ψ_f^*), for which a uniform distribution is chosen with bounds at 0.1 and 2, ensuring that the steady wage markdown stays fairly congruent with empirical evidence indicating a lower elasticity of labor supply in monopsonistic labor markets.[16]

It is also quite challenging to choose priors for the labor share of income of f- and h-workers, α_f and α_h, because not only there is little direct evidence on these shares but also, there is no obvious way to partition the three segments of the labor market.[17] Consequently, we adopt an agnostic stance, assuming that both α_f and α_h are uniformly distributed between 0.05 and 0.50, respectively.

Lastly, Table 3.5 exhibits the parameters characterizing shock processes. Beta distributions with means of 0.5 and standard errors of 0.2 are chosen for the shocks' persistence parameters (ρ) since they are bounded by a unit interval. Furthermore, the standard deviations of shocks (σ) is assumed to follow Inverse-gamma distributions, as in Smets and Wouters (2007), with means of 0.005 and standard errors of 50.

3.4 The results

In this section, we now turn to the estimation results and their implications.

3.4.1 Identification tests

Before properly estimating the model, we perform identification tests on the structural parameters to be estimated. This step is essential for two reasons. First, identification issues arise when different structural parameters of a model produce indistinguishable outcomes, meaning that not all parameters can be consistently estimated. Without proper identification, it becomes challenging to determine the number of parameters that can be reliably estimated and to ascertain which specific parameters are identifiable. Second, conducting identification tests before estimating DSGE models ensures that the estimation and inference processes are meaningful and that the model's parameters genuinely reflect the economic theories and mechanisms under consideration

Dynare's toolbox provides routines to implement the three local identification tests that we consider here.[18].

[16] For example, Peterman (2016) reports micro and macro estimates of the inverse Frisch elasticity around 4 and 0.33, respectively.

[17] To the best of our knowledge, there is no macroeconomic model that takes simultaneously into account the coexistence of three types of competition in the labor market. Moreover, depending on the criterion that is employed, some of the workers assigned to one segment might in fact belong to another one. For instance, even though the unionization rate might be deemed to be a reasonable candidate to proxy in calibrating α_h, certain workers that are not covered by unions may possess significant market power akin to monopolistic competition. For example, that might be the case of some CEOs or highly specialized or skilled workers.

[18] See Dynare version 5.4 as detailed in Adjemian *et al.* (2022)

The first test, developed by Iskrev (2010), uses the rank and order conditions of the Jacobian matrix to check the unique mapping from structural parameters to population moments (the first and the second moments). The second test, from Qu and Tkachenko (2012), also assesses the unique mapping from structural parameters, but to population mean and density based on the rank condition of the Jacobian matrix. Finally, Komunjer and Ng (2011) propose, using restrictions implied by observational equivalence, to derive two sets of rank and order conditions, which are applicable to stochastically singular models and nonsingular models. Their approach allows incorporating various types of restrictions, including measurement errors, mean restrictions, long-run restrictions, and a priori restrictions, to facilitate the identification process.

The results from the identification tests reveal that, given our limited set of observables, it is not possible to identify the autocorrelation and standard deviation parameters, ρ_γ and σ_γ of the wage markup shock and that of the wage markdown simultaneously, because there is no empirical counterpart for hours worked in the monopolistic or monopsonistic segment of the labor market in the data. Therefore, we choose not to include either the autocorrelation parameter of the wage markup shock or its standard deviation. Instead, we arbitrarily calibrate these two parameters since their value does not affect the outcomes of the estimation. This also means that we could have considered an estimation specification in which we do not estimate parameters of the wage markdown shock instead of the wage markup shock.[19]

3.4.2 Posterior estimates

3.4.2.1 Standard parameters

Here the posterior mean estimates of traditional parameters in New Keynesian models across the two distinct subperiods that we consider: pre-1984 (from 1948:Q1 to 1983:Q4) and post-1984 (from 1984:Q1 to 2019:Q4). To contextualize our findings, we compare them to those from seminal contributions in the field, hereafter referred to as the ”references”, that cover various samples. Notably, these include Smets and Wouters (2007), Justiniano *et al.* (2010), Justiniano *et al.* (2011), and Alpanda and Zubairy (2021). The results summarized in Table 3.3 broadly corroborate the parameter values reported in the referenced studies, with a few notable exceptions, particularly in the pre-1984 subperiod.

[19] Estimating the model with both specifications would be interesting and necessary to confirm the robustness of our results.

Tableau 3.3: Prior densities and posterior distributions of conventional New Keynesian structural parameters

		Posterior			
Parameters.	Priors	Pre-84	90% HPD interval	Post-84	90% HPD interval
b	Beta(0.5,0.2)	0.7051	[0.6340,0.7755]	0.7472	[0.6059,0.8767]
θ_p	Beta(0.66,0.1)	0.6706	[0.6137,0.7274]	0.8493	[0.8007,0.8970]
τ	Gamma(4,2)	0.9329	[0.7394,1.1283]	2.2696	[1.7878,2.7313]
ϵ^*	Normal(6,1)	6.7723	[5.2739,8.2368]	6.1109	[4.7165,7.3799]
ρ_R	Beta(0.5,0.2)	0.6614	[0.5999,0.7253]	0.7806	[0.7346,0.8272]
α_Y	Normal(0.3,0.3)	0.2256	[0.1111,0.3380]	0.4542	[0.2350,0.6609]
α_π	Normal(1.5,0.3)	1.2543	[1.0051,1.4560]	1.5970	[1.2021,1.9890]

Notes: In the column ”Priors”, the first number in parentheses is the mean of the distribution, while the second is its standard deviation. For the uniform distribution, the numbers in parentheses are the upper and lower bounds.

We start by comparing our estimates to the references. For the habit formation parameter, b, our estimates, of 0.70 pre-1984 and 0.75 post-1984, are consistent with the range, between 0.70 to 0.90, reported in the references. Similarly, the Calvo price parameter, θ_p, with mean estimates of 0.6706 pre-1984 and 0.8493 post-1984, aligns well within the reference interval of 0.66 to 0.84. The price markup, inferred from our estimates to be between 17% and 19%, also aligns closely with the 20% figure commonly cited in the references. As for the Taylor rule coefficient on inflation, our estimates (1.2543 pre-1984 and 1.5970 post-1984) are within the referenced range of 1.87 to 2.014.

Some deviations from the references are present in our posterior estimates. First, the investment adjustment cost parameter, τ, in the pre-1984 subsample is estimated at 0.9329, markedly lower than the typical range of 2.05 to 5.46 found in the references but its post-1984 estimate (2.2696) is broadly consistent. Second, the Taylor rule smoothing parameter, ρ_R, for the pre-1984 period, estimated at 0.6614, is below the reference range of 0.71 to 0.90, while the estimate for the post-1984 subsample (0.7806) falls within that range. Lastly, the Taylor rule's response to output growth in the post-1984 subperiod, with a mean estimate of 0.4542, is significantly higher than the reference value of around 0.20.

3.4.2.2 The labor market segments' parameters

In the subsequent analysis, we examine the parameters integral to our expanded labor market framework. The parameter estimates presented in Table 3.4 offer some insights from the enriched model's labor dynamics.

Tableau 3.4: Prior densities and posterior distributions of new structural parameters pertaining to the labor market structure

		Posterior			
Parameters	Priors	Pre-84	90% HPD interval	Post-84	90% HPD interval
γ_f	Normal(6,1)	6.2668	[4.1131,8.2457]	6.4372	[4.6323,7.6929]
γ_h^*	Normal(6,1)	6.4539	[4.9717,7.8380]	6.6299	[4.5478,8.8775]
$\theta_{f,w}$	Beta(0.66,0.1)	0.6619	[0.4880,0.8436]	0.6767	[0.5352,0.8213]
$\theta_{h,w}$	Beta(0.66,0.1)	0.7096	[0.5710,0.8520]	0.6659	[0.5111,0.8205]
ψ_h	Gamma(2,0.75)	1.7465	[0.6156,2.9756]	1.4848	[0.4573,2.2641]
ψ_c	Gamma(2,0.75)	1.2586	[0.3599,2.2458]	1.3082	[0.4849,2.1991]
ψ_f^*	Uniform(0.1,2)	0.6556	[0.1,1.6254]	1.0692	[0.3732,2]
α_f	Uniform(0.05,0.50)	0.4445	[0.3655,0.5]	0.3981	[0.2737,0.5]
α_h	Uniform(0.05,0.50)	0.3326	[0.1919,0.4993]	0.3313	[0.1126,0.5]

Notes: In the column "Priors", except for the uniform distribution, the first number in parentheses is the mean of the distribution, while the second is its standard deviation. For the uniform distribution, the numbers in parentheses indicate the lower and upper bounds, respectively.

The elasticities of substitution between f-labor (workers in the monopsonistic segment) and between h-labor (workers in the monopolistic segment) are around 6 and both of them barely change between the two subperiods. On one hand, the elasticity for h-labor aligns with estimates from traditional NK-DSGE models that only feature a monopolistic labor market structure. On the other hand, given the scarcity of studies focusing on monopsonistic labor segments, our specification brings a new angle to characterize and analyze the labor market.

The estimates of the Calvo wage parameters for both types of workers generally accord with figures reported in the literature, ranging between 0.66 and 0.70. Notably, in the pre-1984 subperiod, workers in the monopolistic segment exhibit slightly stickier wage rates (0.7096) compared to those in the monopsonistic segment (0.6619). This discrepancy narrows significantly in the post-1984 period, with the average degree of wage stickiness of both groups converging to a Calvo wage parameter of 0.67.

The estimated inverse Frisch elasticities of labor supply for all workers' types are consistently larger than the results reported in Peterman (2016). Using U.S data from 1968 to 1997, Peterman (2016) estimates a Frisch elasticity of labor supply that reconciles macroeconometric and microeconometric estimates. To do so, he relaxes two restrictions: he incorporates movements in hours from the whole population and includes fluctuations in both intensive and extensive margins. Peterman (2016)'s estimates implies an inverse Frisch elasticity of 0.33. In particular, we find posterior estimates between 1.4848 and 1.7465 for h-workers, 1.3082 and 1.2586 for c-workers, and 0.6556 and 1.0692 for f-workers. These findings may result from considering the level of aggregation in our model, which straddles between micro and macroeconomic scales. Our model's specific focus on distinct labor market segments introduces a granularity that traditional estimates, typically based on aggregate labor data, do not capture.

Furthermore, regarding the labor share of income estimates for f-workers (α_f) and h-workers (α_h), two observations merit emphasis. First, the labor income share for workers in the competitive segment (c-workers) consistently registers as the lowest among the three groups (0.2229 and 0.2706 for the pre- and post-1984 subsamples, respectively), even though it increases by 21% between the two subperiods. Second, while the estimates for α_h remain relatively stable across subperiods, around 0.33, there is a notable decrease in the proportion of f-workers, indicative of a marginal shift from monopsonistic to perfect competition. This subtle yet significant realignment in the labor market composition reflects broader economic and policy shifts, meriting further exploration and analysis but beyond the scope of this work.

3.4.2.3 Shocks' parameters

Table 3.5 reports the estimates of shock processes including autoregressive and standard deviation parameters. Overall, these estimates are also broadly in line with the literature.

Tableau 3.5: Prior densities and posterior distributions of shock processes

		Posterior			
Autoregressive parameters	Priors	Pre-84	90% HPD interval	Post-84	90% HPD interval
ρ_A	Beta(0.5,0.2)	0.7426	[0.6742,0.8144]	0.8211	[0.7648,0.8799]
ρ_Z	Beta(0.5,0.2)	0.4591	[0.3275,0.5883]	0.6856	[0.5943,0.7832]
ρ_M	Beta(0.5,0.2)	0.1881	[0.0723,0.2995]	0.2639	[0.1334,0.3969]
ρ_ω	Beta(0.5,0.2)	0.2785	[0.1245,0.4257]	0.5036	[0.2280,0.8006]
ρ_g	Beta(0.5,0.2)	0.8202	[0.7473,0.8942]	0.8441	[0.7552,0.9373]
ρ_ψ	Beta(0.5,0.2)	0.8527	[0.7268,0.9659]	0.7459	[0.5766,0.9277]
ρ_ϵ	Beta(0.5,0.2)	0.6509	[0.5381,0.7610]	0.5925	[0.4312,0.7566]
Standard deviations					
σ_A	IGamma(0.005,50)	0.0027	[0.0024,0.0030]	0.0020	[0.0018,0.0022]
σ_Z	IGamma(0.005,50)	0.0126	[0.0103,0.0148]	0.0087	[0.0070,0.0104]
σ_M	IGamma(0.005,50)	0.0011	[0.0009,0.0012]	0.0005	[0.0004,0.0006]
σ_ω	IGamma(0.005,50)	0.0067	[0.0050,0.0083]	0.0059	[0.0032,0.0086]
σ_g	IGamma(0.005,50)	0.0028	[0.0025,0.0030]	0.0014	[0.0012,0.0015]
σ_ψ	IGamma(0.005,50)	0.0261	[0.0057,0.0509]	0.0193	[0.0079,0.0345]
σ_ϵ	IGamma(0.005,50)	0.0205	[0.0134,0.0272]	0.0206	[0.0129,0.0282]

Notes: In the column ”Priors”, the first number in parentheses is the mean of the distribution, while the second is its standard deviation.

Focusing initially on the autoregressive parameters, we observe that, in the pre-1984 period, the wage markdown is the most persistent (0.8527), while the government spending shock is the most persistent in the post-1984 subperiod (0.8441). The monetary shock is the least persistent in both subsamples i.e. 0.1881 and 0.2639, respectively. In the references, it appears that the government shock is the most persistent while there is no consensus on the least persistent shock. Interestingly, the wage markdown shock displays some high degree of persistence, ranking first (0.8527) and third (0.7459) in the first and second subperiods, respectively. A striking overall feature across the board is an uptick in shock persistence between the two subperiods, with the exceptions of the wage markdown and the price markup shocks.

Shifting our attention to the standard deviation parameters, there seems to be no consensus in the references regarding which shock has the smallest (or the largest) standard deviation. However, our results suggest that the monetary policy shock, regardless of the subsample, has the smallest standard deviation, i.e. 0.0011 in the pre-1984 and 0.0005 in the post-1984 subsample. We also find that the wage markdown shock has the largest volatility (0.0261) in the pre-84 subperiod, while the price markup has the largest volatility (0.0205) in the post-84 subperiod.

3.4.3 The Great Moderation and the rise in firms' market power

The early 1980s marked the onset of two pivotal economic transformations. First, there was the onset of the Great Moderation in 1984, a period noted for its unusually low and stable inflation alongside reduced output and inflation volatility, compared to the past years. Secondly, this era witnessed a surge in firms' market power in both product and labor markets, a trend thoroughly documented by De Loecker *et al.* (2020).

In assessing our model's ability to capture the first shift, we focus on parameters indicating significant persistence in economic agent behaviors and those characterizing shock processes. Among standard structural parameters, we noted a 27% increase in price stickiness measured by the Calvo price parameter, θ_p, and the investment adjustment costs parameter, τ, which is 1.5 times bigger. Both estimates are consistent with the findings in Smets and Wouters (2007) and fewer fluctuations in output and inflation during the Great Moderation. Another striking change is the Federal Reserve policy stance captured by variations in the Taylor rule parameters. In particular, the Taylor rule smoothing, ρ_R, response to output growth, α_Y, and response to inflation, α_π, all increase by 18%, 100% and 27%, respectively, pointing to a more aggressive monetary policy. Surprisingly, our estimates imply a higher focus on output growth gap than on inflation control gap, opposing the findings in Smets and Wouters (2007) and Justiniano *et al.* (2010) who report a slight fall in the value of α_Y, while α_Y and ρ_R rise.

Furthermore, our analysis of autocorrelation parameters in the shocks' processes revealed a general rise in their respective persistence. For instance, the autocorrelation parameters of the shocks on either preferences, MEI or monetary policy increase by 85%, 50% and 40%, respectively. The rise in the other shock persistence is not significantly high. However, persistence in wage markdown and price markup shocks slightly decrease.

Shifting our attention to the standard deviations of the shocks, we find overall there is a decrease in the volatility after 1984:Q1. Estimates of standard deviations of the shocks on the government, MEI and monetary policy in the post-1984 subperiod decrease by 50% (from 0.0028 to 0.0014), 31% (from 0.0126 to

0.0087) and 55% (from 0.0011 to 0.0005), respectively, compared to the pre-1984 period. The only exception is the price markup shock volatility that barely changes, i.e. 0.0205 in the pre-1984 subsample and 0.0206 in the post-1984 subsample.

Supporting the findings of Smets and Wouters (2007), as well as Justiniano *et al.* (2010), our results also indicate a shift in shock volatilities between the pre- and post-1984 subperiods. The model's estimates align with the consensus summarized by Galí and Gambetti (2009)'s argument that the Great Moderation stemmed from less volatile shocks and monetary policy adjustments.

To evaluate our model's alignment with the second economic shift of the early 1980s, we examined parameters indicative of firms' goods market power, i.e. the elasticity of substitution between goods, ϵ^*, and firms' labor market power i.e. the inverse-Frisch elasticity of labor supply, ψ_f^*. In the goods market, the elasticity of substitution between goods across the two subperiods falls from 6.77 to 6.11, suggesting an about 10% increase in price markup. This result is broadly consistent with De Loecker *et al.* (2020)'s findings of a markedly increase in goods market power in the early 1980s from a 18% price markup above marginal cost in 1980 to 63% in 2014.

We find that the change in the firms' labor market power is very significant with a 63% increase in wage markdown between the two subperiods. It is difficult to contextualize this result as not only there is no clear consensus in the empirical literature regarding the evolution of wage markdown, but also the subsample considered in these studies is not identical to our subsamples. For instance, Yeh *et al.* (2022) find that wage markdown decreases between 1977 and 2000 and significantly rises afterward, while Kirov and Traina (2023) find that it increases from one to two during the same subperiod.

3.4.4 Impulse responses

In this section, we discuss how the differences in estimates between the two subsamples translate into the cyclical paths of key variables, following structural shocks. The latter shocks include the neutral technology, the MEI and the monetary policy shocks. To put the analysis into perspective, we may eventually distinguish between the responses on impact (the first quarter), the short-run responses (from quarter one to quarter five after the impact), the medium-run responses (from quarter five to quarter 15) and the responses in the longer run (beyond 15 quarters).

A positive neutral technology shock

Figure 3.1 illustrates the variables' responses to a productivity shock. The solid black lines denote the model's responses based on pre-1984 subsample estimation, contrasting with the red dashed lines which depict the responses derived from post-1984 subsample estimates. A positive neutral productivity shock typically stimulates economic activity, evidenced by increases in output, consumption, investment, and labor. At first glance, the pre-1984 model responses exhibit more pronounced fluctuations compared to the relatively stable post-1984 responses. In addition, the magnitude of the variables' responses is more important in the pre-1984 estimates, yet they exhibit greater persistence in the post-1984 estimates. Notably, the cyclical paths of output, consumption, investment, aggregate wage, and capital with the pre-1984 subsample generally surpass those of the post-1984 subsample, especially in the short-run. These observed differences can be attributed to both shifts in structural parameters and changes in the shock processes' parameters.

The differences in the responses based on the two subsamples typically manifest in the magnitude rather than the direction of the response. However, an exception is found in the response of the aggregate wage. Specifically, during the initial three quarters, the aggregate wage response is negative in the post-1984 subperiod, whereas it's positive in the pre-1984 subperiod. This post-1984 result aligns with existing literature findings, suggesting that a positive neutral technology shock induces a real wage increase upon impact, as documented by Liu and Phaneuf (2011). Conversely, the pre-1984 outcome, a product of the interplay between structural and shock parameters, diverges from the general consensus in the literature. As shown by Table 3.4, the inverse Frish elasticity parameters exhibits the largest change between the two subperiods, from 0.6556 to 1.0692, thus making it the main driver of this difference in outcome.

Figure 3.1: Impulse responses functions of the cyclical components of macroeconomic variables following a neutral technology shock (one period is a quarter)

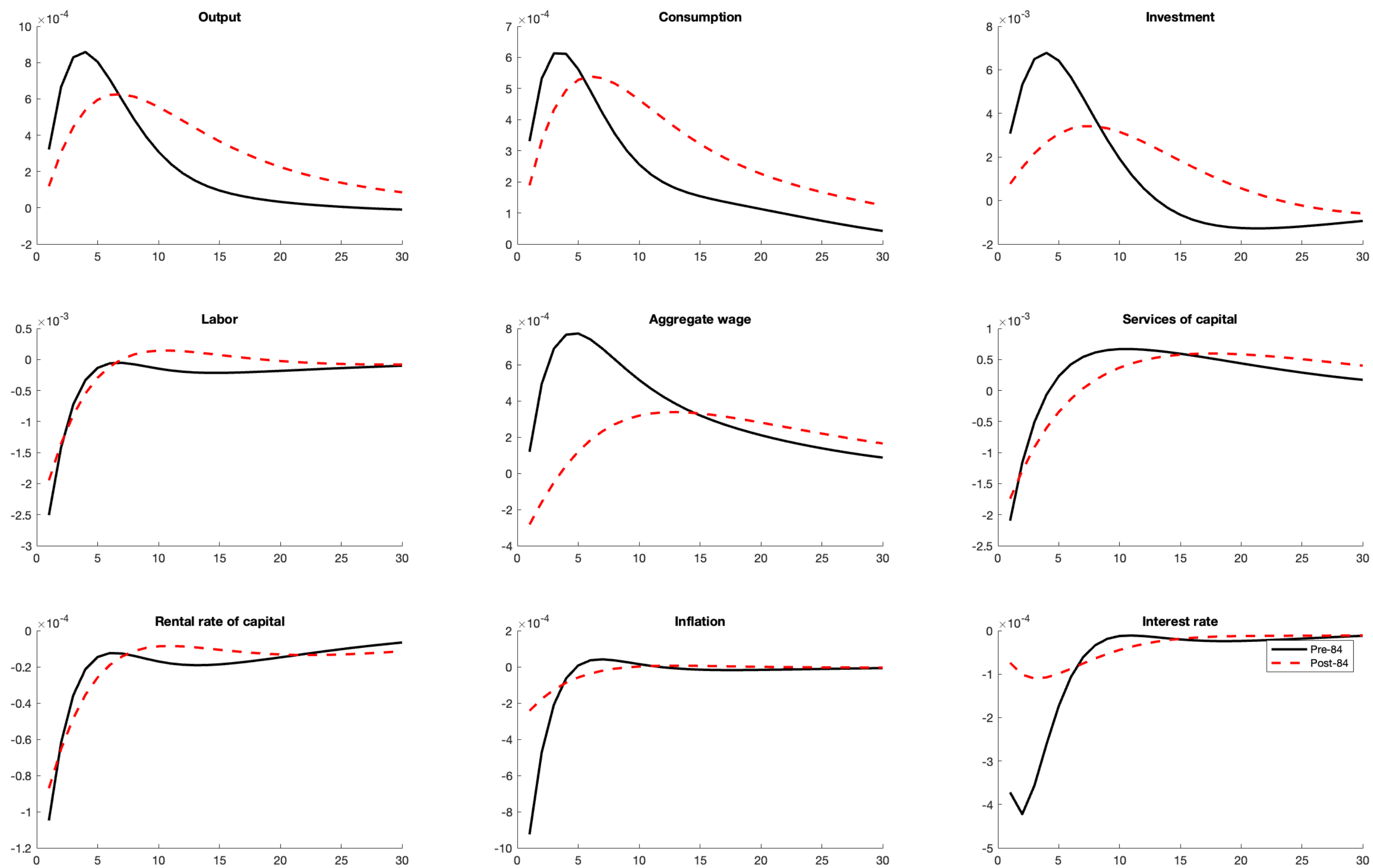


Figure 3.2: Impulse responses functions of the cyclical components of macroeconomic variables following a MEI shock (one period is a quarter)

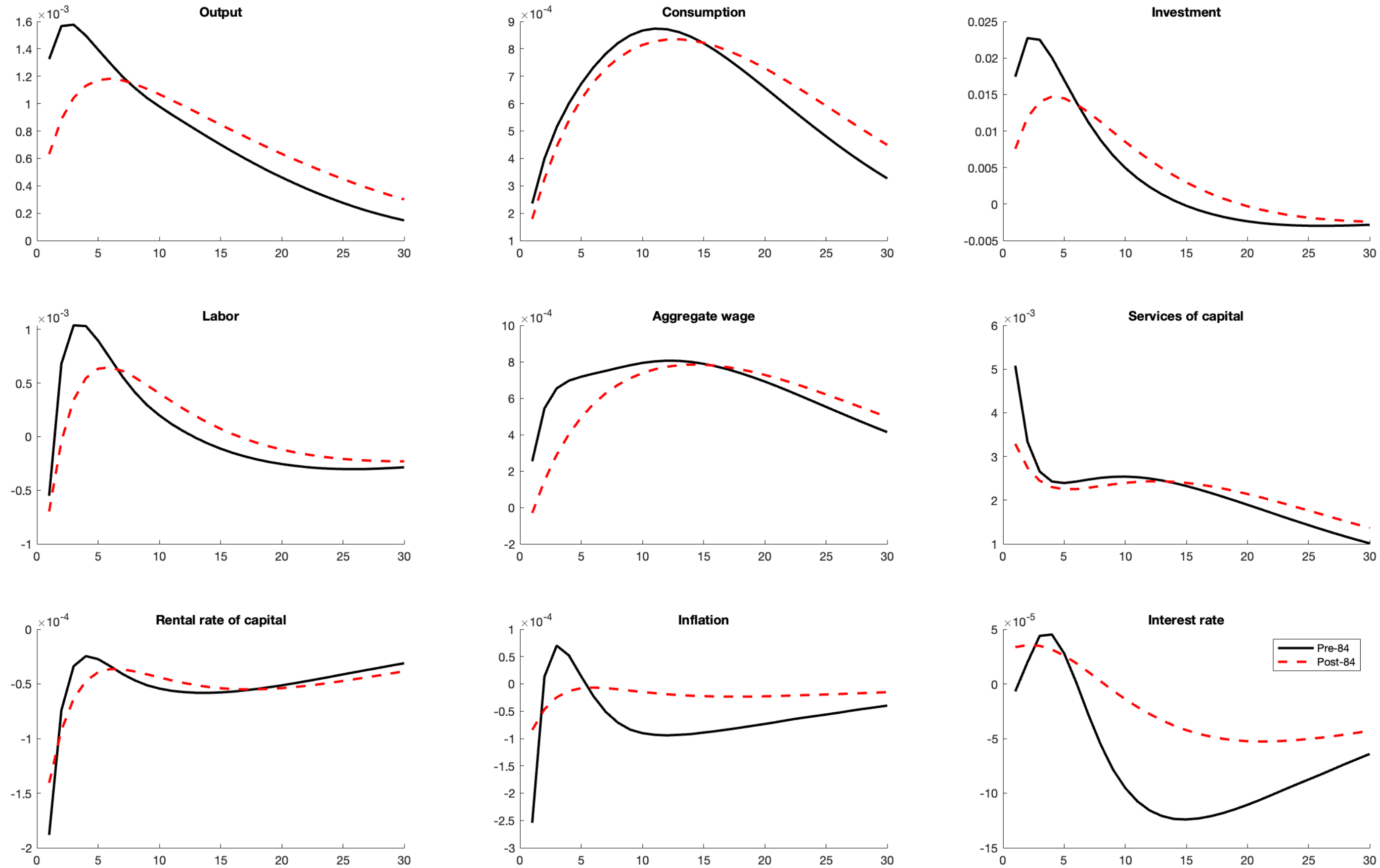
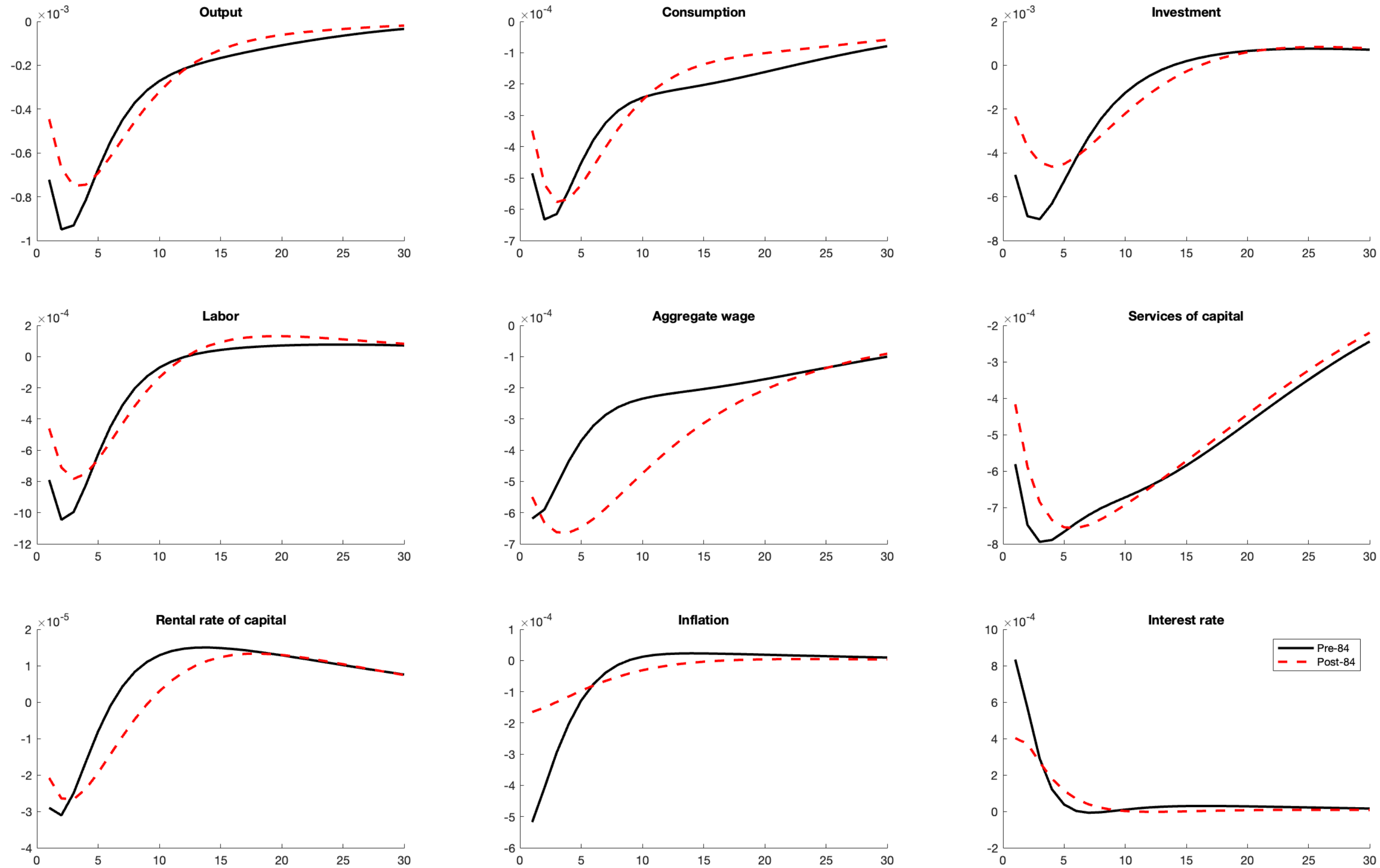


Figure 3.3: Impulse responses functions of the cyclical components of macroeconomic variables following a contractionary monetary policy shock (one period is a quarter)



A positive MEI shock

We then explore the variables' responses to the MEI shock in Figure 3.2. Consistent with the neutral technology shock observations, the direction of the responses are not affected, but we note sizeable differences between the subsamples. The model indicates an economic upswing characterized by increases in output, consumption, investment, and labor. Notably, the model's short-run responses are more pronounced in the pre-1984 subsample. For example, the impact response of output is approximately twice as high in the pre-1984 subsample. Similar to the neutral technology shock scenario, a slight negative response in aggregate wage is observed in the pre-1984 subperiod, contrasted with a positive response in the post-1984 subsample.

A restrictive monetary policy shock

Finally, Figure 3.3 presents the impact of a restrictive monetary policy shock. Typically, a rise in interest rates induces an economic downturn, marked by decreases in output, consumption, investment, labor, and aggregate wage. However, this economic contraction is generally more tempered in the post-1984 subsample, particularly in the short-run, which again is consistent with of the Great Moderation era captured by our estimates. Moreover, unlike the previous shocks, the model's responses maintain consistent signs across both subsamples, even in the case of aggregate wage responses.

3.4.5 The sources of business cycle

Next, we delve into the analysis of the sources of business cycles by examining the forecast error variance decomposition of key economic variables such as output, aggregate labor, aggregate wage, and inflation. This exploration is conducted across various temporal horizons: on impact, at a one-year horizon, and at a ten-year horizon. The computations are based on the posterior means derived from our estimations.

Table 3.6 reveals that the shock to government spending predominantly drives output fluctuations at all considered horizons. This shock is closely followed by preferences and MEI shocks. On impact, these three shocks collectively account for over 90% of the forecast error variance of output, while at the one-year horizon, their contribution is around 75%. These findings are broadly in line with the established literature, such as Smets and Wouters (2007), who identify these three shocks as the main contributor of the forecast error variance of output up to one year. However, our results diverge somewhat from Justiniano *et al.* (2010), who emphasize the investment shock as explaining 50% of output fluctuations at business cycle frequencies, i.e., between 6 and 32 quarters. Our reconciliation with this perspective arises at the ten-year horizon, where the MEI shock emerges as the main driver of output fluctuations. Additionally, while the contribution of the wage markdown shock is very small on impact (0.44%), its influence notably increases to 15.61% at the ten-year horizon, particularly in the pre-1984 subperiod.

Tableau 3.6: Forecast error variance decomposition of output (expressed in percent).

	Horizons					
	On impact		1 year		10 years	
Shocks	Pre-84	Post-84	Pre-84	Post-84	Pre-84	Pro-84
Neutral technology	0.82	0.32	5.46	3.17	6.19	8.90
MEI	14.62	9.54	25.27	19.15	35.36	42.50
Monetary policy	4.20	4.66	8.23	9.43	6.92	7.36
Preference	24.62	41.49	20.18	42.02	11.44	19.51
Government	53.34	41.92	34.43	20.91	19.95	9.11
Wage markdown	0.44	0.27	1.57	0.45	15.61	8.86
Price markup	1.95	1.80	4.86	4.87	4.53	3.76

Notes: The variance decomposition is computed at the mean of the posterior distribution of parameters on impact, at the 1-year horizon (t=4 quarters) and at the 10-year horizon (t=40 quarters).

As displayed in Table 3.7, the government spending shock explains most of the fluctuations in aggregate labor in the pre-1984 subperiod, regardless of the horizon considered. In the post-1984 subsample, the neutral technology shock is predominant driver on impact (37.84%), whereas the preferences shock is the most important driver at the one year (41.04%) and the 10-years horizon (33.13%). We note that the MEI shock does not play a significant role in labor fluctuations, with its contribution not exceeding 9%, regardless of the horizon and the subsample. These findings contrast with those reported in Justiniano *et al.* (2010), who underscore the investment shock as the main determinant of labor variance at business cycle frequencies. Similar to the case of error variance, we observe a temporal increase in the the contribution of wage markdown shock. It grows from 4.04% at the initial impact to 21.90% over a ten-year horizon.

Tableau 3.7: Forecast error variance decomposition of aggregate labor (expressed in percent).

	Horizons					
	On impact		1 year		10 years	
Shocks	Pre-84	Post-84	Pre-84	Post-84	Pre-84	Post-84
Neutral technology	27.92	37.84	18.50	24.41	13.48	17.29
MEI	1.23	4.74	6.01	3.24	9.20	9.63
Monetary policy	2.74	2.10	6.98	6.82	5.95	7.89
Preference	19.97	25.77	22.48	41.04	15.80	33.13
Government	43.28	25.83	38.53	20.39	28.05	15.55
Wage markdown	4.04	3.09	5.20	1.48	21.90	12.19
Price markup	0.82	0.62	2.31	2.63	5.61	4.32

Notes: The variance decomposition is computed at the mean of the posterior distribution of parameters, on impact, at the 1-year horizon (t=4 quarters) and at the 10-year horizon (t=40 quarters).

The decomposition of aggregate wage fluctuations is detailed in Table 3.8, where the wage markdown shock is the dominant factor influencing wage error variance decomposition across all time horizons. On impact, the wage markdown shock accounts for 90% of the wage fluctuations in the pre-1984 period and 95% in the post-1984 period. Over time, however, the role of the wage markdown shock diminishes, while the impacts of MEI and wage markup shocks gain prominence, each accounting for approximately 23% at the ten-year horizon, compared to 8% in total on impact. Unlike the findings of Justiniano *et al.* (2010), our analysis suggests that the fluctuations in aggregate wages are primarily driven by shifts in firms' labor market power, rather than their product market power, i.e. the price markup shock. In other words, aggregate wage fluctuations in our model are driven by changes in the firms' labor market power instead of changes in the firms' products market power.

Tableau 3.8: Forecast error variance decomposition of aggregate wage (expressed in percent).

	Horizons					
	On impact		1 year		10 years	
Shocks	Pre-84	Post-84	Pre-84	Post-84	Pre-84	Pro-84
Neutral technology	0.08	0.47	3.66	0.36	8.17	3.66
MEI	0.39	0.00	3.60	0.87	23.12	24.04
Monetary policy	2.24	1.76	3.31	5.07	3.66	8.27
Preference	0.27	0.34	0.27	1.72	0.50	1.97
Government	0.57	0.46	0.38	0.85	1.59	0.83
Wage markdown	90.00	95.24	65.76	82.16	40.23	46.67
Price markup	6.45	1.73	23.02	8.97	22.74	14.56

Notes: The variance decomposition is computed at the mean of the posterior distribution of parameters, on impact, at the 1-year horizon (t=4 quarters) and at the 10-year horizon (t=40 quarters).

Lastly, the error variance decomposition of inflation, presented in Table 3.9, corroborates the findings in Justiniano *et al.* (2010). The price markup shock is the primary force behind inflation fluctuations across all examined time horizon and both subperiods. For instance, its contribution on impact is 72.97% in the post-1984 subperiod and 56.34% at ten-year horizon in the same subperiod. In addition to the price markup shock, the neutral technology shock plays a significant role. It explains 19.63% and 18.28% of inflation fluctuations in the pre-1984 subsample, respectively on impact and at the ten-year horizon. A notable finding is the stark contrast in the impact of the wage markdown shock between the two subperiods. Its contribution in the pre-1984 period is significantly higher than in the post-1984 period, indicating a shift in its relative importance over time. For instance, on impact, the wage markdown shock accounts for 24.07% of inflation variation in the pre-1984 subsample, while its contribution falls to 5.03% in the post-1984 subperiod. This result suggests, for example, that while the wage markdown shock played a more crucial role than the neutral technology shock in explaining inflation fluctuations in the pre-1984 period, its influence waned post-1984, ceding prominence to the neutral technology shock. This variation in shock contributions highlights the dynamic interplay of economic forces and illustrates how their effects on inflation have shifted over time.

Tableau 3.9: Forecast error variance decomposition of inflation (expressed in percent).

	Horizons					
	On impact		1 year		10 years	
Shocks	Pre-84	Post-84	Pre-84	Post-84	Pre-84	Pro-84
Neutral technology	19.63	10.25	19.54	13.33	18.28	12.44
MEI	1.48	1.24	1.25	1.17	3.43	2.12
Monetary policy	6.20	4.81	9.80	9.55	9.60	11.27
Preference	2.93	3.90	4.06	7.50	3.95	8.63
Government	5.27	1.80	7.39	3.17	7.82	3.88
Wage markdown	24.07	5.03	22.95	4.10	23.05	5.32
Price markup	40.43	72.97	35.00	61.17	33.87	56.34

Notes: The variance decomposition is computed at the mean of the posterior distribution of parameters, on impact, at the 1-year horizon (t=4 quarters) and at the 10-year horizon (t=40 quarters).

3.5 Concluding remarks

In this paper, we estimate a medium-scale New Keynesian DSGE model using Bayesian likelihood techniques. Our approach diverges from the standard polar views of the labor market by introducing a three-segment labor market framework. This innovative structure encompasses segments characterized by perfect competition, monopolistic competition, and monopsonistic competition, providing a more nuanced depiction of labor market dynamics.

We performed our estimations over two distinct subsamples, one spanning from the 1948:Q1 to the onset of the Great Moderation, set at 1983:Q4 and the other from the start of the Great Moderation to 2019:Q4. The Bayesian estimates of standard parameters align broadly with seminal contributions in the field, such as those by Smets and Wouters (2007), Justiniano *et al.* (2010) and Justiniano *et al.* (2011). Furthermore, we produce estimated values for the parameters related to our enhanced labor market structure. This offers insights into a domain that, to our knowledge, had not yet been explored. This includes, but is not limited to, the inverse Frisch elasticities of labor supply and the share of labor income of workers under various competition scenarios.

In line with results from De Loecker *et al.* (2020), our findings resonate with narratives of increasing firms' goods market power in the early 1980s, as evidenced by our estimates of the elasticity of substitution between goods. The rise in firms' labor market power as shown by our estimates of the inverse-Frisch elasticity of f-labor, do not find entire support in the literature as Yeh *et al*. (2022) find that wage markdown declines from 1977 to 2000 and rises afterwards. Additionally, our results align with the widely acknowledged decline in output and inflation volatilities that characterizes of the Great Moderation. Our findings suggest that this pattern can be attributed not only to changes in shock parameters, but also to structural shifts within the economy. These shifts manifest in the impulse responses, where we observe stronger cyclical upturns in the pre-Great Moderation era than thereafter.

While it's pivotal to analyze business cycles from an aggregate perspective, it's equally crucial to recognize that a labor market characterized solely by monopoly, monopsony, or perfect competition is an oversimplification of reality. Our model's contribution allows to incorporate a richer labor market structure, backed by preliminary estimates. However, further research is essential, not only in terms of data collection to identify different segments of the labor market but also in terms of the specification of the estimation. For instance, in order to adress an issue with identification, we arbitrarily estimate the wage markdown shock parameters instead of the wage markup shock parameters. This is very likely to have implications for the estimation outcomes such as variance decomposition of aggregate variables and should be rigorously addressed. Moreover, the algorithm used to estimate the model mechanically excludes episodes in which the Taylor rule inflation gap parameter might be lower than one because of indeterminacy. However, Coibion and Gorodnichenko (2011) show that during the period between 1969 and 1978, the inflation gap parameter was lower than one, thus contrasting with our results.

Furthermore, we assume that the size of the labor market segments is invariant to changes in the economic activity, especially when it has been argued labor unions shape the bargaining power of firms relative to workers. Finally, no explicit distinction between the extensive and the intensive margins is made in the model, especially since fluctuations in aggregate labor are mainly explained by movements in the extensive margin.

CONCLUSION

La compréhension du cycle économique nécessite des modèles macroéconomiques dans lesquels différents agents interagissent au sein de marchés distincts, chacun d'entre eux étant caractérisé par un certain type de concurrence. L'hypothèse concernant le type de concurrence n'est pas anodine puisque les inférences tirées de ces modèles sont le fruit du comportement des agents économiques, conditionné par les contraintes auxquelles ils sont confrontés, et qui dépendent à leur tour de la structure du marché auquel ils appartiennent. En particulier, les modèles Néokeynésiens de taille moyenne, tels que dans Christiano *et al.* (2005) et Smets and Wouters (2007), supposent traditionnellement que le marché du travail est caractérisé par une position dominante des ménages, qui à cause de leurs aptitudes différenciées, possèdent et exercent un certain pouvoir de monopole. Cette hypothèse des modèles standards de la nouvelle macroéconomique Keynésienne, tout comme les autres hypothèses sur la nature de la concurrence dans marché du travail faites dans cette thèse est limitée par l'inexistence à ce jour de données fines qui permettraient d'identifier assez précisément la proportion du marché du travail appartenant à un ou l'autre segment. Pour autant, il n'en demeure pas moins important d'investiguer les mécanismes de transmission des chocs agrégés avec des types alternatifs de compétitions dans le marché du travail.

Ainsi, cette thèse, qui comprend trois chapitres sous forme d'articles, vise à fournir de nouvelles perspectives concernant la modélisation du marché du travail et les implications qui en découlent.

Reconnaissant que certaines preuves empiriques indiquent un marché du travail américain caractérisé par la présence et l'exercice du pouvoir de monopsone des entreprises, nous modifions le modèle standard de la nouvelle macroéconomique Keynésienne en y incorporant un cadre dans lequel la fixation des salaires et les décisions d'embauche appartiennent exclusivement à ces dernières. En comparant ce nouveau cadre avec le monopsone à l'hypothèse traditionnelle de monopole dans le marché du travail, nous obtenons les résultats principaux suivants. Premièrement, à la suite de chocs technologiques, à l'efficience marginale de l'investissement et de politique monétaire, les deux modèles affichent des comportements assez similaires. Cependant, le choc sur les salaires induit des écarts significatifs entre les réponses des modèles, soulignant les différences d'incitatifs entre les ménages et les firmes. Troisièmement, notre analyse révèle que le rabais sur les salaires est contracyclique, conformément à Depew and Sørensen (2013) et Hirsch *et al.* (2018).

Le deuxième chapitre va plus loin en terme de modélisation d'un marché du travail réaliste basé sur notre conviction que les travailleurs peuvent avoir différents niveaux de pouvoir de négociation face aux entreprises, et ce pour diverses raisons. Dans ce contexte, on modélise un marché du travail qui comporte trois segments. Un premier segment présente l'hypothèse traditionnelle de monopole de ménage, un deuxième segment intègre le monopsone des firmes tel que modélisé au premier chapitre, et un troisième segment est caractérisé par la concurrence pure et parfaite entre ménages et firmes. Premièrement, on trouve que nos sentiers de réponse sont en ligne avec des travaux tels que Gali (1999) et Justiniano *et al.* (2010). Par ailleurs, on trouve que le choc monétaire interagit avec les éléments de la composition du marché du travail, le degré de pouvoir de marché de travail des ménages et des firmes et le degré de rigidités salariales. Deuxièmement, on trouve que les effets cycliques induits par les chocs technologiques, à l'efficience marginale de l'investissement et de politique monétaire sont moins forts dans notre modèle relativement au modèle standard. En outre, notre modèle a une meilleure capacité à reproduire la volatilité observée de la production, de l'investissement, du salaire, du travail, de la productivité marginale du travail et de l'inflation, comparé au modèle Néokeynésien traditionnel. Troisièmement, notre modèle permet de proposer une façon d'évaluer une proposition de la Commission Fédérale du Commerce aux États-Unis qui veut bannir des contrats de travail des clauses donnant un pouvoir de marché excessif aux firmes car celles-ci nuisent au bien-être des ménages. Ainsi, notre analyse montre qu'une diminution de la part des travailleurs dans le segment de monopole du marché du travail conduit à une amélioration du bien-être des ménages.

Le troisième chapitre propose de confronter le modèle du chapitre 2 vec les données en ayant recours à la méthode d'estimation bayésienne, pour évaluer sa pertinence empirique. Notre modèle produit des estimés convergents des paramètres traditionnels tout en fournissant des estimés de nouveaux paramètres. Par ailleurs, en comparant les estimés de sous-périodes échantillonales c'est-à-dire de 1948:T1 à 1983:T4 et de 1984:T1 à 2019:T4, le modèle est cohérent avec les idées de baisse de la volatilité macroéconomique pendant la Grande Modération et d'augmentation du pouvoir de marché du travail et des biens et services des entreprises. Finalement, en réévaluant les sources des cycles économiques, le choc sur le rabais sur les salaires contribue le plus aux fluctuations du salaire réel, contrastant ainsi les résultats reportés par Justiniano *et al.* (2010) et qui suggèrent que le choc sur la marge ajoutée sur les prix joue le rôle prédominant.

Au vu de nos résultats, cette thèse représente une avancée dans la modélisation de la dynamique du marché du travail. Cependant, les limites qu'elle présente laissent place à de nombreuses possibilités d'amélioration. Une première possibilité est liée à la façon dont le travail est modélisé. En effet, dans nos différents modèles, le facteur travail est sous forme d'heures-personnes travaillées. Or, de nombreux travaux empiriques montrent que les fluctuations du facteur travail sont essentiellement des fluctuations de la marge extensive c'est-à-dire du nombre de travailleurs. Ainsi, prendre explicitement en compte cette dimension, ainsi que les frictions inhérentes à la recherche et l'appariement est essentiel pour davantage comprendre le marché du travail, et notamment les questions de chômage.

Une autre possibilité concerne les ingrédients du modèle tel que l'inflation tendancielle positive et l'indexation des prix et des salaires. D'un point de vue théorique, Ascari *et al.* (2018), par exemple, ont démontré qu'avoir une inflation tendancielle positive dans un modèle de la nouvelle macroéconomique Keynésienne, en change significativement les implications. Cette avenue est d'autant plus pertinente étant donné que nous avons montré dans cette thèse qu'il existe une interaction particulière entre les chocs de politique monétaire, la composition du marché du travail, le degré de pouvoir de marché et de rigidités salariales. D'un point de vue normatif, une telle avenue est d'autant plus intéressante dans un contexte dans lequel le lien entre le marché du travail, que nous tentons de comprendre, et la politique monétaire semble être plus flou que ce que les économistes auraient pensé.

ANNEXE A

THE MACROECONOMIC IMPLICATIONS OF FIRMS' LABOR MARKET POWER

A.1 The full set of the FLMP equilibrium equations

$$\Upsilon_t = \frac{1}{C_t - bC_{t-1}} - \frac{\beta b}{C_{t+1} - bC_t} \tag{A1}$$

$$q_t = \frac{1}{Z_t}(\chi_1 + \chi_2(u_t - 1)) \tag{A2}$$

$$\Upsilon_t = \mu_t Z_t \left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2 - \tau\left(\frac{X_t}{X_{t-1}} - 1\right)\left(\frac{X_t}{X_{t-1}}\right)\right) + \beta E_t \mu_{t+1} Z_{t+1}\left(\frac{X_{t+1}}{X_t}\right)^2\left(\frac{X_{t+1}}{X_t} - 1\right) \tag{A3}$$

$$\Upsilon_t = \beta E_t \Upsilon_{t+1}(1 + r_{t+1}) \tag{A4}$$

$$\mu_t = \beta E_t\left(\mu_{t+1}(1-\delta)\right) + \beta E_t\left(\Upsilon_{t+1}\left(q_{t+1}u_{t+1} - \left(\chi_1(u_{t+1} - 1) + \frac{\chi_2}{2}(u_{t+1} - 1)^2\right)\right)\frac{1}{Z_{t+1}}\right) \tag{A5}$$

$$K_{t+1} = Z_t\left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2\right)X_t + (1-\delta)K_t \tag{A6}$$

$$\hat{K}_t = u_t K_t \tag{A7}$$

$$d_{1,t} = d_{2,t}\phi_t^w \tag{A8}$$

$$d_{1,t} = \eta^{\frac{1}{\gamma\psi}} w_t L_t^{\frac{1}{\gamma}} \Upsilon_t^{\frac{\gamma - 1 + \gamma\psi}{\gamma\psi}} + \theta_w \beta E_t (1 + \pi_{t+1})^{\frac{-\gamma+1}{\gamma\psi}} d_{1,t+1} \tag{A9}$$

$$d_{2,t} = (1+\psi) w_t^{\#^{\frac{1+\gamma_t\psi_t}{\gamma_t\psi_t}}} \Upsilon_t^{\frac{\psi+1}{\psi}} + \theta_w \beta E_t (1 + \pi_{t+1})^{\frac{-\psi-1}{\psi}} d_{2,t+1} \tag{A10}$$

$$\pi_{EA,t} = w_t L_t - (1-\theta_w)(1+\psi)^{-\gamma} w_t^{\gamma} L_t Aux_{1,t} \tag{A11}$$

$$Aux_{1,t} = w_t^{\#^{1-\gamma}} + \theta_w (1 + \pi_t)^{\gamma - 1} Aux_{1,t-1} \tag{A12}$$

$$w_t^{-\gamma} = (1-\theta_w)(1+\psi)^{-\gamma} Aux_{2,t} \tag{A13}$$

$$Aux_{2,t} = w_t^{\#^{-\gamma}} + \theta_w(1+\pi_t)^{\gamma} Aux_{2,t-1} \tag{A14}$$

$$w_t = mc_t(1-\alpha)A_t\left(\frac{\hat{K}_t}{L_t}\right)^{\alpha} \tag{A15}$$

$$\frac{\hat{K}_t}{L_t} = \frac{\alpha}{1-\alpha}\frac{w_t}{q_t} \tag{A16}$$

$$Y_t = C_t + X_t + \left(\chi_1(u_t-1) + \frac{\chi_2}{2}(u_t-1)^2\right)\frac{K_t}{Z_t} \tag{A17}$$

$$Y_t = \frac{A_t\hat{K}_t^{\alpha}L_t^{1-\alpha} - \Gamma_t}{v_t^p} \tag{A18}$$

$$v_t^p = (1-\theta_p)(1+\pi_t^{\#})^{-\epsilon}(1+\pi_t)^{\epsilon} + (1+\pi_t)^{\epsilon}\theta_p v_{t-1}^p \tag{A19}$$

$$(1+\pi_t)^{1-\epsilon} = (1-\theta_p)(1+\pi_t^{\#})^{1-\epsilon} + \theta_p \tag{A20}$$

$$1+\pi_t^{\#} = \frac{\epsilon}{\epsilon-1}(1+\pi_t)\frac{f_{1,t}}{f_{2,t}} \tag{A21}$$

$$f_{1,t} = mc_tY_t + \theta_pE_t(1+\pi_{t+1})^{\epsilon}\beta f_{1,t+1} \tag{A22}$$

$$f_{2,t} = Y_t + \theta_pE_t(1+\pi_{t+1})^{\epsilon-1}\beta f_{2,t+1} \tag{A23}$$

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R}\right)^{\rho_R}\left[\left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi}\left(\frac{Y_t}{Y_{t-1}}\right)^{\alpha_Y}\right]^{1-\rho_R}\mu_{M,t} \tag{A24}$$

$$mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\frac{w_t^{1-\alpha}q_t^{\alpha}}{A_t} \tag{A25}$$

$$\ln A_t = \rho_A \ln A_{t-1} + \epsilon_{A,t} \tag{A26}$$

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \epsilon_{Z,t} \tag{A27}$$

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t} \tag{A28}$$

$$ln\phi_t^w = (1-\rho_W)ln(Y_t/Y_{t-1}) + \rho_W ln\phi_{t-1}^w + \epsilon_{W,t} \tag{A29}$$

A.2 The full set of the HLMP standard New Keynesian equilibrium equations

$$\Upsilon_t = \frac{1}{C_t - bC_{t-1}} - \frac{\beta b}{C_{t+1} - bC_t} \tag{B1}$$

$$q_t = \frac{1}{Z_t}(\chi_1 + \chi_2(u_t - 1)) \tag{B2}$$

$$\Upsilon_t = \mu_t Z_t \left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2 - \tau\left(\frac{X_t}{X_{t-1}} - 1\right)\left(\frac{X_t}{X_{t-1}}\right)\right) + \beta E_t \mu_{t+1} Z_{t+1}\left(\frac{X_{t+1}}{X_t}\right)^2\left(\frac{X_{t+1}}{X_t} - 1\right) \tag{B3}$$

$$\Upsilon_t = \beta E_t \Upsilon_{t+1}(1 + r_{t+1}) \tag{B4}$$

$$\mu_t = \beta E_t\left(\mu_{t+1}(1-\delta)\right) + \beta E_t\left(\Upsilon_{t+1}\left(q_{t+1}u_{t+1} - \left(\chi_1(u_{t+1} - 1) + \frac{\chi_2}{2}(u_{t+1} - 1)^2\right)\right)\frac{1}{Z_{t+1}}\right) \tag{B5}$$

$$K_{t+1} = Z_t\left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2\right)X_t + (1-\delta)K_t \tag{B6}$$

$$\hat{K}_t = u_t K_t \tag{B7}$$

$$d_{1,t} = d_{2,t}\phi_t^w \tag{B8}$$

$$d_{1,t} = \eta\gamma w_t^{\gamma(1+\psi)} L_t^{1+\psi} + \theta_w \beta E_t (1 + \pi_{t+1})^{\gamma(1+\psi)} d_{1,t+1} \tag{B9}$$

$$d_{2,t} = (\gamma - 1) w_t^{\#^{1+\gamma\psi}} w_t^{\gamma} \lambda_t L_t + \theta_w \beta (1 + \pi_{t+1})^{\gamma-1} d_{2,t+1} \tag{B10}$$

$$w_t^{1-\gamma} = \theta_w w_{t-1}^{1-\gamma}(1 + \pi_{t,t-1})^{\gamma-1} + (1-\theta_w) w_t^{\#^{1-\gamma}} \tag{B11}$$

$$w_t = mc_t(1-\alpha)A_t\left(\frac{\hat{K}_t}{L_t}\right)^{\alpha} \tag{B12}$$

$$\frac{\hat{K}_t}{L_t} = \frac{\alpha}{1-\alpha}\frac{w_t}{q_t} \tag{B13}$$

$$Y_t = C_t + X_t + \left(\chi_1(u_t-1) + \frac{\chi_2}{2}(u_t-1)^2\right)\frac{K_t}{Z_t} \tag{B14}$$

$$Y_t = \frac{A_t\hat{K}_t^{\alpha}L_t^{1-\alpha} - \Gamma_t}{v_t^p} \tag{B15}$$

$$v_t^p = (1-\theta_p)(1+\pi_t^{\#})^{-\epsilon}(1+\pi_t)^{\epsilon} + (1+\pi_t)^{\epsilon}\theta_p v_{t-1}^p \tag{B16}$$

$$(1+\pi_t)^{1-\epsilon} = (1-\theta_p)(1+\pi_t^{\#})^{1-\epsilon} + \theta_p \tag{B17}$$

$$1+\pi_t^{\#} = \frac{\epsilon}{\epsilon-1}(1+\pi_t)\frac{f_{1,t}}{f_{2,t}} \tag{B18}$$

$$f_{1,t} = mc_t Y_t + \theta_p E_t(1+\pi_{t+1})^{\epsilon}\beta f_{1,t+1} \tag{B19}$$

$$f_{2,t} = Y_t + \theta_p E_t(1+\pi_{t+1})^{\epsilon-1}\beta f_{2,t+1} \tag{B20}$$

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R}\right)^{\rho_R}\left[\left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi}\left(\frac{Y_t}{Y_{t-1}}\right)^{\alpha_Y}\right]^{1-\rho_R}\mu_{M,t} \tag{B21}$$

$$mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\frac{w_t^{1-\alpha}q_t^{\alpha}}{A_t} \tag{B22}$$

$$\ln A_t = \rho_A \ln A_{t-1} + \epsilon_{A,t} \tag{B23}$$

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \epsilon_{A,t} \tag{B24}$$

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t} \tag{B25}$$

$$ln\phi_t^w = (1-\rho_W)ln(Y_t/Y_{t-1}) + \rho_W ln\phi_{t-1}^w + \epsilon_{W,t} \quad \text{(B26)}$$

A.3 The textbook wage markdown

From a static point of view, a firm that holds the labor market monopsony power chooses the labor input, L, that maximizes its profit Π, while facing an upward-sloping labor supply curve. It solves the following problem:

$$\max_L \Pi = f(L) - w(L)L, \quad \text{(C1)}$$

where $f(L)$ is the production function, $w(L)$ is the real wage paid for L quantity of labor input. Solving this problem yields the first order condition,

$$\frac{\partial f(L)}{\partial L} = \frac{\partial w(L)}{\partial L} L + \frac{\partial L}{\partial L} w(L), \quad \text{(C2)}$$

$$f'(L) = \frac{\partial w(L)}{\partial L} \frac{L}{w(L)} w(L) + w(L), \quad \text{(C3)}$$

$$f'(L) = w(L) \left[1 + \frac{1}{\epsilon(L)} \right], \quad \text{(C4)}$$

$$w(L) = \frac{\epsilon(L)}{\epsilon(L)+1} f'(L). \quad \text{(C5)}$$

This last equation links the firm's wage to the marginal revenue product of labor $f'(L)$ and the elasticity of labor supply to an individual firm, $\epsilon(L) \equiv \frac{\partial L}{\partial w(L)} \frac{w(L)}{L}$. Therefore, $\epsilon(L)$ measures the degree of firms wage-setting power. For instance, $\epsilon(L) = 1$ means that the firm pays workers only 50% of their marginal revenue product. One way, quite common in the empirical literature, to measure $\epsilon(L)$ is through a direct estimate from a regression in the form of

$$ln(L) = \epsilon(L)ln(w) + \zeta, \tag{C6}$$

where L is the labor input and w is the real wage. Once $\epsilon(L)$ is estimated, it is possible to infer the extent of the wage markdown using equation (C5). In our model, instead of having the elasticity of labor supply, $\epsilon(L)$, we have the Frisch elasticity of labor supply captured by the parameter $1/\psi$. Therefore, based on some empirical evidence, we can have a target for the wage markdown in our theoretical framework.

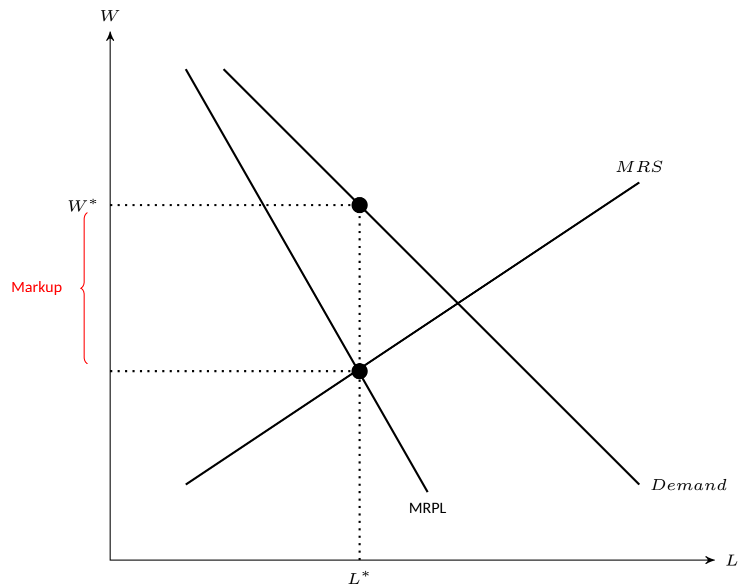


Figure A.1: Households' monopoly in the labor market.

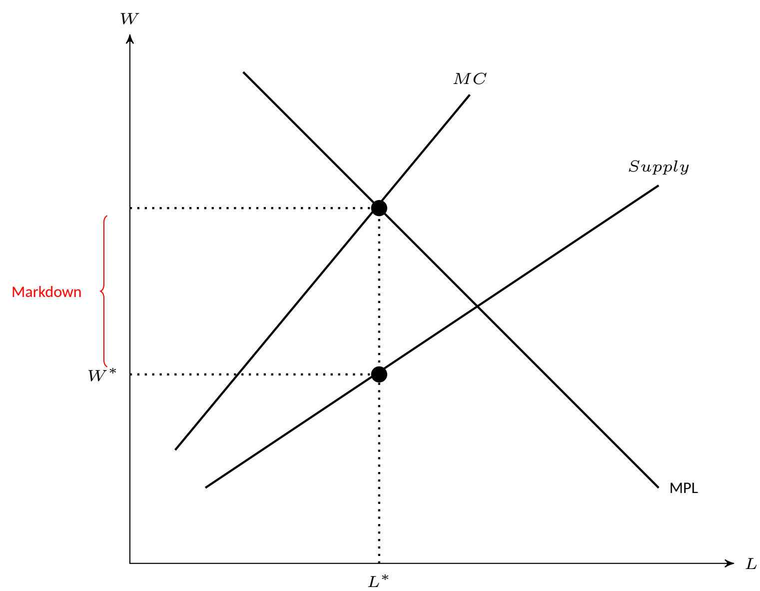


Figure A.2: Firms' monopsony in the labor market.

A.4 Impulse response functions

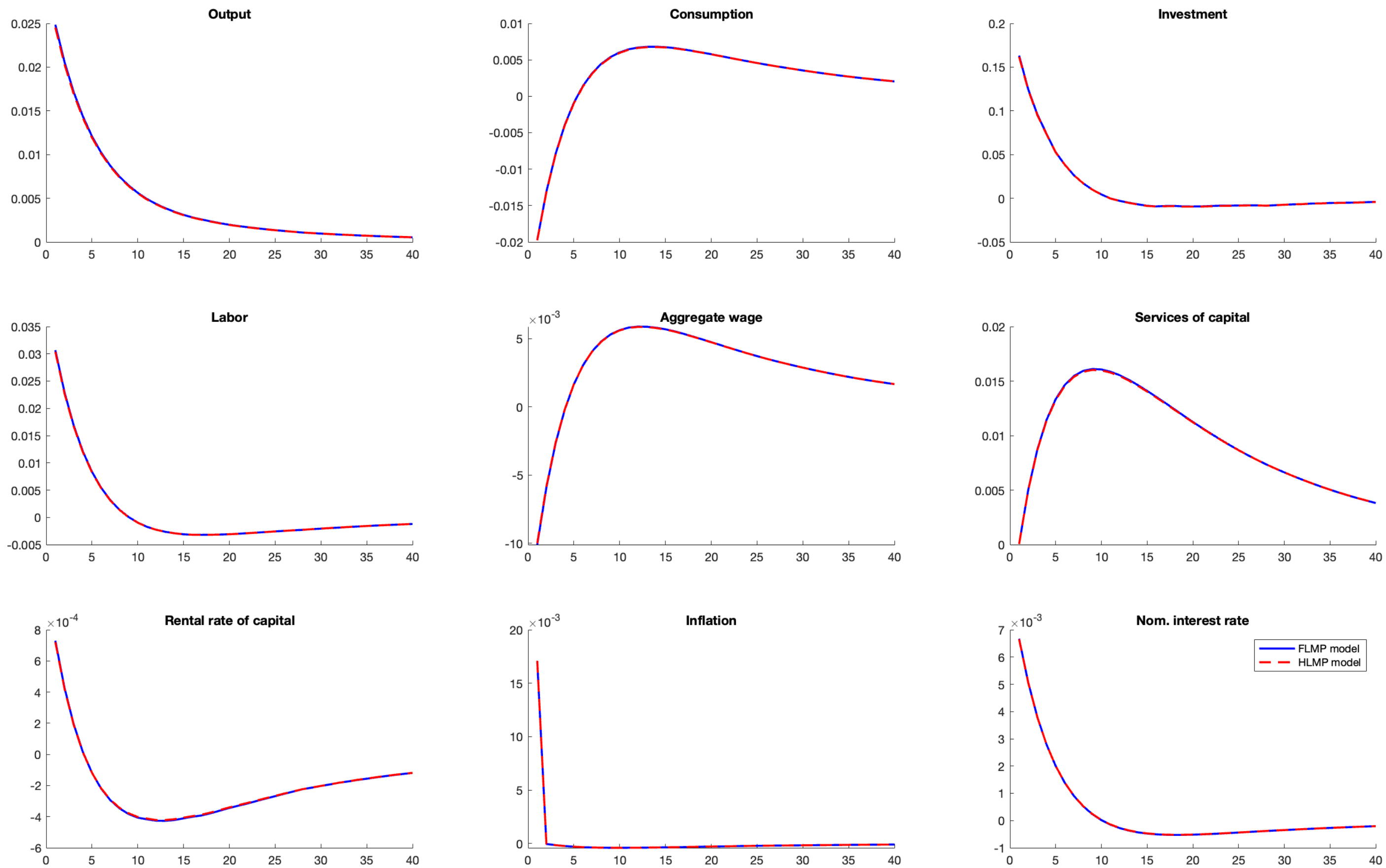


Figure A.3: Impulse responses of the cyclical components of macroeconomic variables following a MEI shock: labor market monopoly versus labor market monopsony, when there are no real and nominal frictions (one period is a quarter).

Note: Real frictions include habits formation in consumption, investment adjustment costs, variable utilization of physical capital. Nominal frictions include nominal price and wage rigidities.

A.5 Business cycle volatilities, contemporaneous correlations and autocorrelation in the absence of a wage shock

Tableau A.1: Volatility: No wage shock

Panel A: Absolute volatility

	$\sigma(Y)$	$\sigma(C)$	$\sigma(I)$	$\sigma(W)$	$\sigma(L)$	$\sigma(MPL)$	$\sigma(\pi)$
Data	0.02	0.008	0.06	0.009	0.01	0.01	0.004
FLMP model	0.03	0.006	0.09	0.007	0.02	0.01	0.004
HLMP model	0.03	0.006	0.1	0.007	0.02	0.01	0.004

Panel B: Relative volatility

	$\sigma(\frac{Y}{Y})$	$\sigma(\frac{C}{Y})$	$\sigma(\frac{I}{Y})$	$\sigma(\frac{W}{Y})$	$\sigma(\frac{L}{Y})$	$\sigma(\frac{MPL}{Y})$	$\sigma(\frac{\pi}{Y})$
Data	1	0.38	3.03	0.44	0.89	0.49	0.20
FLMP model	1	0.21	3.20	0.24	0.84	0.48	0.15
HLMP model	1	0.21	3.20	0.22	0.85	0.46	0.14

Notes: This table displays the volatility and the relative volatility of the cyclical component of HP filtered empirical or simulated series. "σ" refers to standard deviation. ”FLMP” and ”HLMP” refer to firms’ labor market power and households’ labor market power, respectively, and thus they are simulated series. Empirical series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

Tableau A.2: Contemporaneous cross correlations: No wage shock.

	$\rho(Y,C)$	$\rho(Y,I)$	$\rho(Y,W)$	$\rho(Y,L)$	$\rho(Y,MPL)$
Data	0.79	0.89	0.15	0.86	0.44
FLMP model	0.35	0.98	0.52	0.87	0.55
HLMP model	0.40	0.98	0.45	0.89	0.53

	$\rho(Y,\pi)$	$\rho(C,I)$	$\rho(C,W)$	$\rho(C,L)$	$\rho(C,\pi)$
Data	0.32	0.60	0.22	0.73	0.25
FLMP model	0.40	0.27	0.96	0.06	-0.0002
HLMP model	0.38	0.33	0.97	0.13	0.02

	$\rho(L,W)$	$\rho(L,MPL)$	$\rho(L,\pi)$	$\rho(W,MPL)$	$\rho(W,\pi)$
Data	-0.05	-0.05	0.32	0.41	-0.01
FLMP model	0.21	0.08	0.72	0.69	0.09
HLMP model	0.16	0.08	0.68	0.70	0.44

Notes: This table displays the contemporaneous cross correlation between the cyclical component of HP filtered empirical or simulated series. "ρ" refers to the contemporanous cross correlation. "FLMP" and "HLMP" refer to firms' labor market power and households' labor market power, respectively, and thus they are simulated series. Empirical series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

Tableau A.3: Autocorrelation functions (one to four lags): No wage shock.

	Lag	-1	-2	-3	-4
Output	Empirical	0.84	0.60	0.33	0.09
	FLMP model	0.90	0.71	0.49	0.26
	HLMP model	0.90	0.72	0.52	0.29
Consumption	Empirical	0.84	0.66	0.45	0.22
	FLMP model	0.36	0.34	0.32	0.28
	HLMP model	0.42	0.41	0.37	0.33
Investment	Empirical	0.82	0.46	0.26	-0.004
	FLMP model	0.93	0.77	0.57	0.34
	HLMP model	0.93	0.78	0.58	0.36
Real wage	Empirical	0.68	0.47	0.29	0.12
	FLMP model	0.49	0.43	0.34	0.35
	HLMP model	0.41	0.34	0.26	0.18
Labor	Empirical	0.90	0.70	0.45	0.20
	FLMP model	0.88	0.76	0.56	0.34
	HLMP model	0.89	0.77	0.58	0.37
Labor prod.	Empirical	0.70	0.46	0.19	0.009
	FLMP model	0.33	0.16	0.04	-0.05
	HLMP model	0.31	0.15	0.03	-0.06
Inflation	Empirical	0.49	0.27	0.11	-0.07
	FLMP model	0.48	0.43	0.33	0.21
	HLMP model	0.45	0.41	0.32	0.21

Notes: This table displays the autocorrelation coefficients of the cyclical component of HP filtered empirical or simulated series. ”FLMP” and ”HLMP” refer to firms’ labor market power and households’ labor market power, respectively, and thus they are simulated series. Empirical series cover the sample 1948Q1 to 2019-Q4. The simulated series are based on 4000 replications from which we burn the first 500.

ANNEXE B

THE CYCLICAL AND WELFARE IMPLICATIONS OF A COMPLETE LABOR MARKET STRUCTURE IN A MACROECONOMIC MODEL

B.1 The full set of equilibrium equations

$$\Upsilon_t P_t = \frac{1}{C_t - bC_{t-1}} - \frac{\beta b}{C_{t+1} - bC_t} \tag{B1}$$

$$q_t = \frac{1}{Z_t}(\chi_1 + \chi_2(u_t - 1)) \tag{B2}$$

$$\Upsilon_t = \mu_t Z_t \left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2 - \tau\left(\frac{X_t}{X_{t-1}} - 1\right)\left(\frac{X_t}{X_{t-1}}\right)\right) + \beta E_t \mu_{t+1} Z_{t+1} \left(\frac{X_{t+1}}{X_t}\right)^2 \left(\frac{X_{t+1}}{X_t} - 1\right) \tag{B3}$$

$$\Upsilon_t = \beta E_t \Upsilon_{t+1}(1 + r_{t+1}) \tag{B4}$$

$$\mu_t = \beta E_t \left(\mu_{t+1}(1-\delta)\right) + \beta E_t \left(\Upsilon_{t+1}\left(q_{t+1}u_{t+1} - \left(\chi_1(u_{t+1} - 1) + \frac{\chi_2}{2}(u_{t+1} - 1)^2\right)\right)\frac{1}{Z_{t+1}}\right) \tag{B5}$$

$$K_{t+1} = Z_t \left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2\right) X_t + (1-\delta)K_t \tag{B6}$$

$$\hat{K}_t = u_t K_t \tag{B7}$$

$$L_t = L_{f,t}^{\alpha_l} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h} \tag{B8}$$

$$\frac{\hat{K}_t}{L_t} = \frac{\alpha}{1-\alpha}\frac{w_t}{q_t} \tag{B9}$$

$$w_{j,t} = (1-\alpha)\alpha_j A_t \left(\frac{\hat{K}_t}{L_t}\right)^{\alpha} \frac{L_t}{L_{j,t}} mc_t \forall j \in \{f, c, h\} \tag{B10}$$

$$L_t = L_{f,t}^{\alpha_l} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h} \tag{B11}$$

$$w_t = w_{f,t}^{\alpha_l} w_{c,t}^{\alpha_c} w_{h,t}^{\alpha_h} \tag{B12}$$

$$Y_t = C_t + X_t + \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{K_t}{Z_t} \tag{B13}$$

$$Y_t = \frac{A_t \hat{K}_t^{\alpha} \left(L_{f,t}^{\alpha_f} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h} \right)^{1-\alpha} - \Gamma_t}{v_t^p} \tag{B14}$$

$$v_t^p = (1-\theta_p)(1+\pi_t^{\#})^{-\epsilon_t}(1+\pi_t)^{\epsilon_t} + (1+\pi_t)^{\epsilon_t}\theta_p v_{t-1}^p \tag{B15}$$

$$(1+\pi_t)^{1-\epsilon_t} = (1-\theta_p)(1+\pi_t^{\#})^{1-\epsilon_t} + \theta_p \tag{B16}$$

$$1+\pi_t^{\#} = \frac{\epsilon_t}{\epsilon_t - 1}(1+\pi_t)\frac{f_{1,t}}{f_{2,t}} \tag{B17}$$

$$f_{1,t} = mc_t Y_t + \theta_p E_t (1+\pi_{t+1})^{\epsilon_t} \beta f_{1,t+1} \tag{B18}$$

$$f_{2,t} = Y_t + \theta_p E_t (1+\pi_{t+1})^{\epsilon_t - 1} \beta f_{2,t+1} \tag{B19}$$

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R} \right)^{\rho_R} \left[\left(\frac{1+\pi_t}{1+\pi} \right)^{\alpha_\pi} \left(\frac{Y_t}{Y_{t-1}} g^{-1} \right)^{\alpha_Y} \right]^{1-\rho_R} \mu_{M,t} \tag{B20}$$

$$lnA_t = \rho_A lnA_{t-1} + \epsilon_{A,t} \tag{B21}$$

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \epsilon_{Z,t} \tag{B22}$$

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t} \tag{B23}$$

$$a_{1,t} = a_{2,t} \tag{B24}$$

$$a_{1,t} = \eta_f^{\frac{1}{\gamma_f \psi_f}} w_{f,t} L_{f,t}^{\frac{1}{\gamma_f}} \Upsilon_t^{\frac{\gamma_f - 1 + \gamma_f \psi_f}{\gamma_f \psi_f}} + \theta_{f,w} \beta E_t (1+\pi_{t+1})^{\frac{-\gamma_f + 1}{\gamma_f \psi_f}} a_{1,t+1} \tag{B25}$$

$$a_{2,t} = (1+\psi_f) w_{f,t}^{\#\frac{1+\gamma_f \psi_f}{\gamma_f \psi_f}} \Upsilon_t^{\frac{\psi_f + 1}{\psi_f}} + \theta_{f,w} \beta E_t (1+\pi_{t+1})^{\frac{-\psi_f - 1}{\psi_f}} a_{2,t+1} \tag{B26}$$

$$L_{f,t}^{\#} = \left((1+\psi_f) \frac{w_{f,t}^{\#}}{w_{f,t}} \right)^{-\gamma_f} L_{f,t} \tag{B27}$$

$$w_{f,t}^{-\gamma_f} = (1-\theta_{f,w})(1+\psi_f)^{-\gamma_f} b_{1,t} \tag{B28}$$

$$b_{1,t} = w_{f,t}^{\#^{-\gamma_f}} + \theta_{f,w}(1+\pi_t)^{\gamma_f} b_{1,t-1} \tag{B29}$$

$$\pi_{EA,t} = w_{f,t}L_{f,t} - (1-\theta_{f,w})(1+\psi_f)^{-\gamma_f} w_t^{\gamma_f} L_{f,t} b_{2,t} \tag{B30}$$

$$b_{2,t} = w_{f,t}^{\#^{1-\gamma_f}} + \theta_{f,w}(1+\pi_t)^{\gamma_f - 1} b_{2,t-1} \tag{B31}$$

$$\eta_c L_{c,t}^{\psi_c} = \Upsilon_t w_{c,t} \tag{B32}$$

$$w_{h,t}^{\#} = \frac{\gamma_h}{\gamma_h - 1}\frac{c_{1,t}}{c_{2,t}} \tag{B33}$$

$$c_{1,t} = \eta_h \left(\frac{w_{ht}}{w_{h,t}^{\#}}\right)^{\gamma_h(1+\psi_h)} L_{h,t}^{1+\psi_h} + \theta_{h,w}\beta E_t(1+\pi_{t+1})^{\gamma_h(1+\psi_h)} \left(\frac{w_{h,t+1}^{\#}}{w_{h,t}^{\#}}\right)^{\gamma_h(1+\psi_h)} c_{1,t+1} \tag{B34}$$

$$c_{2,t} = \Upsilon_t \left(\frac{w_{h,t}}{w_{h,t}^{\#}}\right)^{\gamma_h} L_{h,t} + \theta_{w,h}\beta E_t(1+\pi_{t+1})^{\gamma_h - 1} \left(\frac{w_{h,t+1}^{\#}}{w_{h,t}^{\#}}\right)^{\gamma_t} c_{2,t+1} \tag{B35}$$

$$w_{h,t}^{1-\gamma_h} = \theta_{h,w} w_{h,t-1}^{1-\gamma_h}(1+\pi_{t,t-1})^{\gamma_h - 1} + (1-\theta_{h,w}) w_{h,t}^{\#^{1-\gamma_h}} \tag{B36}$$

ANNEXE C

AN ESTIMATED DSGE MODEL WITH MULTIPLE TYPES OF COMPETITION IN THE LABOR MARKET

C.1 The full set of equilibrium equations

$$\Upsilon_t P_t = \frac{1}{C_t - bC_{t-1}} - \frac{\beta b}{C_{t+1} - bC_t} \tag{C1}$$

$$q_t = \frac{1}{Z_t}(\chi_1 + \chi_2(u_t - 1)) \tag{C2}$$

$$\Upsilon_t = \mu_t Z_t \left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2 - \tau\left(\frac{X_t}{X_{t-1}} - 1\right)\left(\frac{X_t}{X_{t-1}}\right)\right) + \beta E_t \mu_{t+1} Z_{t+1}\left(\frac{X_{t+1}}{X_t}\right)^2\left(\frac{X_{t+1}}{X_t} - 1\right) \tag{C3}$$

$$\Upsilon_t = \beta E_t \Upsilon_{t+1}(1 + r_{t+1}) \tag{C4}$$

$$\mu_t = \beta E_t\left(\mu_{t+1}(1-\delta)\right) + \beta E_t\left(\Upsilon_{t+1}\left(q_{t+1}u_{t+1} - \left(\chi_1(u_{t+1} - 1) + \frac{\chi_2}{2}(u_{t+1} - 1)^2\right)\right)\frac{1}{Z_{t+1}}\right) \tag{C5}$$

$$K_{t+1} = Z_t\left(1 - \tau/2\left(\frac{X_t}{X_{t-1}} - 1\right)^2\right)X_t + (1-\delta)K_t \tag{C6}$$

$$\hat{K}_t = u_t K_t \tag{C7}$$

$$L_t = L_{f,t}^{\alpha_l} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h} \tag{C8}$$

$$w_t = w_{f,t}^{\alpha_l} w_{c,t}^{\alpha_c} w_{h,t}^{\alpha_h} \tag{C9}$$

$$\frac{\hat{K}_t}{L_t} = \frac{\alpha}{1-\alpha}\frac{w_t}{q_t} \tag{C10}$$

$$Y_t = C_t + X_t + \left(\chi_1(u_t - 1) + \frac{\chi_2}{2}(u_t - 1)^2\right)\frac{K_t}{Z_t} \tag{C11}$$

$$Y_t = \frac{A_t \hat{K}_t^{\alpha}\left(L_{f,t}^{\alpha_f} L_{c,t}^{\alpha_c} L_{h,t}^{\alpha_h}\right)^{1-\alpha} - \Gamma_t}{v_t^p} \tag{C12}$$

$$v_t^p = (1-\theta_p)(1+\pi_t^{\#})^{-\epsilon}(1+\pi_t)^{\epsilon} + (1+\pi_t)^{\epsilon}\theta_p v_{t-1}^p \tag{C13}$$

$$(1+\pi_t)^{1-\epsilon} = (1-\theta_p)(1+\pi_t^{\#})^{1-\epsilon} + \theta_p \tag{C14}$$

$$1+\pi_t^{\#} = \frac{\epsilon}{\epsilon-1}(1+\pi_t)\frac{f_{1,t}}{f_{2,t}} \tag{C15}$$

$$f_{1,t} = mc_t Y_t + \theta_p E_t (1+\pi_{t+1})^{\epsilon} \beta f_{1,t+1} \tag{C16}$$

$$f_{2,t} = Y_t + \theta_p E_t (1+\pi_{t+1})^{\epsilon-1} \beta f_{2,t+1} \tag{C17}$$

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R}\right)^{\rho_R} \left[\left(\frac{1+\pi_t}{1+\pi}\right)^{\alpha_\pi} \left(\frac{Y_t}{Y_{t-1}} g^{-1}\right)^{\alpha_Y}\right]^{1-\rho_R} \mu_{M,t} \tag{C18}$$

$$lnA_t = \rho_A lnA_{t-1} + \epsilon_{A,t} \tag{C19}$$

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \epsilon_{Z,t} \tag{C20}$$

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t} \tag{C21}$$

$$a_{1,t} = a_{2,t} \tag{C22}$$

$$a_{1,t} = \eta_f^{\frac{1}{\gamma_f \psi_{f,t}}} w_{f,t} L_{f,t}^{\frac{1}{\gamma_f}} \Upsilon_t^{\frac{\gamma_f - 1 + \gamma_f \psi_{f,t}}{\gamma_f \psi_{f,t}}} + \theta_{f,w} \beta E_t (1+\pi_{t+1})^{\frac{-\gamma_f + 1}{\gamma_f \psi_{f,t}}} a_{1,t+1} \tag{C23}$$

$$a_{2,t} = (1+\psi_{f,t}) w_{f,t}^{\#\frac{1+\gamma_f \psi_{f,t}}{\gamma_f \psi_{f,t}}} \Upsilon_t^{\frac{\psi_{f,t+1}}{\psi_{f,t}}} + \theta_{f,w} \beta E_t (1+\pi_{t+1})^{\frac{-\psi_{f,t}-1}{\psi_{f,t}}} a_{2,t+1} \tag{C24}$$

$$L_{f,t}^{\#} = \left((1+\psi_{f,t}) \frac{w_{f,t}^{\#}}{w_{f,t}}\right)^{-\gamma_f} L_{f,t} \tag{C25}$$

$$w_{f,t}^{-\gamma_f} = (1-\theta_{f,w})(1+\psi_{f,t})^{-\gamma_f} b_{1,t} \tag{C26}$$

$$b_{1,t} = w_{f,t}^{\#^{-\gamma_f}} + \theta_{f,w} (1+\pi_t)^{\gamma_f} b_{1,t-1} \tag{C27}$$

$$\pi_{EA,t} = w_{f,t} L_{f,t} - (1-\theta_{f,w})(1+\psi_{f,t})^{-\gamma_f} w_t^{\gamma_f} L_{f,t} b_{2,t} \tag{C28}$$

$$b_{2,t} = w_{f,t}^{\#^{1-\gamma_f}} + \theta_{f,w}(1+\pi_t)^{\gamma_f - 1} b_{2,t-1} \tag{C29}$$

$$\eta_c L_{c,t}^{\psi_c} = \Upsilon_t w_{c,t} \tag{C30}$$

$$w_{h,t}^{\#} = \frac{\gamma_{h,t}}{\gamma_{h,t} - 1} \frac{c_{1,t}}{c_{2,t}} \tag{C31}$$

$$c_{1,t} = \eta_h \left(\frac{w_{ht}}{w_{h,t}^{\#}} \right)^{\gamma_{h,t}(1+\psi_h)} L_{h,t}^{1+\psi_h} + \theta_{h,w} \beta E_t (1+\pi_{t+1})^{\gamma_{h,t}(1+\psi_h)} \left(\frac{w_{h,t+1}^{\#}}{w_{h,t}^{\#}} \right)^{\gamma_{h,t}(1+\psi_h)} c_{1,t+1} \tag{C32}$$

$$c_{2,t} = \Upsilon_t \left(\frac{w_{h,t}}{w_{h,t}^{\#}} \right)^{\gamma_{h,t}} L_{h,t} + \theta_{w,h} \beta E_t (1+\pi_{t+1})^{\gamma_{h,t}-1} \left(\frac{w_{h,t+1}^{\#}}{w_{h,t}^{\#}} \right)^{\gamma_t} c_{2,t+1} \tag{C33}$$

$$w_{h,t}^{1-\gamma_{h,t}} = \theta_{h,w} w_{h,t-1}^{1-\gamma_{h,t}} (1+\pi_{t,t-1})^{\gamma_{h,t}-1} + (1-\theta_{h,w}) w_{h,t}^{\#^{1-\gamma_{h,t}}} \tag{C34}$$

$$w_{j,t} = (1-\alpha)\alpha_j A_t \left(\frac{\hat{K}_t}{L_t} \right)^{\alpha} \frac{L_t}{L_{j,t}} mc_t \forall j \in \{f, c, h\} \tag{C35}$$

$$\ln A_t = \rho_A lnA_{t-1} + \epsilon_{A,t} \tag{C36}$$

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \epsilon_{Z,t} \tag{C37}$$

$$ln\mu_{M,t} = \rho_M ln\mu_{M,t-1} + \epsilon_{M,t} \tag{C38}$$

$$\ln \omega_t = \rho_\omega ln\omega_{t-1} + \epsilon_{\omega,t} \tag{C39}$$

$$lng_t = (1-\rho_g) lng + \rho_g lng_{t-1} + \epsilon_{g,t} \tag{C40}$$

$$\psi_{f,t} = (1-\rho_\psi)\psi_{f,t}^* + \rho_\psi \psi_{f,t-1} + \epsilon_{\psi,t}. \tag{C41}$$

$$\gamma_t = (1-\rho_\gamma)\gamma^* + \rho_\gamma \gamma_{t-1} + \epsilon_{\gamma,t} \tag{C42}$$

C.2 The Bayesian estimation of DSGE models

C.2.1 The advantages of Bayesian estimation and key considerations

There are two predominant techniques for estimating DSGE models: Bayesian estimation and maximum likelihood estimation (MLE). The former technique has several interesting advantages over the latter that we consider in this case. First, Bayesian methods adeptly integrate prior theoretical knowledge and empirical findings into the estimation process, enhancing parameter identification, especially in cases of limited data. Second, Unlike MLE, which offers only point estimates, Bayesian estimation elucidates the full probability distribution of parameters, providing a comprehensive assessment of uncertainty and parameter variability. This allows for the assessment of not only the estimates themselves but also the range of plausible parameter values. Third, Bayesian estimation exhibits greater robustness in managing complex models with numerous parameters or latent variables, where MLE may struggle with issues of convergence or parameter identification.

Applying the Bayes' theorem, Bayesian estimation of DSGE models consist of updating priors beliefs on parameters using observed data. From a practical point of view, the following elements are key:

- Prior distributions: they incorporate existing knowledge or beliefs about the parameters' possible values before observing the current data. The choice of priors can be based on previous empirical studies or theoretical considerations. Moreover, they play a critical role in influencing posterior estimates, especially in cases of limited data.

- Likelihood function and model solution: the likelihood function represents the probability of observing the data given specific values of the model parameters. It is formulated around the solution of the DSGE model under different parameter configurations.

- Metropolis-Hasting Algorithm: Bayesian estimation requires Markov Chain Monte Carlo (MCMC) methods, such as the Metropolis-Hastings algorithm. In fact, this algorithm facilitates the approximation of posterior distributions of parameters. It proposes new parameter values based on a proposal distribution and decides on their acceptance based on an acceptance ratio.

- Model calibration and Bayesian inference: the calibration involves setting certain parameters based on prior studies or theoretical insights, while the estimation focuses on those parameters that are crucial for the dynamics of interest and for which prior information is less certain.

C.2.2 Technical summary

The fundamental equation guiding Bayesian estimation is Bayes' theorem:

$$P(\Theta/\Omega) = \frac{P(\Omega/\Theta)P(\Theta)}{P(\Omega)}, \tag{C43}$$

where

- Θ is the vector of model parameters
- Ω represents the observed data
- $P(\Theta/\Omega)$ is the posterior distribution of the parameters given the data
- $P(\Omega/\Theta)p(\Theta)$ is the likelihood function
- $P(\Theta)$ is the prior distribution of the parameters
- $P(\Omega)$ is the marginal likelihood of the observed data.

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