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Essays in Theoretical and Applied Macroeconomics

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RÉSUMÉ

Cette thèse s'articule autour de trois chapitres indépendants qui s'inscrivent dans les champs de la macroéconomie, de l'économie monétaire et de la finance internationale. Dans le premier chapitre, je construis un modèle néo-keynesien d'équilibre général sous incertitude pour examiner les implications de la production domestique des ménages pour la politique monétaire. Le modèle proposé permet de reconcilier deux faits empiriques majeurs : la forte sensibilité du produit intérieur brut aux chocs monétaires—obtenue à partir des modèles VAR—et le faible degré de rigidité nominale observé dans les micro-données. Le deuxième chapitre étudie le role de la transformation structurelle—réallocation de la main d'oeuvre entre secteurs—sur la volatilité de la production aggregée dans un panel de pays. Le troisième chapitre quant à lui met en exergue l'importance de la cartographie des échanges commerciaux pour le choix entre un régime de change fixe et l'arrimage à un panier de devises.

"Household Production, Services and Monetary Policy" (Chapitre 1) part de l'observation selon laquelle les ménages peuvent produire à domicile des substituts aux services marchands, contrairement aux biens non durables qu'ils acquièrent presque exclusivement sur le marché. Dans ce contexte, ils procèdent à d'importants arbitrages entre produire les services à domicile ou les acquerir sur le marché, dépendamment des changements dans leur revenu. Pour examiner les implications de tels arbitrages—qui s'avèrent être importants dans les micro données—le secteur domestique est introduit dans un modèle néo-keyenesien d'équilibre général sous incertitude à deux secteurs—le secteur des biens non durables et le secteur des services—autrement standard. Je montre que les firmes du secteur des services sont moins enclin à changer leurs prix du fait que les ménages ont l'option de produire soit même des services substituts. Ceci se traduit par la présence d'un terme endogène supplémentaire qui déplace la courbe de Phillips dans ce secteur. Ce terme croit avec le degré de substituabilité qui existe entre les services produits à domicile et ceux acquis sur le marché. Cet accroissement de la rigidité nominale amplifie la sensibilité de

la production réelle aux chocs monétaires, notamment dans le secteur des services, ce qui est compatible avec l'évidence VAR selon laquelle les services de consommation sont plus sensibles aux variations de taux d'intérêt que les biens non durables.

"Structural Transformation and the Volatility of Aggregate Output : a cross-country analysis" (Chapitre 2) est basée sur l'évidence empirique d'une relation négative entre la part de la main d'oeuvre allouée au secteur des services et la volatilité de la production aggrégée, même lorsque je contrôle pour les facteurs tels que le développement du secteur financier. Ce resultat aggregé est la conséquence des développements sectoriels : la productivité de la main d'oeuvre est beaucoup plus volatile dans l'agriculture et les industries manufacturière que dans les services. La production aggregée deviendrait donc mécaniquement moins volatile au fur et à mesure que la main d'oeuvre se déplace de l'agriculture et de la manufacture vers les services. Pour évaluer cette hypothèse, je calibre un modèle de transformation structurelle à l'économie américaine, que j'utilise ensuite pour générer l'allocation sectorielle de la main d'oeuvre dans l'agriculture, l'industrie et les services pour les autres pays de l'OCDE. Dans une analyse contre-factuelle, le modèle est utlis e pour restreindre la mobilité de la main d'oeuvre entre secteurs de façon endogène. Les calculs montrent alors que le déplacement de la main d'oeuvre vers le secteur des services réduit en effet la volatilité de la production aggregée.

"Exchange Rate Volatility under Alternative Peg Regimes : Do Trade Patterns Matter ?" (Chapitre 3) est une contribution à la litterature économique qui s'interesse au choix entre divers regimes de change. J'utilise les données mensuelles de taux de change bilatéraux et de commerce extérieur entre 1980 et 2010 pour les pays membre de l'Union Economique et Monétaire Ouest Africaine (UEMOA). La monnaie de ces pays—le franc CFA—est arrimée au franc Francais depuis le milieu des années 40 et à l'euro depuis son introduction en 1999. Au moment de l'arrimage initial, la France était le principal partenaire commercial des pays de l'UEMOA. Depuis lors, et plus encore au cours des dix dernières années, la cartographie des échanges de l'union a significativement changé en faveur des pays du

groupe des BICs—notamment la Chine. Je montre dans ce chapitre que l'arrimage à un panier de devises aurait induit une volatilité moins pronnoncée du taux de change effectif nominal du franc CFA au cours de la décennie écoulée, comparé à la parité fixe actuelle. Ce chapitre, cependant, n'aborde pas la question de taux de change optimal pour les pays de l'UEMOA, un aspect qui serait intéressant pour une recherche future.

Mots clés: Production domestique, Services, Biens non durables, Courbe de Phillips néo-keynésienne ; Transformation structurelle, Volatilité de la production, Chocs sectoriels, Productivité du travail ; Cartographie des échanges commerciaux, Arrimage à un panier de devises, Parité fixe.

ABSTRACT

This thesis includes three independent essays in the fields of macroeconomics, monetary economics and international finance. In the first essay, I build a new Keynesian DSGE model to examine the implications for monetary policy of household production. The proposed theory helps reconcile the relatively strong response of output to monetary policy shocks as suggested by VAR-based evidence and the low degree of price rigidity found in micro data. The second essay analyzes the role of structural transformation—the reallocation of labor across sectors overtime—in shaping the volatility of aggregate output across countries. Finally, the third essay illustrates the importance of trade patterns in choosing between a single currency peg and a peg to a composite basket of currencies.

"Household Production, Services and Monetary Policy" (Chapter 1) builds on the observation that consumer services—unlike consumer nondurable—have close substitutes at home. Households may therefore switch between consuming home and market service as the real wage—the opportunity cost of working at home—changes. To study the implications of this arbitrage for monetary policy, I embed a household sector into an otherwise standard two-sector—a nondurable good sector and a service sector—new Keynesian DSGE model. The fact that households are able to produce services at home makes service sector's firms more reluctant to change their price. This translates into an extra endogenous shift term in the new Keynesian Phillips that is increasing with the extent of substitutability between home and market services. This increased nominal rigidity endogenously amplifies the output response to monetary policy shock, especially in the service sector, which is consistent with VAR-based evidence in the paper that consumer services are more interest-rate sensitive than consumer nondurables.

"Structural Transformation and the Volatility of Aggregate Output: A Cross-country Analysis" (Chapter 2) is based on the evidence of a negative relationship between the employment share of the service sector and the volatility of aggregate output, which I obtain after controlling for several factors—including the level of financial development. This

aggregate result is driven by sectoral labor productivity differentials: Labor productivity is substantially more volatile in agriculture and manufacturing than in services. Aggregate output would therefore become mechanically more stable as labor shifts away from agriculture and manufacturing, and toward the service sector. To quantify this conjecture, I first calibrate a model of structural transformation—secular reallocation of labor across sectors—to the U.S. economy, which I use to match the time path of labor shares in agriculture, manufacturing and services across OECD countries. The model is subsequently used to conduct a set of counterfactual experiments in which labor is endogenously constrained from moving across sectors. Computations suggest that the shift of labor toward the services sector is indeed volatility-reducing.

"Exchange Rate Volatility under Alternative Peg: Do Trade Patterns Matter?" (Chapter 3) is a contribution to the literature on the choice of exchange rate regimes. I use monthly bilateral exchange rate and external trade data from 1980 to 2010 for the member countries of the Western African and Monetary Union (WAEMU). These countries have their common currency—the CFA franc—pegged to the French franc since the mid-40s and to the euro since its introduction in 1999. At the time of the initial peg arrangement, France accounted for most of the external trade of WAEMU countries. Since then, and more notably since the early 2000s, the trade patterns of these countries shifted briskly away from France and other Euro area countries and towards the BICs—China in particular. The chapter finds that a peg to a composite basket of currencies would have led to a less volatile effective exchange rate over the last decade—compare to the current hard peg. This chapter, however, does not derive an optimal exchange rate for WAEMU countries, which is an important area for further research.

Keywords: Household production, Consumer services, Nondurable goods, New Keynesian Phillips curve; Structural transformation, Output volatility, Sectoral shocks, Labor productivity, Service sector; Trade patterns, Basket peg, Hard peg.

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LIST OF ABBREVIATIONS

ATUS	American Time Use Survey
BIC	Brazil, India, China
CEMAC	"Communauté Economique et Monétaire des Etats de l'Afrique Centrale"
CES	Constant Elasticity of Substitution
CFA	"Communauté Française de l'Afrique"
CIREQ	"Centre Inter-universitaire de Recherche en Economie Quantitative"
DSGE	Dynamic Stochastic General Equilibrium Model
IRF	Impulse Response Function
GDP	Gross Domestic Product
GHP	Gross Household Production
GNP	Gross National Product
HP	Hodrick-Prescott
NEER	Nominal Effective Exchange Rate
NKPC	New Keynesian Phillips Curve
OECD	Organization for Economic Co-operation and Development
RBC	Real Business Cycle
REER	Real Effective Exchange Rate
SDR	Special Drawing Rights
VAR	Vector Autoregression
WAEMU	West African Economic and Monetary Union

(dedicace) *À ma fille Abigaël.*

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CHAPTER 1

HOUSEHOLD PRODUCTION, SERVICES AND MONETARY POLICY

ABSTRACT

A distinctive feature of consumer services (which account for nearly two-thirds of total consumption expenditure) is that some of them have close substitutes at home, unlike goods. Households may therefore switch between consuming home and market services in response to changes in the real wage—the opportunity cost of working at home—and changes in the price of market services. This has potential implications for the sectoral responses of output and prices to a monetary policy shock. In order to investigate and quantify these implications, I embed a household sector into an otherwise standard two-sector—a service sector and a nondurable good sector—sticky price model, which I calibrate to the U.S. economy. I show that the extra competition from household production lowers the incentive of service sector firms to change their prices. As a consequence, the real effects of a monetary shock are stronger in the service sector than in the nondurable good sector, which also translates into an amplification of the real aggregate output response. These findings are consistent with VAR-based evidence provided in this paper that consumer services are more interest-rate sensitive than consumer nondurable goods.

Keywords: Consumer services, Nondurable goods, Household production, New Keynesian Phillips curve.

JEL Classification Codes: E12, E32, D13

1.1 Introduction

One of the most striking macroeconomic features of the U.S.—and other industrialized economies—is the large size of its service sector which now accounts for 80% of the economy-wide value-added. In a recent paper, Buera and Kaboski (2009) document that this expansion has been mainly driven by the growth in the consumption of services. The share of consumer services in total consumption expenditures nearly doubled over the past half-century, rising from one-third in 1950 to about two-thirds in 2008. [1]

A distinctive feature of consumer services is that a number of them have close substitutes at home, unlike nondurables goods (see, e.g., Lebergott (1993), Ngai and Pissarides (2008), Reid (1934), Vanek (1973)). [2] Consumers could therefore switch from market to home services (and vice versa) in response to changes in economic conditions. This has the potential to amplify the real effects of monetary shocks in the service sector, which—given its large size—may translate into stronger real aggregate effects.

To assess this conjecture, I embed a household sector into an otherwise standard two-market sector (service and nondurable) sticky price model. Consistent with empirical evidence, the model features an important source of asymmetry: services can be produced both by firms and at home, whereas nondurable goods are exclusively supplied in the market.

Qualitatively, it is reasonable to believe that accounting for household production may lead to improvements over the standard New Keynesian model in understanding the sectoral

1. There are two non-exclusive explanations as to why the service sector expands so much over the course of development (first noted by Kuznets (1966)). One explanation is that service goods feature income elasticities of demand above unity, that is their demand increases as income rises (see Kongsamut, Rebelo, and Xie (2001a) for a recent contribution). Ngai and Pissarides (2007) provide another theoretical rationale consistent with balanced growth. They show that a low (less than one) elasticity of substitution among goods and services is enough to drive labor out of the more productive sectors (e.g., agriculture and manufacturing) and towards the less productive ones (e.g., services). The extent to which labor moves across sectors depends on how low that elasticity of substitution is.

2. Examples of household activities that are substitutes for market services include cooking, cleaning, caring for children and other relatives, shopping, gardening, administration (dealing with bills, keeping bank accounts, etc.), repairs, etc. Buera and Kaboski (2009) also list medical activities such as checking blood sugar (pressure) and home dialysis as examples of previously exclusive market services that are now undertaken at home.

effects of a shock to monetary policy. In fact, a monetary shock that affects the real wage—the opportunity cost of working at home—and the price of market services changes the incentives of households to choose the market over home consumption of services and vice versa. This is not the case for nondurable goods for which home substitutes do not exist.

At a quantitative level, the implications for monetary policy of household production depend on the size of the home sector, and most importantly on the degree of substitutability between market and home services.

As for the size of the home sector, Eisner (1988) estimates Gross Household Production (GHP) in the U.S. at $1,709 billion, which represents 37.5% of the extended GNP of $4,560 billion.[3] In addition, the "American Time Use Survey" (ATUS, hereafter) reveals that people devote a substantial amount of their discretionary time to home activities (nearly 26 hours a week), including cooking, cleaning, caring for children, etc.

Regarding substitutability, Ngai and Pissarides (2008) note that the literature on household production has argued convincingly that household production and market production are close substitutes for each other, with the estimates of the elasticity of substitution ranging from 1.5 to 2.5 across studies (see Aguiar and Hurst (2007a), Chang and Schorfheide (2003), McGrattan, Rogerson, and Wright (1997), Rogerson, Rupert, and Wright (1995)).[4]

Although the implications of household production for the real business cycle have been widely studied in the literature (see, e.g., Benhabib, Rogerson, and Wright (1991), Greenwood and Hercowitz (1991), McGrattan, Rogerson, and Wright (1997)), the implications for monetary policy have not been examined yet.

I show in this paper that when household production is accounted for, the degree of nominal rigidity in the *Augmented* New Keynesian Phillips curve of the service sector, unlike that of the nondurable goods sector, is no longer only summarized by the output gap term. It features an additional endogenous term, which I find to be substantial for a

3. Extended GNP is defined as the sum of market GNP and Gross Household Production (GHP).

4. These studies only estimate the elasticity of substitution between an aggregate of all market goods and services and an aggregate of all home goods and services. Such estimates clearly constitute a lower bound for the elasticity of substitution between market services and household services considered in this this paper. These estimates can however be viewed as a good starting point.

reasonable calibration of parameters. This term increases with the degree of substitutability between market and home services, and co-moves negatively with the output gap, therefore amplifying nominal rigidity in the service sector. Service sector's firms are more reluctant to change prices than nondurable goods firms in response to shocks because they face an additional competitor, households—through home production. They therefore mainly change quantities as a way to adjust to changes in economic conditions. This amplifies the real effects of monetary shocks in the service sector, which translates into an amplification of the response of aggregate output, given that the service sector is large.

These results are consistent with evidence from a sectoral VAR that I estimate using U.S. quarterly data, where I find that consumer services are more interest-rate sensitive than consumer nondurable goods.

The remaining of the paper proceeds as follows. I end this section by a short review of the related literature. Section 1.2 provides an empirical support to the modelling approach adopted. It elaborates on the VAR, and highlights the importance of household production, including its substitutability to market services. Section 1.3 presents the model and its main implications. In Section 1.4, I calibrate the model to the U.S. economy and analyze the simulation results. Section 1.5 draws concluding remarks.

1.1.1 Related Literature

The standard New Keynesian model requires a very high degree of price rigidity in order to fit the data, which is at odds with micro-evidence which suggests that prices change quite frequently (see, e.g., Bils and Klenow (2004), Nakamura and Steinsson (2008)).[5] A solution in the literature has consisted in combining nominal rigidities with real rigidities (factors that make firms reluctant to adjust their relative prices) of some kind, as first introduced by Ball and Romer (1990). In that vein, Eichenbaum and Fisher (2004) assume

5. For example, Gali and Gertler (1999) estimate the New Keynesian Phillips curve and obtain an average price duration ranging from 6 to 8 quarters across their alternative specifications. In the same vein, Eichenbaum and Fisher (2004) estimate a DSGE model and find that Calvo (1983) pricing implies that firms re-optimize their prices nearly once every two years.

variable elasticity of demand of differentiated products as in Kimball (1995), along with firm-specific capital, and obtain a more plausible estimate of price rigidity (2 quarters).[6] This paper complements that literature by showing that the inclusion of household production into an otherwise standard New Keynesian model amplifies the real effects of monetary policy for a given degree of nominal rigidity. Household production can therefore be seen as a way to amplify the degree of price stickiness endogenously, which reduces the reliance on a very high exogenous degree of price rigidity to reproduce the strong response of real output to monetary shocks.

At a disaggregate level, several papers have attempted to explain differences in sectoral responses to a monetary shock. However, VAR-based evidence at the sectoral level, and multi-sector New Keynesian models have mainly distinguished goods according to their durability (see Barsky, House, and Kimball (2007), Carlstrom and Fuerst (2006), Erceg and Levin (2006), Monacelli (2009), among many others).[7] In this paper I make a distinction among goods by tangibility, that is service versus non-service goods. This disaggregation is of particular interest given the large size of consumer services in aggregate consumption, and their substitutability with household services.

A large literature has looked at the impact of home production on market outcomes, since the seminal paper by Becker (1965). Benhabib, Rogerson, and Wright (1991) show that accounting for household production improves the standard RBC model along several dimensions.[8] In particular, the fluctuations in market hours worked implied by their model is closer to the data than the standard model's.[9] McGrattan, Rogerson, and Wright (1997)

6. Christiano, Eichenbaum, and Evans (2005) also estimate a DSGE model featuring staggered price and wage contracts along with four sources of real rigidities: habit formation in consumption, working capital, capital adjustment costs and variable capacity utilization, and obtain an average duration of price and wage contracts of 3 quarters.

7. Two notable exceptions are Bouakez, Cardia, and Ruge-Murcia (2009) who estimate a multi-sector DSGE model including six broad sectors of the U.S. economy (agriculture, mining, construction, durable goods, nondurable goods and services), and Wolman (2009) who analyses the optimal rate of inflation when the relative price of services are trending.

8. Other examples of models that takes into account household production include Freeman and Schettkat (2005), Greenwood and Hercowitz (1991), Greenwood, Seshadri, and Yorukoglu (2005), Rogerson (2008), to name only few.

9. The standard RBC model predicts very little fluctuations in hours worked as compared to the data.

estimate a DSGE model with household production which generates different responses to tax changes than a similar model that abstracts from home production. However, the authors consider a single market sector that produces an homogeneous good, substitute to the home good. I complement these studies by taking into account the fact that virtually all household production is made of services as in Rogerson (2008), substitute to the market service. In addition I focus on monetary policy which has not been studied yet in that literature.

1.2 Empirical evidence

1.2.1 Services versus nondurables: a sectoral VAR

This section examines the sectoral responses of output and prices to a monetary policy shock. I depart from existing VAR models in that I focus particularly on consumer services, which is the category of goods for which substitutes exist at home. The procedure adopted here is closely related to Erceg and Levin (2006). These authors estimate a VAR model with an emphasis on the durability of goods. They find that durable goods react more to monetary shocks than the remaining components of GDP, aggregated into a single entity. They subsequently examine the implication of this finding for optimal monetary policy.

In this paper, I focus on services instead, and disaggregate real GDP into three major components: durables, nondurables and services. I consider a quarterly VAR (with 4 lags and a constant) for the U.S. economy, over the sample period from 1967:Q1 to 2007:Q4. The model is specified as follows:

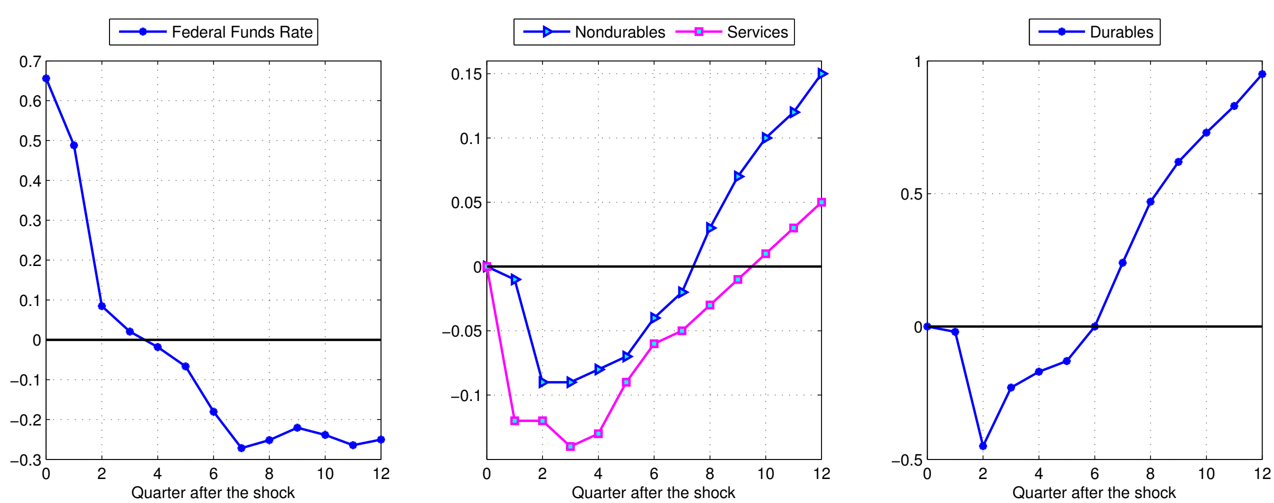
$$\mathscr{X}_t = \Phi_0 + \sum_{j=1}^{4} \Phi_j \mathscr{X}_{t-j} + \Omega \eta_t \tag{1.2.1}$$

where η_t is a vector of contemporaneous disturbances. The vector $\mathscr{X}$ contains the following variables: (i) real consumer durables, (ii) real consumer nondurables, (iii) real consumer services, (iv) price index of durables, (v) price index of nondurables, (vi) price index of services, (vii) capacity utilization (viii) commodity price index from CRB (Commodity Research Bureau), and (iv) the federal funds rate. All the variables, except capacity utilization and the federal funds rate have been logged.

The commodity price index is included to control for supply shocks. In fact, Balke and Kenneth (1994) argue that during the 1960s and 70s, monetary policy would tighten in response to supply shocks, but not by enough to prevent inflation from rising. This counterfactually leads to a positive correlation between inflation and contractionary monetary policy, known as the "price puzzle". Commodity prices signal supply shocks and are therefore important in the VAR analysis. The capacity utilization of the overall economy is also included, as some firms may respond to monetary shocks by simply changing how intensively they use their installed capital.

I follow the procedure in Christiano, Eichenbaum, and Evans (1997) in identifying the monetary policy shock, part of the vector of disturbances η_t. The estimated impulse response functions (IRF) of real variables to a one-standard-deviation innovation to the federal funds rate are portrayed in Figure 1.1 (see the Appendix for sectoral responses of prices, capacity utilization and commodity prices).

Figure 1.1: Estimated responses of real sectoral consumption to a monetary policy tightening.



The service sector noticeably displays the strongest response during the first post-shock quarter. Real spending on services drop by 0.12%, compared to marginal drops of 0.02 and 0.01% for durables and nondurables respectively. In the following quarters however, the response of durables catches up, and even exceeds that of services, reaching a maximum decline of 0.5% in the second post-shock quarter. [10] However, services display a stronger response than nondurables in any quarter. Moreover, the contraction following the shock tend to last longer in the service sector, 9 quarters, compared to 6 and 7 quarters for durables and nondurables respectively. [11]

The results are robust to a wide range of variations such as the re-ordering of variables. I also run a VAR without capacity utilization and the results are roughly unchanged, with the only difference that the response of durables is higher in the first quarter. This confirms the importance of variable capacity utilization in understanding the behavior of the durable good sector as previously noted in the real business cycle literature.

1.2.2 The importance of household production

Household production is the production, usually at home of goods and services for self consumption. However, some activities classified as household production are undertaken outside the house, shopping being the classic example. For household production to matter for aggregate market outcomes, it should first be the case that the home sector is quantitatively important. This section complements the existing literature on the size of the household sector.

1.2.2.1 *Home hours worked*

The amount of time that people spend on household chores is an indication of how important home production is. This is because in working at home, one foregoes the wage

10. As noted before, durable goods are known to respond strongly to monetary shocks (see Barsky, House, and Kimball (2007) and Erceg and Levin (2006) for an empirical evidence, and Barsky, House, and Kimball (2007) for a theoretical explanation). I plot their response separately so as to highlight the difference between nondurables and services which are the main focus in this paper.

11. Bouakez, Cardia, and Ruge-Murcia (2009) estimate a 6-sector DSGE model and find strong evidence of higher and more persistent responses of services to monetary shocks. Their estimates also imply a high degree of price rigidity in the service sector.

earned on market hours worked. As such, an optimizing agent will allocate his time between the market and home so as to equate the real wage and home productivity. The exactness of this relationship depends on how readily people can switch between the house and the market in response to changes in market or home conditions, which depends in part on the extent of labor market friction. Table 1.I reports the amount of time that people spend

Table 1.I: Time devoted to household production in the U.S.
(2003 annual average)

Activity	Weekly Hours		
	All	Men	Women
Housework	4.34	1.61	6.86
Food preparation and clean up	3.71	1.75	5.53
Lawn and garden care	1.4	1.82	0.98
Household management	0.91	0.77	1.05
Purchasing goods and services	5.67	4.76	6.58
Caring for household members	3.85	2.38	4.06
Caring for non-household members	2.03	1.82	2.17
Travel related to household activities	2.31	2.17	2.52
Other household activities	2.31	3.01	1.4
Total hours of home production	**26.39**	**20.09**	**31.15**
Market hours worked	25.83	31.99	20.09
Leisure and Sports	33.46	35.00	32.06

Note: Data refers to persons aged 15 years and over, and includes primary activities only.
Source: American Time Use Survey, U.S. Bureau of Labor Statistics: http://www.bls.gov/tus/

per week in various household activities. I also display market hours worked and leisure time for the sake of comparison. [12] Only the amount of time spent on primary activities is reported. For example, if one is cooking while caring for a child, only the activity declared as the main occupation at that time is recorded. While this simplification may not distort the measurement of market hours worked, it is likely to bias the time devoted to household production downward. This is because many household chores are usually performed simultaneously. Even some important forms of leisure such as watching TV, surfing the in-

12. Although I only report data for 2003, figures are of comparable magnitude in other years for which data do exist.

ternet or answering the phone are not incompatible with home production. [13] Nevertheless, Table 1.I forcefully reveals that people devote a substantial fraction of their time to home production, a fraction that is at least as large as that spent on market activities. [14]

1.2.2.2 *Households and the production of services over the long-run*

Beside the overall quantitative importance of household production, several authors have documented that modern household production is exclusively made of services (see, e.g., Lebergott (1993), Ngai and Pissarides (2008), Reid (1934)). In fact, due to various transformations such as the enlargement of the production scale and the technology innovation that occurred in the market place, the production of home goods became relatively inefficient and was completely marketized by the second quarter of the twenty century. If household production has remained important (see Table 1.I) despite these marketization forces, it is simply because the disappearance of the home production of agricultural and manufacturing goods came along with an increasing need for home services. For example, modern houses require higher cleaning and management standards. Shopping is also one of the household activities that have gained interest overtime.

In a recent paper, Buera and Kaboski (2009) develop a theory whereby the rise of both skill-intensive services and relative wages of high-skilled labor has led to a rise in the importance of market services relative to home services. The authors also cite medical activities such as checking blood sugar (pressure) or home dialysis as recent examples of “market to home product cycles".

Independent of the direction in which the substitution occurred between the home and market production, the household sector seems to have played a key role in determining the production level of market goods, and particularly that of market services overtime.

13. See Aguiar and Hurst (2007b) and Ramey and Neville (2009) for a comprehensive measurement of leisure.

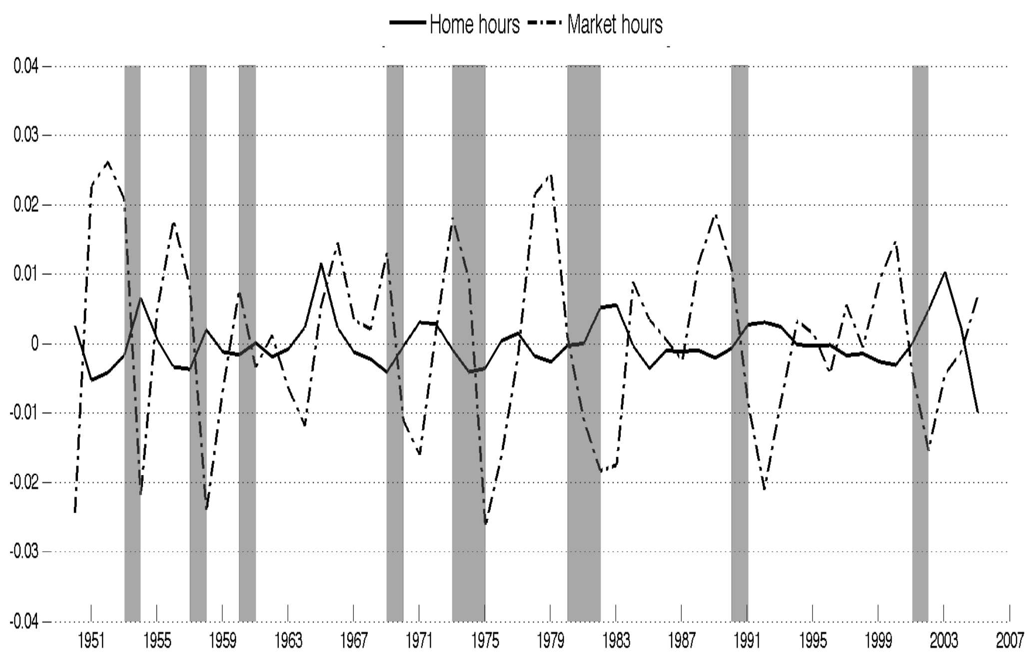
14. Table 1.I also reveals a big discrepancy in the amount of time devoted to homework by men and women, with men spending only about $2/3$ of the amount of time spent by women in household activities.

1.2.3 Household and market production over the business cycle

The previous section has highlighted the importance of household production in a long-run perspective. Another condition, yet necessary for household production to matter for monetary policy is that it be substitutable to market production (and vice versa) at the business cycle frequency. This section makes an empirical assessment of that requirement. I start with the allocation of time between the market and home.

1.2.3.1 *Fluctuations of Home and market hours worked*

Figure 1.2: Home and market hours worked (HP-de-trended series)



Note: Data refers to persons aged 14 years and over.
Source: Ramey and Neville's (2009) dataset, and NBER Business Cycle Dating Committee: www.nber.org/cycles.html

Figure 1.2 portrays de-trended home and market hours worked for persons aged 14 years and over during the period from 1950 to 2005. Annual data on hours worked are from the Ramey and Neville's (2009) dataset. In order to focus exclusively on business cycle fluctuations, I have de-trended the series, using the HP-filter with smoothing parameter $\lambda = 1600^{1/4} \approx 6.25$, which Ravn and Uhlig (2002) show to perform better for annual observations. [15] However, qualitative results are robust to a wide range of filtering technics. The shaded regions in Figure 1.2 highlight the periods during which recessions occurred, as identified by the Business Cycle Dating Committee at the National Bureau of Economic Research.

During all the recessions of the sample period, but the 1973-75', home hours worked increased in the working-age population. Even though home hours worked did not increase for the entire working-age population during the 1973-75 recession, they did increase during the second-half of that recession for the group of persons aged 25-54 years. This group accounts for a substantial fraction of the labor force and is likely to include married couples with children. The counter-cyclicality of home hours worked extends well beyond recession episodes. This adds to the already well documented counter-cyclicality of leisure. Now, given that the three alternative uses of time (housework, market work and leisure) sum to one, market hours should decrease (increase) by enough to preserve the equality whenever leisure and home hours increase (decrease). As a consequence, market hours worked fluctuate much more than both leisure time and home hours worked considered separately. [16]

1.2.3.2 *Substitutability between home and market services over the business cycle*

A distinctive feature of household production is that it can be “outsourced", i.e. someone else can be paid to do it, and the resulting output still provides a similar utility, unlike leisure for which one has to spend one’s own time to benefit from it. Section 1.2.2 has highlighted the substitutability between home and market services in a long-run perspective. This section makes a step further by providing some empirical evidence on that substitutability at the business cycle frequency.

15. 1600 is the standard value used at a quarterly frequency.
16. I find that the fluctuation differential between market and home hours is smaller in the group of people aged 25-54 years.

It would have been interesting to have a measurement of the amount of goods that are actually produced at home, beside the information on home hours worked. This is because the labor productivity in the home sector might be different from the labor productivity in market sectors, so that hours worked do not provide a full picture of the relative importance (in terms of production) of market and home sectors. However, data is rather limited on that matter. Due to this constraint, I focus here on child care, food preparation and shopping to examine the substitutability between household production and market-provided services.

I first consider child care which is one of the most time consuming household activities. Recall from Table 1.I that people spend a bit more than 6 hours per week on average caring for household and non-household members, most of which is accounted for by child care. Moreover, child care is an activity for which clearly distinguishable market substitutes do exist. These are organized facilities in the form of day care centers, nursery/preschool, and other forms of paid arrangements. Table 1.II highlights the importance of child care in family budgets. It reveals that child care expenses account for nearly 7% of the total

Table 1.II: Child care expenses by families with employed mothers, as percentage of monthly income, 1991-2005.

Date of survey	% of monthly income spent on child care		
	All	Below poverty	Above poverty
Fall 1991	7.1	26.6	6.9
Fall 1993	7.3	21.1	7.0
Spring 1997	6.9	20.0	6.6
Spring 1999	6.7	33.3	6.4
Winter 2002	7.1	25.7	6.9
Spring 2005	6.4	29.2	6.1

Source: Survey of Income and Program Participation (SIPP), The U.S. Census Bureau, http://www.census.gov/population/www/socdemo/childcare.html, Historical Time Series Tables (Table C2)

income of families with a working mother during the period from 1991 to 2005, which is a quite large number. This is an argument about the levels.[17] The next step is to check if

17. Substantial disparities exist between households below and above the poverty line, with the former

substitution between market and home care is actually at work in the data.

A large empirical literature has assessed how child care costs affect child care payment and employment decisions of mothers (see Anderson and Levine (1999), Blau and Robins (1988), and Tekin (2007), for U.S. based studies, and Cleveland, Gunderson, and Hyatt (1996) for a Canadian experience, to name only few). These studies yield quite different estimates, stemming from differences in estimation methods, sample restrictions and datasets used. [18] However, as summarized by Anderson and Levine (1999), estimates seem to be clustered around an elasticity of about -0.3 to -0.4. These empirical studies thus consistently suggest that a higher price of childcare lowers the probability that a mother will work and pay for child care.

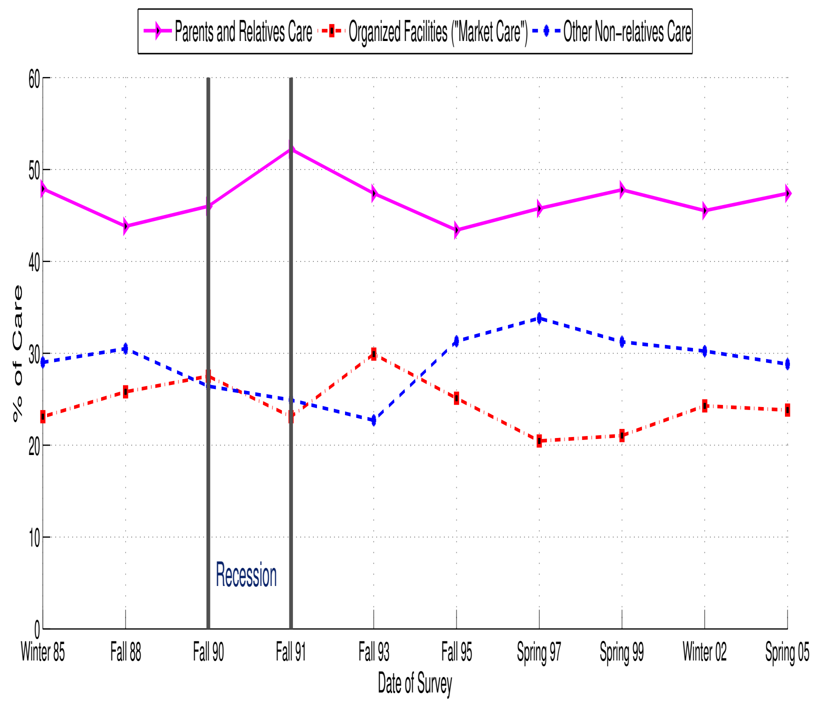
In the same vein, Figure 1.3 portrays the percentage of child care accounted for by different types of arrangements. The data covers a 20-year period, running from the mid-80's to 2005. The graph reveals that the care for preschoolers is almost evenly divided between parents and relatives on one hand and organized facilities and non-relatives on the other hand, which again highlights the importance of household care. In addition, the different types of arrangements exhibit negative pairwise correlations, suggesting room for substitution among them.

Fathers account for about three quarters of the care in the "parents and relatives" category. It might be the case that within a household with an employed mother, the father gives up some market hours worked in order to take care of the child, unless he manages to find alternative child care arrangements (e.g., through organized facilities or non-relatives). The two vertical lines in Figure 1.3 define the 1990-91 recession. Substitution clearly occurred during that episode. The share of child care accounted for by households (parents and relatives) increases by 20%, from 43.8% in the survey prior to recession to 52.2% in the post recession survey. This naturally came along with a decrease in the share of market-provided arrangements of the same magnitude. The timing of surveys do not allow me to carry a similar analysis for the 2001 recession.

devoting more than a quarter of their monthly income to child care.

18. The estimates vary substantially, from values just below zero to values slightly below -1.

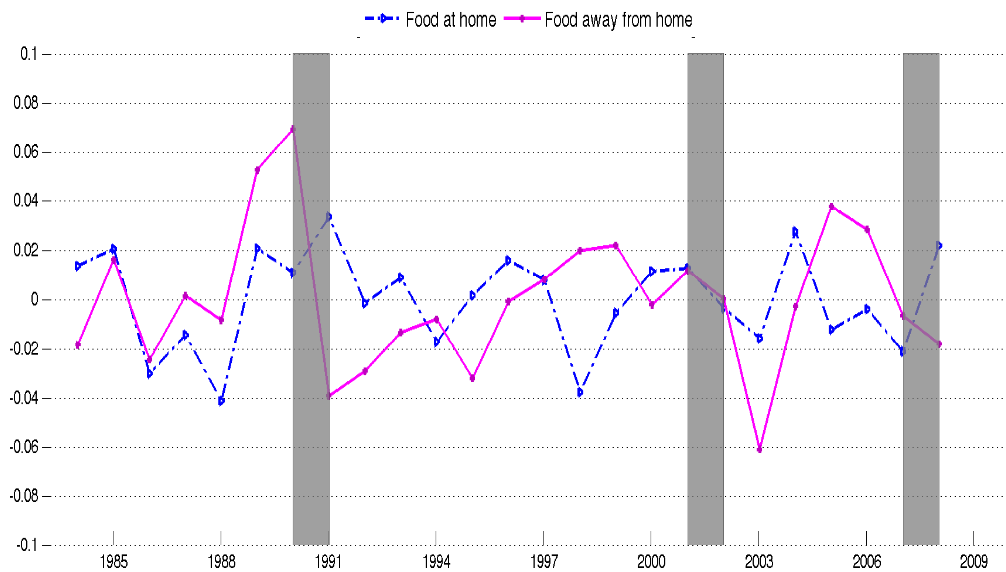
Figure 1.3: Child Care Arrangements of Preschoolers with Employed Mothers.



Source: The U.S. Census Bureau/ Survey of Income and Program Participation (SIPP), http://www.census.gov/population/www/socdemo/childcare.html, and author calculations.

Another market-provided service for which a close substitute clearly exists at home and for which some data exist for comparison is food service. What makes food service an interesting case is the fact that one can readily decide whether to go out for dinner or prepare food at home. In addition, this is quantitatively important as food at home and food away from home account for up to $5,6\%$ and 8% respectively of total household expenditure on average over the sample period. Figure 1.4 reveals that food at home and food away from home co-move negatively over the business cycle. This is even more striking looking at the recession episodes, as represented by the shaded regions in the figure. In bad times, people cut on spending on food out of their house and opt for having dinner at home instead. A notable exception is the 2001 recession during which spending on both items actually

Figure 1.4: Expenditures on food at home and food away from home
(HP-de-trended series)



Source: author calculations from BLS data, Consumer Expenditure Survey
http://www.bls.gov/cex/data.htm.

decreased. But overall, the figure suggests that households do switch between cooking at home and going out for dinner in response to changes in economic conditions.

Shopping is also a household activity that is worth examining, given its relatively large share of time in household production (see Table 1.I). Aguiar and Hurst (2007a) document a substantial heterogeneity in the prices that households pay at a given point in time for identical items in the same area. They find that doubling shopping frequency lowers the price of a good by 7 to 10%, which suggests that households do indeed substitute time for money. The authors then use a Becker (1965) type of model and estimate elasticity of substitution between time and money due to shopping (home production) of nearly 1.8. Also, Rogerson (2008) argues (see footnote 8, p. 244) that the service sector allows for substitution between employee time and consumer time, by having for example fewer cashiers and longer lines in stores, or letting customers bag their own groceries.

1.3 The Model Economy

1.3.1 The Economic Environment

The economy is populated by a continuum of identical and infinitely-lived households of measure one. There are three sectors in the economy, two-market sectors and a home sector. At home, households produce services that cannot be sold on the market and are therefore used for self-consumption only. The two market sectors are a nondurable goods sector and a service sector, each of which is populated by a continuum of monopolistically competitive firms which produce differentiated intermediate goods. We assume that their prices are sticky *à la* Calvo (1983). Intermediate goods are further bundled into final consumption goods by perfectly competitive producers in each market sector. There is also a monetary authority who obeys a Taylor-type rule, and the only source of aggregate uncertainty in the model is a shock to monetary policy. The following sections describe the behavior of all these entities in details.

1.3.2 The Representative Household

The "unitary" representative household derives utility from the aggregate consumption index (C) and leisure (L), and seeks to maximize its expected lifetime utility: [19]

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left(\log(C_t) + \Phi L_t \right) \right\}, \quad \Phi > 0$$

where $\beta \in (0,1)$ is the subjective discount factor. Consumption is a Cobb-Douglas aggregate of the nondurable good (labeled g) and the service aggregate (labeled S):

$$C = C_g^{\omega} C_S^{1-\omega}, \quad 0 < \omega < 1. \tag{1.3.1}$$

19. Unitary household in the sense that I do not distinguish between different members of a given household (and between spouses in particular), which amounts to assuming that household members simply pool resources together and make joint decisions. This is by opposition to the "collective" household type of model in which each spouse makes his (her) own decisions, taking (most likely) into account that of his (her) partner. Collective household models are suitable for addressing intra-household issues that involve strategic behavior, which is not the case here.

Wolman (2009) uses a similar specification to examine optimal monetary policy when the relative price of services (compared to goods) is trending up, but with the service aggregate S made of market services only. This specification—unit elasticity of substitution between the nondurable good and the service aggregate—allows me, as will become clear later, to isolate the implications for monetary policy of the household sector.

The consumption of services (S) is a CES aggregate of market-provided services (C_s), and services that are produced at home (C_h):

$$C_S = \left[\gamma C_h^{\frac{\nu-1}{\nu}} + (1-\gamma) C_s^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}, \qquad \nu > 0, \quad 0 \leq \gamma < 1. \tag{1.3.2}$$

I choose the CES specification so that the parameter ν governing the elasticity of substitution between market-provided services and home-services is not constrained.[20] This parameter will be key to the analysis. To see why, consider the two following extreme cases: if market and home production are perfect complements, the consumption aggregate becomes $C_S = \mathbb{M}\text{in}(C_s, C_h)$, which implies that households would consume the same quantity of both items. In that case, household production is likely to add nothing to standard models in terms of fluctuations of real market activities. In fact, people have no room to substitute away from the market in "bad times". In contrast, if both items are perfect substitutes, the aggregate is linear and households have the maximum margin for arbitrage, which is an additional channel through which shocks can impact fluctuations in market activities.

A more general specification of the consumption aggregate would be one in which I also allow for a non-unit elasticity of substitution between nondurable goods and the aggregate of services.[21] But, one would then have two competing forces: the substitutability between market-provided services and market nondurables on one hand, and the substitutability between home-services and market-provided services on the other hand. Though more

20. Rogerson (2008) adopts this modelling of the service sector when explaining the relatively poor performance of the European labor market *vis à vis* the U.S.

21. $C = \left[\omega C_g^{\frac{\rho-1}{\rho}} + (1-\omega) C_S^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$ where $C_S = \left[\gamma C_h^{\frac{\nu-1}{\nu}} + (1-\gamma) C_s^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}$

general, this specification adds nothing to the understanding of the question treat in this paper, which focuses primarily on the relative sectoral responses and not in their level *per se*.

The representative agent has four alternative uses of his unit of discretionary time. He spends part of it working in the market (a fraction N_g in the goods-producing sector and a fraction N_s in the services-providing sector). The remaining time is allocated to household production (N_h), and leisure (L).

$$N_{h,t} + N_{s,t} + N_{g,t} + L_t = 1 \qquad \forall t. \tag{1.3.3}$$

The representative household faces two budget constraints. The first one is a standard budget constraint which requires that total spending (on market items) do not exceed total income. The household earnings come from wage income (W), interest payments on bonds (R) and dividends received from firms of which he owns shares (Π), so that:

$$P_{g,t}C_{g,t} + P_{s,t}C_{s,t} + B_t \leq R_{t-1}B_{t-1} + W_t(\underbrace{N_{g,t} + N_{s,t}}_{\text{Market Hours}}) + \underbrace{\Pi_{g,t} + \Pi_{s,t}}_{\text{Total Profits}} \tag{1.3.4}$$

where P_g and P_s are the price of the market good and market-provided service respectively.

The second constraint is an intra-household resource constraint. It states that households cannot consume more home services than they actually produce. This amounts to assuming that household production is for self-consumption, and can therefore not be sold on the market:

$$C_{h,t} \leq \Gamma(N_{h,t}) \tag{1.3.5}$$

where Γ is the production function in the household sector, which takes labor as the only input.

The household then chooses the optimal sequences of market goods, allocation of time to each sector (including to the household sector), bond holdings—subject to the no-Ponzi game condition—and firms' shares. The corresponding first order conditions are: [22]

$$\frac{MU_{g,t}}{MU_{s,t}} = \frac{P_{g,t}}{P_{s,t}} \tag{1.3.6a}$$

$$MRS_{k,t} = \frac{\Phi}{MU_{k,t}} = \frac{W_t}{P_{k,t}}, \quad k \in \{g,s\} \tag{1.3.6b}$$

$$\frac{W_t}{P_{k,t}} MU_{k,t} = \left(\frac{\partial \Gamma}{\partial N_h}\right) MU_h, \quad k \in \{g,s\} \tag{1.3.6c}$$

$$\Lambda_t = \beta R_t \mathbb{E}_t(\Lambda_{t+1}). \tag{1.3.6d}$$

where Λ_t is the Lagrange multiplier associated to the date t budget constraint, and MU_i is the marginal utility of good i, $i \in \{g,h,s\}$.

These are optimality conditions. For example, Equation 1.3.6c compares the benefits from two alternative uses of an extra unit of time. If the agent decides to work in the market, he earns the nominal wage income W. With each unit of money he can purchase $\frac{1}{P_k}$ units of consumption good or service in sector k. Now, each extra unit of consumption provides the marginal utility MU_k. The left hand side of that equation therefore summarizes the gain from working on the market and consuming the resulting revenue. The right hand side gives the benefits of devoting that extra unit of time to household production instead. $\frac{\partial \Gamma}{\partial N_h}$ is what the agent would produce if he works at home. Given that each unit of the home produced good provides the marginal utility MU_h, the equation thus simply suggests that the agent must be indifferent between working at home and working on the market at the optimum.

1.3.3 Final Goods Producers

At each date t, the representative competitive final good producer of the market-sector $k \in \{g,s\}$, bundles intermediate products into the sector final consumption good, using the

22. After substituting for (1.3.5), which holds with equality at the optimum, since the utility function is strictly increasing in C_h.

following technology *à* la Dixit and Stiglitz (1977):

$$Y_{k,t} = \left(\int_0^1 Y_{k,t}(z)^{\frac{\varepsilon_k - 1}{\varepsilon_k}} dz \right)^{\frac{\varepsilon_k}{\varepsilon_k - 1}} \tag{1.3.7}$$

where $\varepsilon_k > 1$ is the constant elasticity of substitution between differentiated products. $Y_{k,t}(z)$ denotes the time t amount of intermediate input purchased from firm z by the final good producer of sector k.

The competitive firm takes its price as given and combines intermediate inputs so as to minimize production costs. This yields the following demand schedule for each intermediate good in each sector:

$$Y_{k,t}(z) = \left(\frac{P_{k,t}(z)}{P_{k,t}} \right)^{-\varepsilon_k} Y_{k,t}, \qquad \forall z \; \varepsilon \; (0,1). \tag{1.3.8}$$

The resulting price level in sector k is the Lagrange multiplier of the cost minimization problem:

$$P_{k,t} = \left(\int_0^1 P_{k,t}^{1-\varepsilon_k}(z) dz \right)^{\frac{1}{1-\varepsilon_k}}, \qquad k \in \{g, s\}. \tag{1.3.9}$$

1.3.4 Intermediate Goods producers

Besides final good producers, each sector is populated by a continuum of monopolistically competitive firms of measure one. The monopolistic firm z in sector $k \in \{g, s\}$ produces output $Y_{k,t}(z)$ using a linear technology in labor:

$$Y_{k,t}(z) = AN_{k,t}(z) \tag{1.3.10}$$

where A is a constant labor productivity parameter, which I normalize to one for simplicity.[23] The demand for labor is determined by unit-cost minimization. Since I assume

23. In principle, any shock that affects the real wage and the prices of market goods (and services in particular) could be accounted for in this setup. However, I focus here on monetary shocks that I have found (see Section 1.2.1) to have differential impacts on nondurables and services.

perfect mobility of labor, wages are equalized across sectors in equilibrium and one has:

$$\Psi_{k,t} = W_t / A \tag{1.3.11}$$

where $\Psi_{k,t}$ is the nominal marginal cost in sector k, which, given the previous equation is sector-independent.

I assume price rigidity *à* la Calvo (1983). In each period, a firm z in sector k has a constant probability $1-\theta_k$ of resetting its price if lucky enough. If not '"selected" to change its price, the firm simply keep its previous price. [24]

The problem of a re-optimizing firm then reads:

$$\underset{P_{k,t}(z)}{Max} \left\{ \mathbb{E}_t \sum_{t=0}^{\infty} (\beta \theta_k)^i \frac{\Lambda_{t+i}}{\Lambda_t} \left[P_{k,t}(z) - \Psi_{k,t+i} \right] Y_{k,t+i}(z) \right\}$$

$$\text{s.t.} \qquad Y_{k,t+i}(z) = \left(\frac{P_{k,t}(z)}{P_{k,t+i}} \right)^{-\varepsilon_k} Y_{k,t+i}, \qquad \forall i$$

where $\Lambda_t = \frac{MU_{k,t}}{P_{k,t}}$ is the "price-adjusted" marginal utility of wealth. [25] Ψ_t is the nominal marginal cost of production, which is equal to the nominal wage (up to a constant), as noted previously. The solution to this problem is given by the following expression which does not depend on z as all re-optimizing firms set the same price:

$$P^{\star}_{k,t} = \left(\frac{\varepsilon_k}{\varepsilon_k - 1} \right) \frac{\mathbb{E}_t \sum_{i=0}^{\infty} (\beta \theta_k)^i MU_{k,t+i} \Psi_{k,t+i} P^{\varepsilon_k - 1}_{k,t+i} Y_{k,t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} (\beta \theta_k)^i MU_{k,t+i} P^{\varepsilon_k - 1}_{k,t+i} Y_{k,t+i}}. \tag{1.3.12}$$

24. I do not assume price indexation. Price indexation has proven to be useful in explaining inflation persistence, which is not the focus in this paper. However, when I consider the zero-inflation steady state later, the setup becomes equivalent to one in which non-optimizing firms keep pace with the steady state inflation rate.

25. Recall that Λ is the Lagrange multiplier associated to the budget constraint of the consumer problem.

If $\theta_k = 0$, prices are fully flexible and:

$$P^{\star}_{k,t} = \left(\frac{\varepsilon_k}{\varepsilon_k - 1}\right)\Psi_{k,t}.$$

Using (1.3.9), and given the mass $1-\theta_k$ of firms that reset their price at each period, the aggregate price level in sector k simply becomes:

$$P_{k,t} = \left((1-\theta_k)(P^{\star}_{k,t})^{1-\varepsilon_k} + \theta_k P^{1-\varepsilon_k}_{k,t-1}\right)^{1/(1-\varepsilon_k)}. \tag{1.3.13}$$

1.3.5 Sectoral New Keynesian Phillips curves

Let π_g and π_s denote the inflation rate in the market-good and market-service sectors respectively. The following result holds.

Proposition 1.3.5.1. *SECTORAL NEW KEYNESIAN PHILLIPS CURVES*

In the presence of household production, the New Keynesian Phillips curve remains standard in the nondurable goods sector $\left[\pi_{g,t} = \kappa_g y_{g,t} + \beta \mathbb{E}_t(\pi_{g,t+1})\right]$ *whereas that of the service sector is "Augmented" as follows:*

$$\pi_{s,t} = \underbrace{\kappa_s y_{s,t}}_{\textit{Output gap term}} + \underbrace{(1-1/\nu)\kappa_s(y_{S,t} - y_{s,t})}_{\textit{Endogenous "shift term"}} + \beta \mathbb{E}_t(\pi_{s,t+1}) \tag{1.3.14}$$

where $y_S = c_S$ denotes the aggregate of market and home services.
$\kappa_j = (1-\theta_j)(1-\beta\theta_j)/\theta_j,\ j \in \{g,s\}$ is a decreasing function of θ_j, where small case letters denote deviations from the deterministic steady state.

Proof. (see appendix) □

As in most sticky price models, the dynamic effects of a shock to monetary policy are well captured through the New Keynesian Phillips Curve (NKPC thereafter). From the previous proposition, the inflation in the goods producing sector is entirely driven by the output gap, to an extent that decreases with the exogenous degree of price stickiness in that sector.[26] Conversely, in addition to the output gap term, the NKPC in the service sector

26. The output gap is weighted by $\kappa_i, i \in \{g,s\}$, which is a decreasing function of θ_i, the probability that a firm in sector i does not re-optimize its price in a given period.

features an extra endogenous term:

$$(1-1/\nu)\kappa_s(y_{S,t}-y_{s,t}).$$

This term shifts the NKPC and is key to understanding how household production affects the transmission mechanism of monetary policy to the economy. Its magnitude depends critically on the elasticity of substitution between household and market services, ν. The “shift term" vanishes when ν equals unity. This can be seen either by replacing ν by one in the previous expression, or by examining the utility function. Recall that for $\nu = 1$, the consumption aggregate (C) becomes Cobb-Douglas in market services (C_s), home services (C_h) and market goods (C_g):

$$C = C_g^{\omega} C_s^{(1-\gamma)(1-\omega)} C_h^{\gamma(1-\omega)}. \tag{1.3.15}$$

This, combined with log utility yields complete separability of home-services from market goods and services:

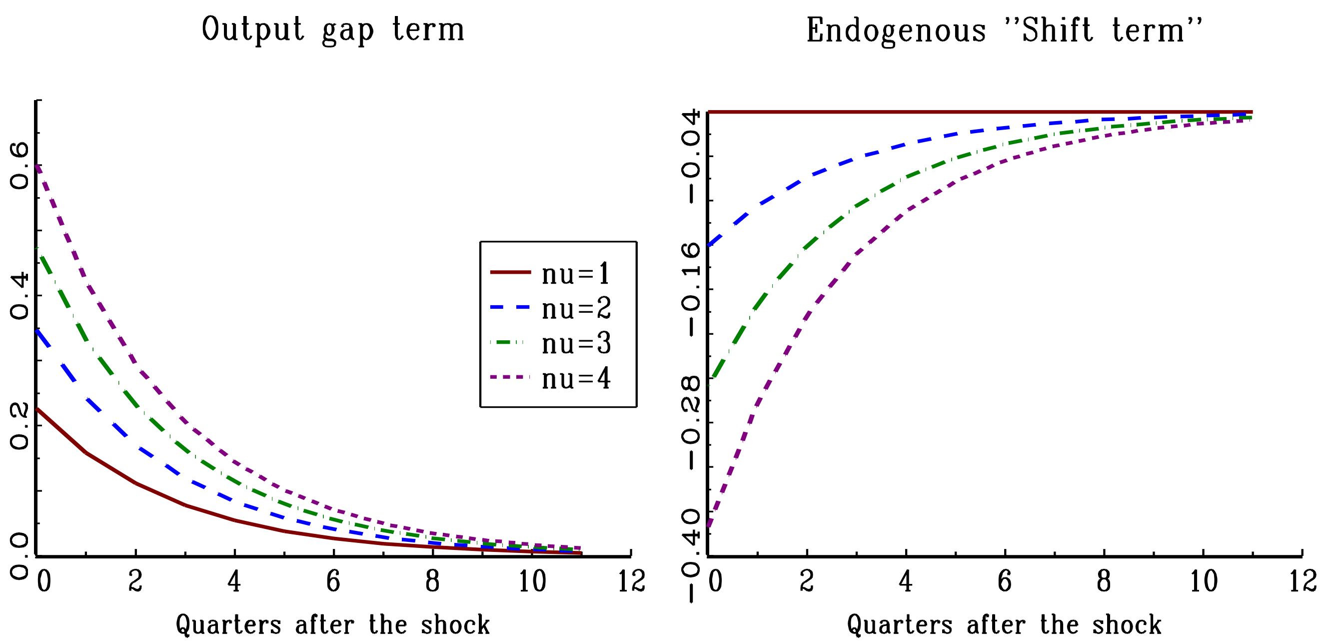
$$U(C,L) = \omega \ln C_g + (1-\gamma)(1-\omega)\ln C_s + \gamma(1-\omega)C_h + \Phi L.$$

The NKPC then reduces to the standard one and home production has no impact on inflation dynamics.[27] It follows that the real effects of a shock to monetary policy are identical to that obtained in a similar model without household production.

Proposition 1.3.5.1 confirms the conjecture made in the introduction that household production matters qualitatively for monetary policy. Its quantitative importance in shaping inflation dynamics and thus impacting the real effects of monetary shocks lays in the magnitude of the shift term, relative to the output gap. This depends in particular on the size of the home sector, and most importantly on the substitutability between market and home services. The higher the value of ν, everything else equals, the bigger the shift term. But

27. Benhabib, Rogerson, and Wright (1991) also show (in a RBC framework) that home production changes nothing to aggregate fluctuations in the case of a log utility. However, this result could not be assumed blindly here, as one did not necessarily know (in advance) how home production would play out in the presence of price rigidity.

Figure 1.5: Contribution of the output gap term and the shift term to inflation dynamics (see Equation 1.3.14, Proposition 1.3.5.1).



Note: The shift term is the term associated with household production: $(1-1/\nu)\kappa_s(y_{S,t}-y_{s,t})$, and the output gap term is simply $\kappa_s y_{s,t}$.

everything else is not equal in this model, due to the endogeneity of the expression $y_S - y_s$. Recall that $y_S = c_S$ is the aggregate of market-provided and home-produced services. It is hard, however, to infer the behavior of the shift term analytically. I rely on simulations to examine its relative contribution to inflation dynamics through the following exercise: for a given value of the parameter ν, I solve for the time path of both the output gap and the shift terms, following an expansionary monetary policy. The magnitude of those two terms are portrayed in Figure 1.5. The first thing to note is that the two terms are of opposite sign and co-move negatively as ν changes. In addition, these terms all expand in absolute value as ν rises (from 1 to 4 in the figure).

A high value of ν corresponds to a high output gap, as people are more likely to switch between consuming home and market services. In the absence of the shift term, this would induce a price increase, for a given degree of price rigidity. In this model however, the shift term, by dampening the effect of the output gap, prevents this price increase from happening (recall that the shift term and the output gap term are of opposite signs). As a consequence, firms in the service sector are able to produce more without a further increase in their prices. Intuitively, this reluctance of service sector firms to increase their prices is due to the extra competition from household production. In fact, if the firms in the service sector decide to increase their prices, individuals may substitute away from the market and produce the services at home instead.

The general message conveyed by the proposition is that the degree of nominal rigidity in the NKPC of the service sector is no longer only summarized by the output gap. Instead, home production adds substantial rigidity in the service sector. As a consequence, monetary policy will tend to have larger real effects in that sector as shown below.

1.3.6 Monetary Policy

I assume that the monetary authority sets the nominal interest rate according to the Taylor (1993) rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y} \xi_t, \qquad \phi_\pi > 1, \quad \phi_y \geq 0 \tag{1.3.16}$$

where $\bar{R}$ and $\bar{Y}$ are respectively the gross nominal interest rate and the market-output associated with the zero inflation deterministic steady state.
ξ is a persistent shock such that:

$$\ln(\xi_t) = \rho_r \ln(\xi_{t-1}) + \zeta_t, \quad 0 < \rho_r < 1; \quad \text{with } \zeta_t \sim \text{iid}(0, \sigma_r^2). \tag{1.3.17}$$

1.3.7 Aggregation

Since households are identical, bonds are in zero net supply in equilibrium.

For a market sector k one has:

$$N_{k,t} = \int_0^1 N_{k,t}(z)dz \quad \forall t. \tag{1.3.18}$$

It is useful to express the aggregate production in a market sector $k \in \{g,s\}$ as:

$$Y_{k,t} = \Upsilon_{k,t} Y^{f}_{k,t} \tag{1.3.19}$$

where $Y^{f}_{k,t} = \int_0^1 Y_{k,t}(z)dz = AN_{k,t}$ is the amount of goods that would be produced if all markets where perfectly competitive, and $\Upsilon_{k,t}$ is the efficiency loss incurred in sector k at time t, due to the fact that intermediate goods producers charge different prices (monopolistic competition).

It is easily shown that the "efficiency distortion" is given by:

$$\Upsilon_{k,t} = \left(\frac{P^{\star}_{k,t}}{P_{k,t}}\right)^{-\varepsilon_k}, \quad k \in \{g,s\} \tag{1.3.20}$$

where $P^{\star}_{k}$ and P_k are given respectively by Equations 1.3.12 and 1.3.13.

Note that:

$$\begin{cases} \Upsilon_{k,t} = 1 \quad \text{if} \quad P_{k,t}(z) = P_{k,t}(z') \; \forall z, z' \\ \Upsilon_{k,t} \leq 1 \quad \text{in general.} \end{cases} \tag{1.3.21}$$

Market clearing also requires that $C_{k,t} = Y_{k,t}$ and $N_t = N_{g,t} + N_{s,t}$.

In this setup it is not as obvious to obtain an expression for the aggregate price level. The problem emerges from the fact that the consumption aggregate nests market variables (consumption of nondurables goods and market services) and the home production of services in a non-separable way. In fact, the aggregate services is a general CES function of market services and home services. It turns out that one can actually get an expression for the deviation of real output from the steady state, which is precisely the object of interest here.

I define real output at date t as:

$$Y_t = \bar{P}_g Y_{g,t} + \bar{P}_s Y_{s,t} \tag{1.3.22}$$

where $\bar{P}_i, i \in \{g,s\}$, are the sectoral price levels in the steady state.

Linearizing the above expression, one obtains the following expression in which small case letters represent deviations from the steady state:

$$y_t\bar{Y} = \bar{P}_g\bar{Y}_g y_{g,t} + \bar{P}_s\bar{Y}_s y_{s,t}; \Rightarrow \; y_t = \chi y_{g,t} + (1-\chi) y_{s,t}$$

where $\chi = \bar{P}_g\bar{C}_g/\bar{Y}$ can be inferred straightforwardly from the national accounts (see calibration in the next section).

The aggregate price level in the economy is simply defined as nominal over real output, that is:

$$P_t = \frac{P_{g,t}Y_{g,t} + P_{s,t}Y_{s,t}}{\bar{Y}} \tag{1.3.23}$$

which after linearization becomes:

$$p_t = \chi p_{g,t} + (1-\chi) p_{s,t} \;\Rightarrow\; \pi_t = \chi \pi_{g,t} + (1-\chi)\pi_{s,t}.$$

1.4 Calibration and Results

1.4.1 Parameter values

Consistent with the VAR-based evidence presented in Section 1.2.1, the model is calibrated at quarterly frequency. The discount factor, β, is set so as to imply an annualized real interest rate of 4% ($\beta = 1.04^{-1/4} = 0.99$). I set the elasticity of substitution between differentiated products—ε_g and ε_s—to imply an equal steady-state markup of 10% in both market sectors. This value is consistent with the findings in Basu and Fernald (1994).

The calibration of Φ and γ is based on households' time allocations in Table 1.I. This table implies that people spend 30% of their reported discretionary time on market work and 31% on homework.[28] θ_g and θ_s are set such that prices last for 3 quarters on average in each sector. In principle, allowing for a higher degree of price rigidity in the service sector would result in stronger real effects of monetary shocks in that sector. I shut down that

28. It is usually assumed in standard RBC models that people devote 1/3 of their discretionary time to market activities, which is very close to the value implied by Table 1.I (30%). Data from the Michigan Time Use Survey suggest that people spend 28% of their discretionary time on household activities, which is also close to the corresponding value in Table 1.I (31%). I re-compute Φ and γ with these alternative figures and the resulting values are very similar to those reported in Table 2.I.

channel in order to isolate the role of household production in amplifying the real effects of monetary shocks. Many authors adopt a similar calibration for price stickiness in two-sector models (See, e.g., Carlstrom and Fuerst (2006), Barsky, House, and Kimball (2007) and Monacelli (2009)).

The coefficient on inflation in the Taylor rule is fixed at 1.5, and the persistence of the shock to the interest rate is $\rho_r = 0.7$. Those values are standard in the calibration of the simple Taylor rule (see, e.g., Carlstrom and Fuerst (2006), and Monacelli (2009)). I also consider variants of the Taylor rule in which the weight on the output gap ϕ_y is different from zero. Because this weight is essentially small—especially at quarterly frequency—as suggested by estimations, the results are very similar qualitatively, and quantitatively close to those obtained with $\phi_y = 0$.

The elasticity of substitution between market services and home services (ν) is central to the analysis. Fortunately, many authors have estimated the elasticity of substitution between market and home produced goods as a whole.[29] Home production, however, consists almost exclusively of services (see Section 1.2.2.2). This suggests that existing estimations, which range from 1.5 to 2.5, are likely to provide a downward biased estimate of the elasticity of substitution that I refer to in this paper. Recall that ν in the model considered here is the elasticity of substitution between market and home services. I choose $\nu = 2.3$, which is the estimate in Chang and Schorfheide (2003). Note that this is still conservative as I refer here to the substitution between market and home services (which constitute a specific subset of products), whereas the previous authors have estimated the elasticity of substitution between a single aggregate of market goods and a single aggregate of home goods.

Finally, I fix χ to match the 2008 expenditure share of nondurables goods (in the aggregate of nondurables and services). This allows me to pin down ω, using a set of first order conditions from the optimization problem of consumers. Table 2.I summarizes the values of calibrated parameters.

29. See Rogerson, Rupert, and Wright (1995), McGrattan, Rogerson, and Wright (1997), Chang and Schorfheide (2003), and Aguiar and Hurst (2007a).

Table 1.III: Parameter values

β	ν	Φ	γ	χ	ω	ε_g	ε_s	θ_g	θ_s	ϕ_π	ϕ_y	ρ_r
0.99	2.3	1.62	0.5	0.4	0.24	11	11	2/3	2/3	1.5	0	0.7

I linearize the system around the zero inflation deterministic steady state and solve the model using Blanchard and Kahn's (1980) method. The simulation results follow.

1.4.2 Simulation Results

In analyzing the simulation results, I consider 3 scenarios. The first scenario consists of a baseline model without household production and with equally sticky prices across sectors (which I label "No H.P."). In the 2 remaining scenarios, I consider household production ("H.P.") along with: flexible prices in each sector; and equally sticky prices across sectors (the preferred specification). The impulse response functions of endogenous variables to a negative percentage point innovation in the interest rate are portrayed in the appendix. The results can be summarized as follows.

Household production, as one would expect, has no implications for monetary policy when prices are flexible. The impulse response functions of real variables in that scenario therefore simply correspond to the horizontal axis in the figures. This result holds independently of the size of the home sector and the degree of substitutability between home and market services. Flexible prices adjust instantaneously so as to completely offset the shock. As a consequence, the real wage remains unchanged, and individuals therefore have no incentive to reallocate their time between the market and home.

The most relevant scenarios are those with sticky prices. Simulations indicate that the real effects of a monetary shock are substantially larger in the service sector when household production is accounted for. The initial responses of consumption of market services to a 1% cut in the nominal interest rate are 2.4% in the model with home production and 1.4% in the baseline model. [30] Conversely, home production does not augment the real

30. These values all subsequently return to their steady state level asymptotically.

effects of a monetary shock in the nondurable goods sector, so that the initial response of real spending on nondurables is the same as in the baseline model, that is 1.4%.

The rationale for the above results is as follows. An expansionary monetary policy, by raising the overall demand in the economy, increases the production costs (the nominal wages) incurred by firms. Since prices are rigid (only the luckiest firms, a fraction $1-\theta$, re-optimize their prices at a given period in time), they do not rise as much as nominal wages. As a consequence, the real wage increases (by 1.4% initially). In the baseline model households will only decrease leisure to take advantage of that increased real wage. Accounting for the home sector provides individuals with an additional margin they can operate on, namely the reallocation of time between home and market activities. This explains why market hours worked increases more in a model with home production following a monetary expansion. [31] Now, why is it that all the increase in market hours is allocated to the service sector? The answer to this question lies in the substitutability differential among goods. Recall that market services are closer substitutes to home services than market nondurables are. In order to keep pace with the optimal level of the aggregate services consumption which would prevail in the absence of substitutability between market and home services, households replace their lost consumption of home services (due to their increased time working in the market) by the consumption of market services.

The claim that individuals ultimately keep pace with their consumption of aggregate services that would prevail in the absence of substitutability between market and home services holds for any parameter values. The impulse response functions of the aggregate services in the model with household production is very close to that of the baseline model.

The prediction by the model that monetary shocks have stronger real effects in the service sector compared to the nondurable goods sector is consistent with VAR-based evidence that services are more interest-rate sensitive than nondurables goods.

As for prices, the increased response of market services happens without further increase in their prices as compared to the baseline model without home production. The

31. Given that technology is linear in labor, the dynamics of hours worked micmic that of the corresponding consumption variables in the model, and are therefore not reported in the figures in appendix.

rationale for this result is that market-service producers in this model face “extra” competition from households, producers of home services, making them more reluctant to increase their prices. They therefore mainly re-optimize quantities as a way to adjust to shocks.

The model also has aggregate implications and aggregate responses are simply weighted averages of sectoral responses. Since services account for a larger share of aggregate output than nondurable goods, the behavior of aggregate variables is closer to that of services. When household production is brought into the picture, the real effects of monetary shocks on aggregate output are 50% larger compared to the benchmark model without home production.

1.5 Concluding Remarks

In this paper, I develop a three-sector (market services sector, market nondurable goods sector, and household sector) sticky price model to examine the implications for monetary policy of household production. Households are allowed to produce services at home whereas nondurable goods are exclusively supplied in the market. I find that the inclusion of household production amplifies the real effects of monetary shocks in the service sector, which translates into a higher response of real aggregate output. The mechanism operates through two main channels.

On the supply side, I show that the degree of nominal rigidity in the *Augmented* New Keynesian Phillips curve is no longer only summarized by the output gap. It now features an additional endogenous “shift term", stemming from the extra competition from household production. The higher the elasticity of substitution between home and market services, the higher that term. For a reasonable calibration of parameters, I find that term to be substantial. The shift term reduces the incentives of the service sector firms to change their prices, and they therefore adjust to monetary shocks mainly by changing quantities.

On the demand side, an expansionary monetary shock, by increasing the real wage—the opportunity cost of working at home—increases the incentive of individuals to substitute away from home production and towards market services.

Since household production does not impact the response of nondurable goods, the real effects of monetary shocks are stronger in the service sector than in the nondurable goods sector. This is consistent with VAR-based evidence provided in this paper that services are more interest rate-sensitive than nondurables.

The results obtained in this paper suggest that household production is an important source of real rigidity. Accounting for it may therefore improve our understanding of the transmission of monetary policy shocks to the economy.

CHAPTER 2

STRUCTURAL TRANSFORMATION AND THE VOLATILITY OF OUTPUT: A CROSS-COUNTRY ANALYSIS

ABSTRACT

Using a panel of OECD countries, this paper finds a negative relationship between the employment share of the service sector and the volatility of aggregate output, after controlling for various factors—including the level of financial development. This aggregate result is driven by volatility differentials across sectors: labor productivity is the most volatile in agriculture, followed by manufacturing, and then services. Aggregate output would therefore *mechanically* become less volatile as labor moves away from agriculture and manufacturing, and towards the service sector. This paper examines the role of structural transformation—the secular reallocation of labor across sectors—on the volatility of aggregate output. I first build and calibrate to the U.S. economy a model in which labor shifts across sectors emerge endogenously from exogenous differences in sectoral labor productivity growth. The set-up is then used to generate time paths for labor shares in agriculture, manufacturing and services in OECD countries. Finally, the model is used to perform a set of counterfactual analyses in which labor mobility across sectors is constrained endogenously. Computations suggest that the secular shift of labor towards the relatively stable service sector is volatility-reducing.

Keywords: Structural transformation, Output volatility, Sectoral shocks, Labor productivity, Service sector.

JEL Classification Codes: E32, O14.

2.1 Introduction

Half a century ago, Arthur Burns (Burns, 1960), during his presidential address to the American Economic Association stated:

> "The new stabilizing tendency is as yet weak, but it is being gradually reinforced by the spread of 'white-collar' workers...Moreover, much of this type of employment is by its nature of an overhead character and therefore less responsive to economic fluctuations than are the jobs of machine operators, craftsmen, assembly-line workers, truck drivers, labourers and others in the 'blue-collar category."

This view is suggestive that fluctuations in aggregate output would be less pronounced as resources shift away from (high-volatility) agriculture and manufacturing towards (low-volatility) services. Many papers have since attempted to assess the quantitative role of output composition on aggregate output volatility. The subsequent interest in the topic is not surprising in light of the sharp decline in output volatility, both in the U.S. and across most OECD countries over the last quarter century, as portrayed in appendix. [1] This has been labeled "The Great Moderation", which is still one of the most striking macroeconomic features of the U.S. economy and other industrialized countries, although the recent global financial crisis has casted doubts on the tendency of economies to mute cycles.

However, studies on the role of composition on output volatility, almost exclusively based on the U.S. economy, have led to apparently contradictory findings, despite the very intuitive prediction by Burns (1960). McConnell and Pérez-Quirós (2000), after documenting a break in U.S. output volatility in the first quarter of 1984, find that output composition was of little importance in stabilizing output. They attribute the sharp decline in output volatility to the reduction in the magnitude of inventories investment, an extremely volatile component of durables output. Stock and Watson (2002) attribute the decreased U.S. output volatility to various factors, namely improved policy ($20-30\%$), "good luck" in the form of productivity and commodity price shocks ($20-30\%$), and other unidentified good luck factors.

1. All members of the Group of Seven (G-7) industrial countries witnessed the great moderation. Notable exceptions in the OECD group are Korea, Turkey and the Netherlands. The timing and magnitude of the moderation differ substantially across countries. For example, the great moderation can be dated back in around 1992 in the U.K., as opposed to the mid-80's in the case of the U.S.

McConnell and Pérez-Quirós (2000), and Stock and Watson (2002) build on the premise that, if compositional shifts were to impact the volatility of aggregate output, the series obtained by holding the shares of various GDP components constant would display no change in volatility over time.[2] McConnell and Pérez-Quirós (2000) hold each sector share's at its sample average, whereas Stock and Watson (2002) keep them at their 1965 levels. Comparing the volatility of the resulting series to the original GDP series, these authors find no significant evidence that composition matters for output volatility. One common feature among the above studies is that they focus on the break that emerged in aggregate volatility in the mid-80s. Blanchard and Simon (2001) view moderation through a longer lens, arguing that the decline in U.S. output volatility has been steady over several decades. It started in the early 1950's or earlier, was temporarily interrupted in the 1970's and early 1980's, and returned to trend afterwards.[3] They also conduct a counterfactual experiment similar to that described above, and find that composition plays little role in reducing the volatility of aggregate output.

Statistical support to the output compositional shifts hypothesis emerge from two recent empirical studies. Alcala and Sancho (2004) argue that the above methodology used to assess the role of composition on output volatility suffers from the same anomaly as does the fixed-weight (Laspeyres type) indexes that were used in the past to compute real aggregate series in the National Accounts, and that have been replaced by chain-weighted (Fisher type) indexes. In fact, given that sector's shares have experienced large changes over the sample period, output volatility is not immune from the particular base year one chooses. Allowing these shares to vary, the authors find that shifts across broad sectors of the U.S. economy account for about 30% of the volatility decline since the 1950's.

More recently, Eggers and Ioannides (2006), decomposing output by one-digit industry, find that a little less than half of the sharp decrease in U.S. volatility after the mid-1980's is accounted for by compositional shifts, and mostly the decline of manufacturing.

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2. Output volatility is computed as the standard deviation of real output growth over a backward-looking rolling window, as specified later in the text.

3. They note that the interruption in the 70's was due to large supply shocks.

In this paper, I use a model of structural transformation in which the reallocation of labor across sectors—that underpins output composition—emerges endogenously from changes in sectoral labor productivities. This is a major departure from previous studies which take output composition as given. Also, since data tend to suggest that the reallocation of labor across sectors is a continuous phenomenon—unlike the single mid-80s' break which characterizes the great moderation—this paper is about the long and lasting decline in output volatility depicted in Blanchard and Simon (2001).

This paper is a contribution to the large literature that seeks to understand the differences in business cycles patterns across countries. In fact, if aggregate output volatility is found to decline with the size of the service sector, countries with a large share of labor in the service sector will on average tend to feature lower volatility of aggregate output. The use of a panel has the unique advantage of controlling for eventual time and country effects. For example, the "normal" occurrence of business cycles in a given country at a point in time will tend to imply that output is still too volatile in that country, even if output volatility shows an overall decreasing trend when viewed through a longer lens. A cross-country analysis allows one to control for such country effects. The time effect would also allow to control for business cycle that hits all countries simultaneously at a point in time (such as the recent global financial crisis).

The subject tackled in this paper is closely related to Da-Rocha and Restuccia (2006), but differs from it along several dimensions. First, I emphasize the role of the low-volatility service sector, whereas these authors focus on agriculture. Second, the authors simulate their model around various steady states which differ by the share of employment in agriculture. This paper instead studies cross-country volatility patterns along a transitory path towards the balanced growth path. This allows me to account for the fact that OECD countries are at different stages of the process of structural transformation, as highlighted—but not accounted for—by Da-Rocha and Restuccia (2006). [4]

4. We recognize that countries such as Turkey and even the United States are undergoing a process of structural transformation (from agriculture to non-agriculture), and that Turkey may be lagging behind in this transitory path. However, our simplification is a tractable way of implementing our research question..."

From a methodological stand point, this paper is close to Duarte and Restuccia (2010) who also use a model of structural transformation to perform a set of counterfactual analyzes in order to examine the role of sectoral labor allocation on aggregate productivity levels in a long run perspective. This paper, however, differs from their in that it studies fluctuations in output, which captures changes at a business cycle frequency. A first step of the analysis consists to building a model of structural transformation that is calibrated to the experience of a given country (the U.S. here), in order to put discipline on preference parameters. It is critical that the model matches not only the process of structural transformation in the benchmark economy, but also that of other countries in the sample given that the counterfactual analysis is performed across countries.

In order to quantify the role of structural transformation on aggregate output volatility, I perform a set of counterfactual experiments in which the secular labor shifts across sectors are constrained endogenously. Computations suggest that labor reallocation toward the service sector is volatility-reducing.

The remainder of the paper proceeds as follows. Section 2.2 provides some cross-country volatility facts—both at sectoral and aggregate level. In Section 2.3, I present and calibrate a simple model of structural transformation to the U.S. experience, which I use to match the process of structural transformation across countries. Section 2.4 performs the counterfactual analysis, and Section 2.5 draws concluding remarks.

2.2 Empirical Evidence

Structural transformation typically involves three stages, as described by Kuznets (1966). Countries are characterized by a sizeable labor force in agriculture in the first stage. For example, at the beginning of the sample period (1970), the agriculture employment share—as a percentage of the civilian employment—was 63% in Turkey, nearly 50% in Korea, 41% in Greece, and 30% in Portugal and Spain. Countries then progressively shift resources from agriculture to manufacturing in the second stage. The third stage is characterized by the shift of employment away from manufacturing and towards services. For example, the

U.S., the U.K. and Canada now have more than 70% of their employment in the service sector, and less than 3% in agriculture. Since labor productivity is more volatile in agriculture than manufacturing, and more volatile in manufacturing than services, aggregate output volatility is likely to decrease as countries undergo the process of structural transformation. To gauge the extent of volatility differentials across sectors, Table II.I in appendix provides detailed data on sectoral and aggregate volatility across OECD countries.

In order to investigate the above conjecture empirically, Figure 2.1 portrays the volatility of aggregate output growth in OECD countries against the employment share of the service sector. For a given country i, volatility is computed at any point in time t, as the standard deviation of aggregate output growth over a rolling window. I consider a 10-year backward-looking window, so that the volatility at date t is the standard deviation of output growth from period $t-9$ to period t. Varying the window value does not alter the results. [5]

For a window value w, the volatility of a variable y in a given country i at date t is then defined as: [6]

$$\sigma^i_{t,w}(y) = \left(\frac{1}{w-1} \sum_{s=t-w+1}^{t} \left(y^i_s - \bar{y}^i_{t,w} \right)^2 \right)^{1/2}, \quad \text{where} \quad \bar{y}^i_{t,w} = \frac{1}{w} \sum_{s=t-w+1}^{t} y^i_s.$$

The vertical axis of the graph on the left panel of Figure 2.1 represents the volatility of aggregate output growth in a panel of OECD countries. The horizontal axis represents the average employment share of the service sector over the same window that is used to compute the volatility of output. A coordinate on that graph is therefore related to a given country at a specific point in time. The chart on the right panel is the cross-sectional representation of the chart on the left panel, as it represents average values. It therefore provides a cross-country picture of the link between output volatility and the employment share of the service sector.

5. A window value of 20 quarters is standard in the literature that studies the volatility of output growth at quarterly frequency (see Alcala and Sancho (2004), Blanchard and Simon (2001), McConnell, Pérez-Quirós, and Kahn (2002), among many others). I do not, however, use a 5-year window which appears too small for computing standard deviations.

6. Note that $\sigma^i_{T,T}(y) = \sigma^i(y)$, the usual standard deviation.

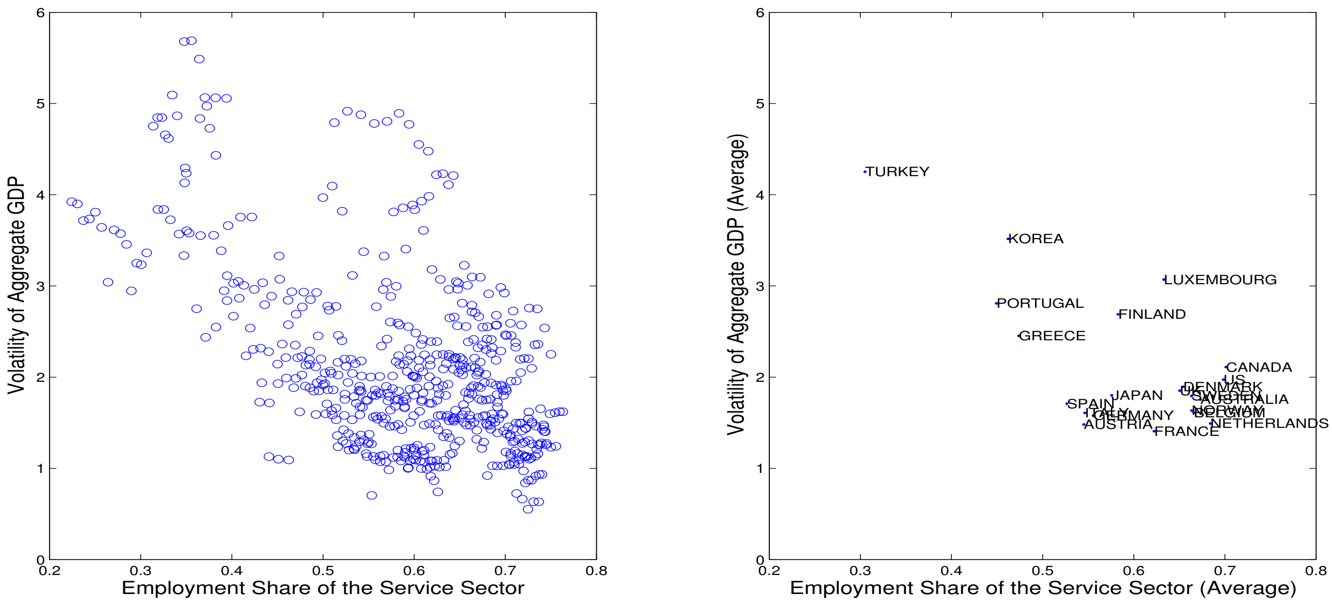

Figure 2.1: Employment Share of the Service Sector and Aggregate Output Volatility Across OECD Countries, 1970-2006.

It appears from these charts that a higher employment share in the service sector tends to be associated with a lower volatility of aggregate output growth. The correlation between these two variables is -0.68 across countries (right panel chart) and -0.56 in the panel (left panel chart). However, correlation does not imply causality. For example, more advanced countries tend to have both a more stable output growth (see Acemoglu and Zilibotti (1997))—stemming for instance from the development of their financial markets—and a high share of employment in the service sector, given that they are further ahead in the process of structural transformation.[7] The correlation of output volatility with GDP per capita is -0.54 across countries, and -0.45 in the panel, which are all smaller than the corresponding correlation between output volatility and the employment share of the service sector. This suggests that the employment share of the service sector may explain reduced volatility beyond the level of development—as proxied by the GDP per capita. To check

7. See Dynan, Elmendorf, and Sichel (2006) on the role of financial innovations in reducing the volatility of economic activity.

this conjecture, I regress output volatility on both the employment share of the service sector and the level of GDP per capita, and find that GPD per capita is not significant, whereas the employment share of the service sector is. [8] Another key factor that might affect output volatility is the level of financial markets development, as proxied by the credit to the private sector. I run a regression in which I also control for the credit to the private sector as a share of GDP and the effect of the employment ratio of the service sector on output volatility remains highly significant. I also perform a wide range of robustness checks, such as varying the window for computing the volatility, replacing the above measure of volatility by the standard deviation of the de-trended series, and the qualitative result is unaltered. [9]

2.3 The Model

2.3.1 The economic environment

The economy consists of 3 sectors, namely agriculture (a), manufacturing (m), and services (s). [10] Production in each sector is undertaken using a linear technology with labor as the only input:

$$Y_i = A_i L_i \ , \quad i \in \{a, m, s\}, \tag{2.3.1}$$

where A_i is the labor productivity specific to sector i, and L_i is the labor input that goes to that sector. A_i is thus a measure of the productivity per employee, which captures any factor that may affect production beyond the labor input. Capital and local institutions are examples of such factors.

8. Output volatility is obviously explained by several other factors beyond these two, but this simple exercise allows me to assess whether the observed correlation between the employment share of the service sector and aggregate output volatility is due to the fact that both variables are linked to a third one, namely the level of development. A regression with GDP per capita as the only explanatory variable obviously leads to the conclusion that the level of development matters for aggregate fluctuations, with more developed countries having a less volatile output on average.

9. The de-trended series are obtained by taking the difference between the (log of the) original series and the series obtained by applying the Hodrick-Prescott filtered with smoothing parameter $\lambda = 100$ (as it is standard for annual observations) to the (log of the) original series.

10. The terms manufacturing and industry are used interchangeability throughout the paper and both refer to the broader concept of industry which includes mining and construction beside manufacturing strictly speaking.

Because there are no externalities nor any other distortion in this economy, and since I'm not interested in tracking prices, I adopt the social planner approach to solving the model. The economy is populated by a continuum of identical and infinitely-lived households of measure one, who form the basis for the labor force. Population grows over time at an exogenous rate η, and each household is endowed with a unit of time in each period. Because employment data is used (rather than hours worked), I consider a model with indivisible labor as in Hansen (1985), based on the seminal work by Rogerson (1988). In that setup, an agent either work for a constant number of hours, or do not work at all. The model is thus silent about the intensive margin of the labor input. This is innocuous for the purpose of this study, as the extensive margin of labor accounts for most of the fluctuations in total labor input (see Hansen (1985)). [11] Since the number of hours worked are sector-specific, households care about which sectors they are allocated to, which is not the case in a the standard business cycle model.

The reason why I choose to use employment data over hours worked is the lack of a comprehensive dataset on hours worked for the relatively large set of countries that I am considering in this paper. For example, data on hours worked from the 10-Sector Database are only available for 9 out of the 21 countries in the sample. [12] One advantage of using employment data though is that they are likely to be measured more accurately, compared to data on hours worked.

In each period, an individual, if lucky enough do not work. [13] The probability of such

11. Hansen (1985) makes the following variance decomposition, where H is total number of hours worked, h is the average number of hours worked per employee, and L is the number of employees ($H_t = h_t L_t$):

$$\sigma^2_{\log H_t} = \sigma^2_{\log h_t} + 2cov(\log h_t, \log L_t) + \sigma^2_{\log L_t} \tag{2.3.2}$$

where the variables are deviations from trend. He finds that 55% of the variance of H is due to variations in L, while only 20% of this variance can be directly attributed to h, the remainder of the variations in H being due to the covariance term.

12. Data on sectoral hours worked also exist for few other countries from the ILO database, but this covers only a very short period of time, mostly running from 1990 on.

13. Not working is a matter of luck because the social planner provides full insurance to each agent in equilibrium (conditional on the strict concavity of the utility function), regardless of the working status. An unemployed agent then enjoys both leisure and the same consumption bundle as an individual who actually works.

event is independent across individual, and denoted $1-\pi_t$. L_t/N_t, the employment to population ratio, is the data counterpart of the equilibrium value of π_t. The probability that an agent works in sector i is given by $\pi_{i,t} = L_{i,t}/N_t$, so that $\pi_{a,t}+\pi_{m,t}+\pi_{s,t} = \pi_t$. It is of interest at this stage to define the probability of working in sector i, conditional on working: $n_i = L_i/L = \pi_i/\pi$. Note that $n_{a,t}+n_{m,t}+n_{s,t} = 1$.

2.3.2 Preferences

The representative household has preferences over the consumption of all three goods. There are two standard channels to generating reallocation of labor across sectors. One can either assume a low (less than 1) elasticity of substitution among goods (see Ngai and Pissarides (2007)) or non-homothetic preferences. In the latter case it is usual to assume an income elasticity of demand for the agricultural good less than unity (see Gollin, Parente, and Rogerson (2002, 2007)), and/or an income elasticity for the demand of services above unity (see Kongsamut, Rebelo, and Xie (2001b)). One can also combine a low elasticity of substitution among goods and non-homothetic preferences (see Rogerson (2008)).

In principle, a trade-off does exist: allowing for both channels to operate reduces the reliance on how low the elasticity of substitution among goods has to be in order to generate substantial reallocation of labor across sectors. The specification adopted in this paper is close to Duarte and Restuccia (2010), which is somewhat an hybrid of the above specifications. However, I focus on the extensive margin of labor for the reasons mentioned above, which makes the Hansen (1985) indivisible labor model more appropriate.

The planner's objective function reads:

$$\sum_{t=0}^{\infty} \beta^t \left[U\left(\frac{C_{a,t}}{N_t}, \frac{C_t}{N_t}, 1-h_t \right) \right] N_t, \quad 0<\beta<1,$$

where N is the population size, so that $C_i/N = c_i$ is the per capita consumption of good or service $i \in \{a,m,s\}$. h is the per-capita hours worked, so that $1-h$ is leisure (households are endowed with a unit of time). The following specification is adopted for the utility function:

$$U(c_{a,t}, c_t, h_t) = \omega \log(c_{a,t} - \bar{a}) + (1-\omega)\log(c_t) + \phi \log(1-h_t), \quad 0 < \omega, \phi < 1,$$

where $\bar{a}$ can be thought of as the subsistence level of agricultural goods. This parameter—which implies a lower than one income elasticity of agricultural goods—will drive labor out of agriculture as income rises, consistently with the data. [14]

The composite of the manufacturing and service goods takes the general CES functional form:

$$c = \left[\theta c_m^{(\varepsilon-1)/\varepsilon} + (1-\theta)(c_s + \bar{s})^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}, \qquad 0 < \theta < 1, \tag{2.3.4}$$

where $0 < \varepsilon < 1$ is a constant elasticity of substitution between the two goods. $\bar{s} > 0$ implies an income elasticity of services that is greater than unity. [15] This would induce the planner to shift resources out of manufacturing and towards services as income rises. [16]

2.3.3 Solving the model

The planner problem, in per capita terms, reads:

$$\underset{(\pi_{a,t};\pi_{m,t};\pi_{s,t})_{t=0}^{\infty}}{Max} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\omega \log(c_{a,t} - \bar{a}) + (1-\omega)\log c_t + \phi \left(\pi_{a,t}\log(1-\bar{h}_a) + \pi_{m,t}\log(1-\bar{h}_m) + \pi_{s,t}\log(1-\bar{h}_s)\right)\right]$$

14. An alternative way to drive labor out of agriculture at a high pace is provided in Duarte and Restuccia (2006) who adopt the following specification:

$$V(c_{a,t}) = \begin{cases} -\infty & \text{if} \quad c_{a,t} < \bar{a} \\ \min(c_{a,t}, \bar{a}) & \text{otherwise.} \end{cases} \tag{2.3.3}$$

But this modelling approach predicts a constant level of agricultural consumption through time ($\bar{a}$), which is at odds with the observation that output in agriculture fluctuates a lot. Although this specification was innocuous in their analysis which deals with long-run trends, it can clearly not be used to study fluctuations around the trend.

15. $\bar{s}$ is generally though of as a short cut to accounting for household production, since higher income drives people out of their home and leads to a rise in the demand for market services.

16. Duarte and Restuccia (2010) note that $\bar{s}$ is needed for the model to be able to drive labor towards services, while relying on a reasonable value of ε.

$$\text{s.t.} \quad \begin{aligned} c_{a,t} &\leq A_{a,t}\pi_{a,t} \\ c_{m,t} &\leq A_{m,t}\pi_{m,t} \\ c_{s,t} &\leq A_{s,t}\pi_{s,t} \\ c_t &= \left(\theta c_{m,t}^{(\varepsilon-1)/\varepsilon} + (1-\theta)(c_{s,t}+\bar{s})^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)} \end{aligned} \tag{2.3.5}$$

and

$$\pi_{a,t+}\pi_{m,t} + \pi_{s,t} = \pi_t$$

Since sectoral productivities are observed before the production of goods and services is undertaken, the solution to this problem is a sequence of static conditions. [17] Because the focus here is not on the level of employment *per se*, but on its allocation across sectors instead, the level of aggregate employment (L_t) is treated exogenously. Duarte and Restuccia (2010) and Da-Rocha and Restuccia (2006) adopt a similar approach by considering the total number of hours worked to be exogenous in their divisible labor model. [18]

The solution to the planner's problem can be casted in two stages. First, for a given value of the labor share in agriculture, π_a, the planner solves for the share of labor in manufacturing and services—π_m and π_s—given that $\pi_m + \pi_s = \pi - \pi_a$. In the second stage, the planner optimizes on π_a given π_m and π_s, which are now both functions of π_a—from the first stage.

The optimal reallocation path in the first stage is given by the following relationship:

$$\frac{\pi_s + \bar{s}/A_s}{\pi_m} = \left(\frac{1-\theta}{\theta}\right)^{\varepsilon} \left(\frac{\log(1-\bar{h}_m)}{\log(1-\bar{h}_s)}\right)^{\varepsilon} \left(\frac{A_s}{A_m}\right)^{\varepsilon-1} \tag{2.3.6}$$

If hours worked per employee are identical across sectors, then one obtains a relation which is standard in the literature on structural transformation. When they are allowed to differ, the sector with the lower number of hours worked tends to attract more labor, everything else equal. In fact, for given sectoral labor productivities, the sector with the higher number of hours worked per employee induces more disutility to the worker. But everything else is not equal. In fact, since $\varepsilon < 1$, Equation 2.3.6 implies that a lower rela-

17. I have therefore removed the time subscript to simplify the notations.
18. π_t is thus also exogenous here since the working-age population, N_t, is taken as given.

tive productivity in services drives labor out of manufacturing and towards services. [19] The intuition for this result is as follows: the low elasticity of substitution between manufacturing and services implies that households would like to have a fairly balanced consumption bundle of both goods. To ensure that, the social planner has to shift resources out of the most productive sector and towards the less productive one.

Equation 2.3.6 also implies that, for a given value of ε, the reallocation of labor towards services intensifies as $\bar{s}$ increases. To see this, let's shut down the substitution channel by either assuming $\varepsilon = 1$, or by assuming equal labor productivity in manufacturing and services. Now, combining Equation 2.3.6 with the equilibrium condition $\pi_m + \pi_s = \pi - \pi_a$—for given values of π_a and π—one gets:

$$\pi_s = \frac{1}{1+\psi}\left[\psi(\pi - \pi_a) - \bar{s}/A_s\right], \tag{2.3.7}$$

which implies that π_s increases as labor productivity rises.

Also, data shows—see the section on calibration—that sectoral hours worked are also lower in the service sector, so that the planner now has an additional incentive to move labor towards the service sector—beside the two standard channels induced by a low elasticity of substitution and the non homotheticity of preferences. [20]

Solving for π_a one obtains:

$$\pi_a = \frac{(\bar{a}/A_a)(1+\psi)(1-\omega) + \omega(\pi + \bar{s}/A_s)(\alpha_m/\alpha_a + \psi\alpha_s/\alpha_a)}{\omega(\alpha_m/\alpha_a + \psi\alpha_s/\alpha_a) + (1+\psi)(1-\omega)} \tag{2.3.8}$$

where $\alpha_i = \log(1 - \bar{h}_i),\ i \in \{a, m, s\}$, and

$$\psi = \left(\frac{1-\theta}{\theta}\right)^{\varepsilon}\left(\frac{\alpha_m}{\alpha_s}\right)^{\varepsilon}\left(\frac{A_s}{A_m}\right)^{\varepsilon-1}. \tag{2.3.9}$$

19. This is in line with Baumol's 1967 prediction on the evolution of the progressive and stagnant sectors.

20. Note that this channel emerges from the fact that I did not use data on hours worked but employment data.

When $\alpha_a = \alpha_m = \alpha_s = \alpha$, Equation 2.3.8 boils down to:

$$\pi_a = (1-\omega)\frac{\bar{a}}{A_a} + \omega(\pi + \bar{s}/A_s), \tag{2.3.10}$$

which is similar to the relation in Duarte and Restuccia (2010). Since A_a and A_s are increasing over time, $\bar{a}/A_a$ and $\bar{s}/A_s$ both vanish in the long-run. Since π will also be constant then, the share of labor that goes to agriculture is dictated by ω, the share of the agricultural good in the utility function.

2.3.4 Calibration

In this section, I calibrate the model to the U.S. experience over the period from 1970 to 2006. The time unit in the model is a year.

2.3.4.1 Parameter values

The calibration consists in assigning values to the parameters $\bar{h}_a$, $\bar{h}_m$, $\bar{h}_s$, $\bar{a}$, ω, ε, θ, $A_{a,0}$, $A_{m,0}$ and $A_{s,0}$. I follow the standard practice in the literature on structural transformation which consists in normalizing initial productivities to one, as choice of units (see Duarte and Restuccia (2006, 2010), Gollin, Parente, and Rogerson (2002), Rogerson (2008), among many others.)

$\bar{h}_i$, $i \in \{a,m,s\}$ are simply set to match the average per capita fraction of discretionary time that the economy devoted to sector i over the sample period. Data on total sectoral annual hours worked and persons employed in the U.S. are available from the 10-Sector Database. I aggregate these series into the three broad sectors considered in this paper, namely agriculture, manufacturing, and services. From these sectoral data, I compute the total number of annual hours worked per person employed for each sector, which I first divide by 365 to obtain daily working hours, and further by 16 to obtain the figure as a fraction of the discretionary time available to individuals. After adjusting for an employment to population ratio of 66%—a standard calibration value in the real business cycles literature—one gets: $\bar{h}_a = 0.49$, $\bar{h}_m = 0.54$, and $\bar{h}_s = 0.46$. These figures imply that a service sector employee spends on average 15% less hours working than a manufacturing employee, and 7% less than an employee in agriculture. Interestingly aggregate hours worked per employee from these computations average nearly to the calibrated value of 0.5 that Hansen (1985) obtains in a one sector RBC model.

I set the weight of the manufacturing good in the CES aggregate of manufacturing and services consumption (θ) to 0.05. This is somewhat in the middle range of the values in the literature on structural transformation. For example, Rogerson (2008) calibrates that parameter to 0.07, whereas Duarte and Restuccia (2010) obtain a calibrated value of 0.04.[21] ω is set so as to imply a long-run share of employment in agriculture of 1%.[22]

The remaining parameters $\bar{a}$, $\bar{s}$ and ε are calibrated jointly, using a procedure similar to the one described in Duarte and Restuccia (2010). Given an initial value for ε, $\bar{a}$ and $\bar{s}$ are chosen so as to match the initial share of labor in agriculture (using Equation 2.3.10), and in services (using Equation 2.3.6). Now, given these computed values for $\bar{a}$ and $\bar{s}$, ε is re-computed to match the time path of the service sector's labor share, as given by Equation 2.3.6. The value obtained for ε is again used to recompute $\bar{a}$ and $\bar{s}$, and the procedure is re-iterated until convergence is achieved. The resulting values are summarized in Table 2.I below. Two key parameters that drive the reallocation of labor from manufacturing to services following sectoral productivity changes are $\bar{s}$, which characterizes the non-homotheticity of preferences, and ε which is the elasticity of substitution between services and manufacturing goods. The value of 0.45 obtained here for $\bar{s}$ is lower than the calibrated values of 0.89 in Duarte and Restuccia (2010), and the value of 0.77 in Duarte and Restuccia (2006). The calibrated value for ε is 0.46, which is very close to the val-

Table 2.I: Parameter values

$A_{i,0}$	$\bar{h}_a$	$\bar{h}_m$	$\bar{h}_s$	ω	$\bar{a}$	$\bar{s}$	θ	ε
1	.49	.54	.46	.01	.018	.45	.05	.46

21. The sensitivity analysis on that parameter was reassuring.
22. Duarte and Restuccia (2010) set a similar target.

ues obtained elsewhere in the literature. For example, the corresponding values implied by Rogerson (2008) and Duarte and Restuccia (2010) are respectively 0.44 and 0.40—after using the appropriate mapping.

2.4 Results

2.4.1 Taking the model to data

Figure 2.2 portrays the time path of sectoral labor allocation in the United States as implied by the model. For the sake of comparison, the corresponding time series in the data are also displayed. Although the model tends to predict less re-allocation of labor from manufacturing to services than observed in the data, it captures the overall pattern of structural transformation pretty well. In addition, the model nicely captures the entire time path of the employment share of agriculture, although I only target the initial share.

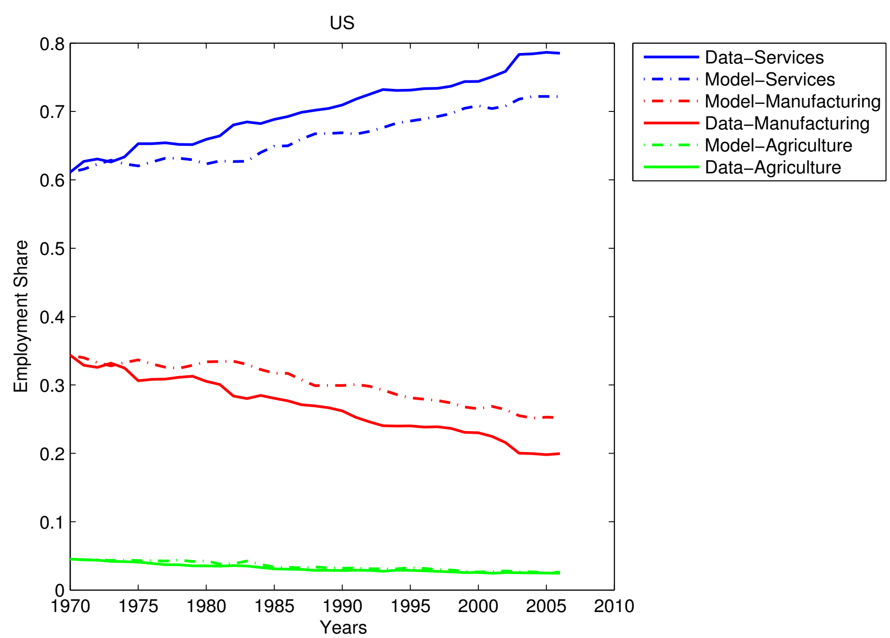

Figure 2.2: Sectoral Labor allocation in the U.S.: Model vs. Data.

The next step consists to using the model to replicate the time path of labor reallocation across sectors in the remaining countries of the sample over the period 1970-2006. Now that I have put discipline on preference parameters,[23] the initial levels of sectoral labor productivities are the only inputs needed to generate the time path of sectoral labor shares for the remaining countries in the sample, using Equation 2.3.6 and 2.3.10. In fact, given initial productivity levels, and the time path of the growth rate of labor productivity $(\tau_{i,t})_t$ computed from the data, the time path of sectoral labor productivity levels are uncovered, using the relation $A_{i,t+1} = (1+\tau_{i,t})A_{i,t}$.

Following Duarte and Restuccia (2010), initial labor productivity levels for any country in the sample are simply set so as to match 3 targets: the initial labor share in agriculture and services, and the initial aggregate productivity relative to the U.S. The reallocation of labor across sectors as predicted by the model are portrayed in Figure 2.3 and 2.4, along with the corresponding figures in the data. Overall, the model does a good job in replicating the structural transformation in OECD countries but in Korea, Germany and Turkey.[24]

23. The only preference parameter which is allowed to vary across countries is $\bar{s}$. Recall that $\bar{s}$ can be viewed as a shortcut to modelling home production of service goods. Duarte and Restuccia (2010) argue that $\bar{s}$ can therefore not be constant across countries with large differences in labor productivity in services. $\bar{s}$ is then set so as to keep the ratio $\bar{s}/A_s$ constant across countries.

24. As for Korea and Germany, the model perfectly captures the reallocation of labor out of agriculture, but fails to predict the reallocation of labor out of manufacturing in the magnitude of what is observed in the data. The mixed success of the model in the German case might be due to the fact that East and West Germany were at different stages of structural transformation at the time of reunification. Also, the model is not successful in explaining the process of structural transformation in Turkey. Perhaps a more targeted model is needed as more than 60% of the labor force was still in agriculture at the beginning of the sample period, substantially higher than in a typical OECD country where the corresponding value is as half as large at most.

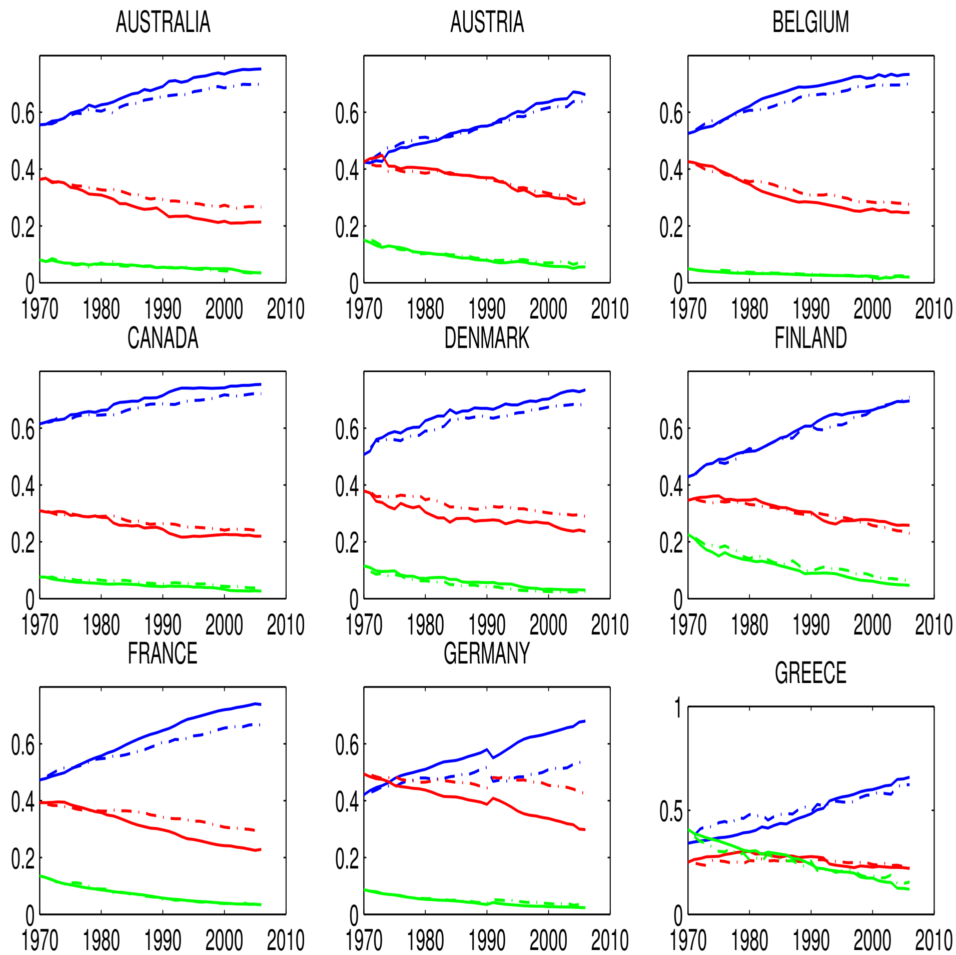

Figure 2.3: Sectoral Labor allocation in Selected OECD Countries: Model vs. Data (first part)

2.4.2 Counterfactual experiments

In this section, I perform a set of counterfactual experiments to assess the quantitative role of sectoral labor reallocation on the volatility of aggregate output. For such exercise to be meaningful, the model presented in this paper should be able to replicate the negative relationship between the volatility of aggregate output and the employment share of the service sector found in the data. Figure 2.5 suggests that the model does pass the test pretty comfortably. However, although Turkey is the most volatile economy both in the

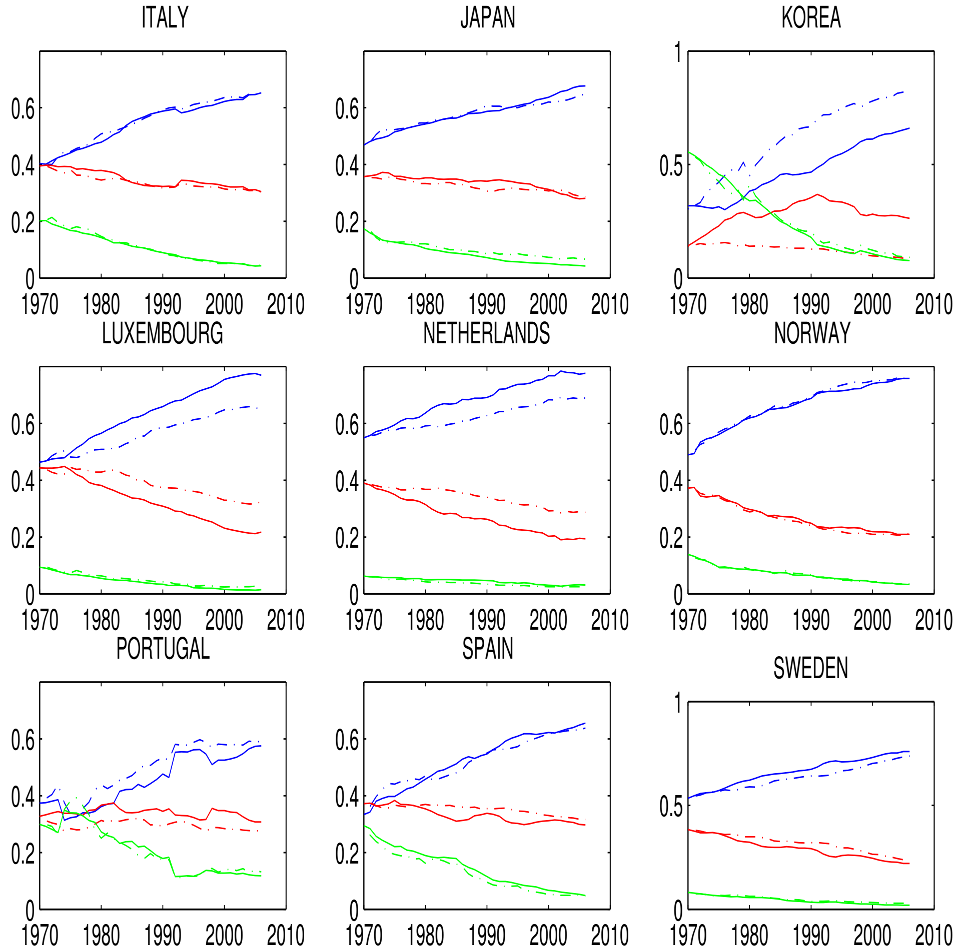

Figure 2.4: Sectoral Labor allocation in selected OECD countries (continued): Model vs. Data

model and in the data, the model tends to over-predict aggregate output volatility in Turkey. Aggregate output volatility in Germany is also much higher in the model than in the data. Some potential explanations of the mixed success of the model in the cases of Turkey and Germany are provided in Section 2.4.1. Nonetheless, the overall picture is preserved.

A particular feature of the model used in this paper is that it emphasizes long-run dynamics—structural transformation—in analyzing short-run dynamics—volatility of aggregate output. As such, any counterfactual experiments should reflect that feature. On a methodological stand point, the approach adopted here is different from standard practices

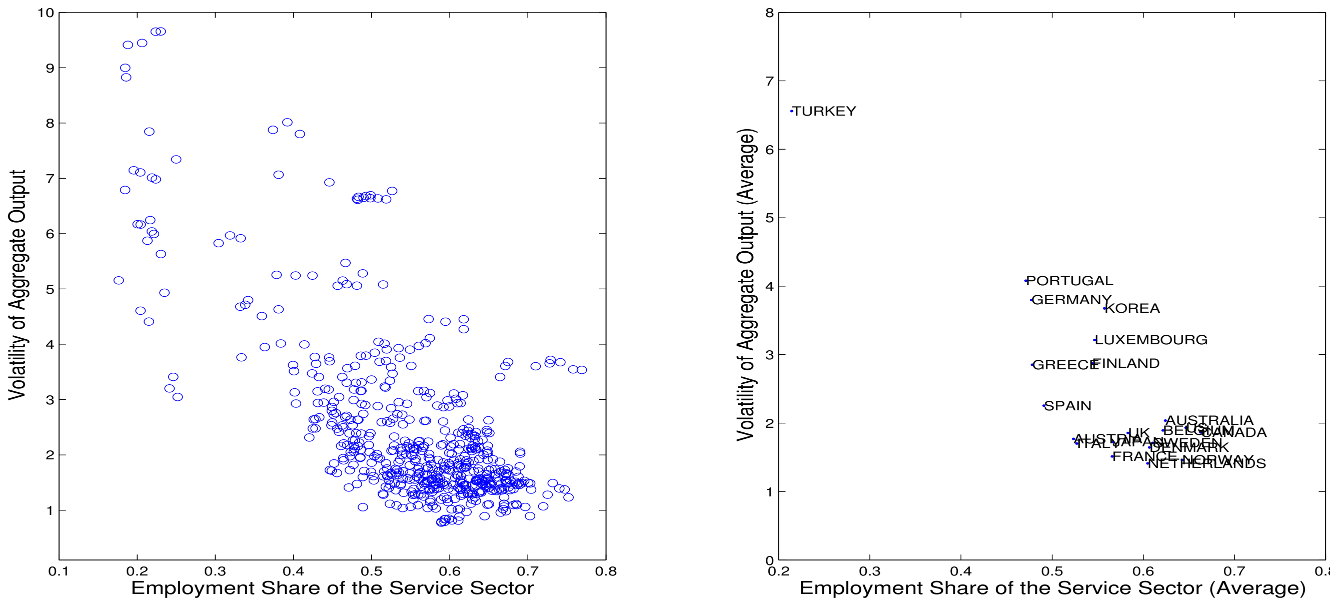

Figure 2.5: Model prediction: Employment Share of the Service Sector and Aggregate Output Volatility Across OECD Countries, 1970-2006.

in the real business cycle literature where the models are simulated around a steady state—after an appropriate de-trending of the system. In the baseline model, computations are made along a growing path instead. The idea behind the counterfactual experiments is to prevent labor from moving systematically and permanently from agriculture to manufacturing, and from manufacturing to services, and evaluate the resulting volatility of aggregate output. One could therefore pin down the contribution of permanent labor shifts in the baseline model where labor move freely across sectors.

Given that labor shares across sectors are endogenously determined, one cannot simply set their values in performing this exercise. One should instead change sectoral labor productivities—the driving exogenous forces—accordingly. In order to shut down structural transformation—long-run dynamics—I use the HP-filter to decompose labor productivities into permanent and cyclical components as follows:

$$A_{i,t} = A_{i,t}^{trend} + A_{i,t}^{cycle} \quad i = a, m, s \tag{2.4.1}$$

where $A_{i,t}^{trend}$ is the trend component of labor productivity ($A_{i,t}$) in sector i , and $A_{i,t}^{cycle}$ is the corresponding cyclical component.

The first counterfactual experiment keeps labor productivity unchanged in services and agriculture, and assumes the same trend in labor productivity in manufacturing as in services, the cyclical component remaining unchanged. It is indeed critical for the analysis here that the cyclical behaviour of labor productivities be preserved. Changing both the trend and cyclical components of labor productivity would make it hard to disentangle the effect of structural transformation on aggregate output volatility simply because the volatility of sectoral labor productivities would also affect the volatility of aggregate output.

The initial values of labor productivities are kept the same as in the baseline model. This ensures that labor shares are the same in the baseline and in the counterfactual experiments at the beginning of the sample period. Recall that the initial labor productivities are set so as to meet three targets: initial labor share in agriculture and services, and aggregate productivity relative to the US in the first period.

Labor productivities in the first counterfactual experiment are therefore given by:

$$A_{i,0}^{1} = A_{i,0}, \quad i = a, m, s \tag{2.4.2}$$

$$A_{a,t}^{1} = A_{a,t}; \quad A_{m,t}^{1} = A_{s,t}^{trend} + A_{m,t}^{cycle}; \quad A_{s,t}^{1} = A_{s,t}, \quad \text{for} \quad t = 2, ..., T. \tag{2.4.3}$$

The second counterfactual differs from the first one only in that the labor productivity in agriculture is also distorted. I assume that its trend is also the same as in the service sector, the cyclical component remaining unchanged, so that:

$$A_{i,0}^{2} = A_{i,0}, \quad i = a, m, s \tag{2.4.4}$$

$$A_{a,t}^{2} = A_{s,t}^{trend} + A_{a,t}^{cycle}; \quad A_{m,t}^{2} = A_{s,t}^{trend} + A_{m,t}^{cycle}; \quad A_{s,t}^{2} = A_{s,t}, \quad \text{for} \quad t = 2, ..., T. \tag{2.4.5}$$

The results suggest that the reallocation of labor towards the service sector is volatility-reducing. The average cross-country reallocation of labor toward the service sector from the first to the last period is about 22% of total employment in the model. The correspond-

Table 2.II: The role of Structural transformation on aggregate volatility

	Changes[1] in Share of Employment			Changes[2] in Aggregate Output Volatility
	Agriculture	Manufacturing	Services	
Model	-11.9	-9.8	21.7	-35.6
Counterfactual 1	-11.9	-3.2	15.0	-24.0
Counterfactual 2	-4.8	-4.6	9.4	-16.1

[1]Changes from the first to the last period (in percentage).
[2] Changes from the first volatility data point to the last volatility data point (in percentage). Recall that volatility is computed as the standard deviation of output growth over a rolling window of 10-year backward looking window.

ing drop in output volatility—from the first to the last data point—is 35.6%.

The reallocation of labor toward the service sector from the first to the last period is reduced to 15% in the first counterfactual experiment, which results in a drop of 24 percentage points in output volatility. The drop in output volatility is less than in the baseline model, highlighting the role of labor shifts in accounting for the reduction in aggregate output volatility. When one further shuts down the shift of labor toward the service sector in the second experiment—by also preventing labor from moving away from the highly volatile agriculture—the volatility of aggregate output falls by only an average 16% between the first and last period, compare to a high 35.6% in the baseline model. [25]

2.5 Conclusion

This paper uses a model of structural transformation—secular reallocation of labor across sectors—to illustrate the importance of labor shifts across sectors on the volatility

25. Note that one cannot completely shut down labor reallocation toward the service sector given the greater than one demand elasticity for services. Also as a consequence, a counterfactual experiment in which labor productivity in the services sector was allowed to change do not yield a change in aggregate output volatility.

of aggregate output. The model is calibrated to match the allocation of labor across agriculture, manufacturing, and services in the U.S. economy during 1970-2006. The set-up is then used to generate the time paths of employment shares in agriculture, manufacturing and services in OECD countries. The reallocation of labor in the model emerges from differences in labor productivity growth across sectors, coupled with uneven income elasticities. The predicted time paths of labor across sectors resemble the data quite well.

In the data, labor productivity is more volatile in agriculture and manufacturing than in services. Aggregate output would therefore *mechanically* become less volatile as labor moves away from agriculture and manufacturing and toward the (low-volatility) service sector. In order to disentangle the role of long-run dynamics—structural transformation—from the role of short-run dynamics—volatility of labor productivities—on the volatility of aggregate output, the paper resorts to a set of counterfactual experiments in which (exogenous) labor productivities are modified in a way that distorts their long-run dynamics (permanent component) but preserves their short-run dynamics (cyclical component). This is achieved through HP-filtering. Imposing the same trend to labor productivity across sectors limits the extent of secular labor reallocation and allows one to pin down the contribution of structural transformation in the reduction in aggregate output volatility obtained in the baseline model. Computations suggest that the shift of labor toward the relatively stable service sector does on average reduce the volatility of aggregate output.

There are two possible extensions to this paper. Due to data availability and the necessity to having a balanced panel, the sample starts in 1970. At the time, countries like the U.S., the U.K., and Canada had very few amount of labor left in agriculture—typically less than 10% of their total employment—which may limit the scope of the analysis presented in this paper when it comes to labor mobility away from agriculture. The model, however, still captures the implications of labor mobility from manufacturing to services in these countries. Extending the data back in the early 50s for all OECD countries—and beyond—would substantiate the results obtained in this paper. This implies uncovering sectoral labor productivities in less advanced countries like Poland, Uruguay and the Czech Republic. A challenge in doing this, however, would be to keep the tractability of the model which currently has a close form solution for sectoral labor reallocation.

CHAPTER 3

EXCHANGE RATE VOLATILITY UNDER PEG: DO TRADE PATTERNS MATTER?

ABSTRACT

This paper assesses the role of trade patterns in shaping the volatility of the nominal effective exchange rate under two alternative peg regimes: a peg to a single currency and a peg to a composite basket of currencies. I use monthly bilateral exchange rates data and annual trade data from 1980 to 2010 of the member countries of the West African Economic and Monetary Union (WAEMU). These countries have their common currency—the CFA franc—pegged to the French franc since 1945, and to the euro since its introduction in 1999. At the time of the initial peg arrangement, France accounted for most of the external trade of WAEMU countries. Since then, and more notably since the early 2000s, the trade patterns of these countries shifted briskly away from France and other Euro area countries and towards the BICs—China in particular. This paper examines the implications of these shifting trade patterns on the volatility of the effective exchange rate of WAEMU countries. I first compare the volatility of the effective exchange rate under the current hard peg to the corresponding volatility under a hypothetical and more diversified peg to a composite basket of currencies, such as SDR—Special Drawing Rights. I find that while the effective exchange rate of the CFA would have been equally volatile under SDR peg during the first two decades of the sample period, pegging to SDR would have resulted in an effective exchange rate nearly half as volatile as what was observed during the past decade. Moreover, computations show that nearly half of the volatility of the effective exchange rate of the past decade was accounted for by shifts in trade patterns. Finally, with trade patterns at their initial level, the effective exchange rate under SDR peg would have been significantly more volatile than what was observed under hard peg over the past decade. These findings altogether suggest that policy makers should pay as much attention to the type of peg as to pegging *per se*, with a particular focus on the dynamics of trade patterns.

JEL Classification: F31, F33.

Keywords: Trade patterns, hard peg, basket peg.

3.1 Introduction

The debate over the appropriate exchange rate regime for small open developing economies is very prominent among policy makers. The spectrum of choices is very large, expanding from the two "corner solutions"—hard peg and pure floating—to a continuum of intermediate regimes, including basket peg, crawling peg and "dirty" floats.

In a comprehensive survey covering the period 1970-99, Rogoff, Hussain, Mody, Brooks, and Oomes (2003) document that countries that adopted a flexible exchange rate regime outperformed those which opted for peg. The annual real per capita growth rate averaged 3.6 percent in the former category, and only 2 percent in the latter over the sample period. The corresponding figure was 2.8 percent in countries that adopted intermediate regimes. Also, the study shows that the volatility of the real GDP growth was highest in fixed exchange rate countries (4 percent on an annual basis) and lowest (1.6 percent) in countries that adopted intermediate regimes. Although these results may be subject to a selection bias problem, the discrepancy is striking. [1]

Notwithstanding this relatively low performance of fixed exchange rate regimes, the 2010 IMF report on exchange rate arrangement suggests that nearly 10 percent of countries in the world still have their currency pegged *de jure* to a major currency. The choice of exchange rate regime ultimately depends on a number of factors, including the level of domestic financial development, and the strength of local institutions—e.g. the ability of country's authorities to manage a currency credibly. Countries with a weak track record in containing inflation may peg their currency to a major currency in order to import low inflation and credibility from the anchor country. Also, some countries peg their currency to a basket of major currencies as an intermediate step toward pure floating.

Although an extensive literature covers the degree of exchange rate flexibility, little at-

1. The selection bias may arise from the fact that countries that adopt flexible exchange rate regimes have relatively well developed financial markets. Now, since financial markets are growth-enhancing, and also help smooth-out consumption—through the sale and purchase of financial instruments—countries with flexible exchange rate regimes will tend to display both higher growth rates and lower growth volatility in the data.

tention has been devoted to different types of peg arrangements. This paper is an attempt to close that gap. The decision of how to peg might in fact be as critical as pegging *per se*. The paper discriminates among different types of peg arrangements on the basis of a particular criterion: the volatility of the nominal effective exchange rate. This is an important criterion as Duarte, Restuccia, and Waddle (2007)—using a panel of developed and developing countries—document that real macroeconomic variables—output, consumption, investment, net exports, real exchange rate—co-move significantly with the nominal effective exchange. In addition, the co-movement is substantially stronger in developing than developed countries. In a more recent paper, Aghion, Bacchetta, Ranciere, and Rogoff (2009) find that the volatility of the real effective exchange rate is detrimental for productivity growth. [2] The paper, however, does not aim at deriving an optimal peg. Such exercise would require taking into account not only considerations related to trade and exchange rate volatility, but also the extent of imported inflation, the currency denomination of countries' liabilities, as well as institutional constraints that countries face.

In examining the volatility of the effective exchange rate across peg regimes, the paper put an emphasis on the role of shifting trade patterns. In principle, when the domestic country carries most of his trade with a single major country, pegging the local currency to that country's currency would limit the volatility of the effective exchange rate. This is because the effective exchange rate precisely captures the average value of the local currency vis-*à*-vis the currencies of its trading partners, weighted by partners' trade shares. However, as the domestic country's trade patterns diversify, the hard peg to an anchor may at some point cease to be the most appropriate regime in stabilizing the nominal effective exchange rate. This is because—as shown in Section 3.3—the fluctuations of the effective exchange rate depends on the behaviour of the anchor vis-*à*-vis other trading partners' currencies, to an extent that is decreasing with the trade share of the anchor country.

In the application, I use a sample of height West African countries that have their com-

2. Although the authors focus on the real effective exchange rate, their findings are also relevant for this paper which focuses on the nominal effective exchange rate, given that Duarte, Restuccia, and Waddle (2007) document a very strong co-movement between the nominal and real effective exchange rate, with the correlation ranging from 0.76 for developing countries to 0.92 for developed countries.

mon currency—the CFA franc—pegged to the French franc since the mid-40s and to the euro since its introduction in 1999. These countries now constitute a substantial part of the world sample of fixed exchange rate countries, and form the Western African Economic and Monetary Union (WAEMU).[3] I consider these countries as a group instead of analyzing them separately because their monetary policy is implemented at the union level. Although one should expect some heterogeneity in the volatility of the effective exchange rate across these countries, the difference is likely to be small as they have pretty similar production structures and trade with the same set of countries.

At the time of the initial peg arrangement, France accounted for most of the external trade of WAEMU countries. Since then, and even more since the early 2000s, the trade patterns of WAEMU countries shifted briskly away from France and other Euro area countries and towards the BICs—China in particular. This paper addresses the following two questions: (i) what are the implications of the above trade patterns' shifts on the volatility of the nominal effective exchange rate of the WAEMU? (ii) Would pegging their currency to a basket of currencies *in lieu* of the current hard peg arrangement have resulted in a lower volatility of their effective exchange rate?

I gauge the current hard peg against a simple benchmark basket peg: the SDR (Special Drawing Rights) which is a weighted average of the main worldwide trading currencies: the US dollar, the Euro, the Japanese yen and the British pound. This basket of currencies, although not used directly in trade (at least not yet), is easy to monitor. In addition, it has two nice features for the set of countries under consideration. First it embeds the currencies of all WAEMU countries' major trading partners. Second, although the weights in the SDR basket[4] may not fully capture the trade shares of WAEMU partners, they do reflect—to some extent—countries' weights in the world demand of intermediate goods. Now, given that WAEMU countries mainly export commodities—used as intermediate goods—their demand and price would be highly influenced by the demand of countries that constitute

3. The WAEMU includes eight countries in West Africa: Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo.

4. The weights are 41.9 percent for the U.S. dollar, 37.4 percent for the Euro, 11.3 percent for the Pound sterling, and 9.4 percent for the Japanese yen as of December 2010.

the SDR basket. Third, it seems more convenient in promoting intra-regional trade than alternative import weights composite basket. This is because unilateral basket pegs might pose an extra harmonization issue at the regional level.

Using monthly bilateral exchange rates data and annual trade data from 1980 to 2010, I find that nearly half of the volatility of the effective exchange rate of the CFA over the past decade was accounted for by shifts in WAEMU countries trade patterns. In addition, given these shifts, a peg to SDR would have resulted to an effective exchange rate as half as volatile over the same episode. On the other hand, with trade patterns at their 1980 configuration, SDR peg would have resulted to a substantially more volatile effective exchange rate than what was observed under hard peg.

The remainder of the paper is organized as follows. I end this Section with a brief review of the literature. Section 3.2 presents some background elements to the analysis, including the evolution of the institutional CFA peg's arrangement, and the dynamics of WAEMU trade patterns. Section 3.3 derives the analytical result which forms the basis for the application in Section 3.4. Section 3.5 concludes and draws policy implications.

3.1.1 Related Literature

This paper is a contribution to the literature that examines the volatility of the nominal effective exchange rate across alternative regimes, most of which follows the South-East Asian's financial crisis during 1997-98. Bird and Rajan (2002) find that the pre-crisis soft peg to the US dollar was sub-optimal, and argues that South-East Asian countries would have avoided the third currency phenomenon [5]—which may have contributed to the crisis—had they pegged their currencies to a basket of composite currencies. In addition, the author finds that South East Asian countries would be better-off with a common basket peg rather than each individual country adopting its own basket. In a related paper, Williamson (1996) and Azis and Puttanapong (2008) also build the case for a common basket peg—as opposed to unilateral peg—in South-East Asia.

5. The third currency phenomenon is a situation whereby changes in the exchange rate of the anchor vis-*à*-vis other currencies translate into changes in the domestic currency's exchange rate.

The most related study to this paper is perhaps Crockett and Nsouli (1977). The authors find—using data from 1970 to 1975—that the nominal effective exchange rate of the CFA franc was significantly less volatile under French Franc peg than it would have been under the hypothetical peg to SDR. That result, which is apparently in contrast with the finding in this paper, is not. In fact, Crockett and Nsouli (1977)—as most of the papers in the existing literature—keeps trade patterns unchanged throughout the sample period, hypothesis which is innocuous for their analysis given the relatively short period of time that the authors cover. In contrast, I consider a longer period, spanning three decades over which trade patterns have shifted substantially. I show that such shifts have a major impact on the volatility of the effective exchange rate across different types of peg arrangements.[6] The paper confirms the finding that the peg to the French franc would have been volatility-reducing with trade patterns at their level thirty years ago. More importantly, I find that the peg to SDR would have been more effective in containing the volatility of the nominal effective exchange rate of the WAEMU over the past decade, owing to the substantial shifts in trade patterns—away from the Euro area.

3.2 Background

3.2.1 Institutional arrangement of the CFA franc's peg

The peg arrangement between France and WAEMU countries dates back in 1945. The introduction of the Euro in 1999, and the subsequent withdrawal of the French franc from circulation, did not have major institutional implications on the CFA zone.

One of the major changes in the history of this institutional arrangement is the devaluation of the CFA franc that occurred in January 1994. This devaluation, which aimed at restoring the CFA zone's external balances, brought the value of a unit of CFA franc down to 0.01, from 0.02 French francs.

The entire CFA zone now includes fourteen countries grouped in two monetary unions:

6. This makes the framework dynamic, which an important departure of this paper—where trade patterns are allowed to shift over time—from the existing literature.

the WAEMU which includes height countries, and the CEMAC with six countries. Although the currencies of these two unions share the same acronym—CFA—they are technically different as they are not convertible.

3.2.2 The dynamics of WAEMU's trade patterns (1980-2010)

Table 3.I summarizes the trade (sum of imports and exports) patterns of the WAEMU zone (including intra-regional trade) over the past three decades. It calls for several observations. First and most striking, the France's trade share dropped substantially (by three-

Table 3.I: Shift in WAEMU trade (sum of exports and imports) patterns, 1980-2010

	1980	1995	2005	2010
Euro area	54.2	45.4	35.4	26.1
of which France	31.2	24.1	20.0	10.4
USA	5.2	4.3	6.3	4.9
BICs	2.1	5.7	7.6	15.2
of which China	1.4	1.6	3.5	10.8
India	0.3	2.9	2.9	3.3
Intra-WAEMU	7.5	8.3	10.5	10.9
Other selected countries				
Nigeria	3.9	5.2	10.5	8.4
Ghana	0.2	1.2	1.3	2.6

Source: IMF Direction of Trade Statistics and author's calculations.

folds) over the sample period. From one third of WAEMU's trade in 1980 it went down to about only 10 percent in 2010. More generally, Euro area became less of an important trading partner over the sample period. While it accounted for more than half of the WAEMU's external trade in 1980, its trade share had dropped by half by 2010. These shifts away from France and the euro area were mainly counterbalanced by a more prominent role of the

BICs, and China in particular. A breakdown of the table into imports and exports show similar shifts. China has indeed become a more attractive market for imports (its import share rose from a low 2 percent in 1980 to 15 percent in 2010). As for exports, the Indian markets have attracted a larger share of WAEMU exported goods. Their export share went from 0 to 5 percent between 1980 and 2000. These developments at the regional level are reflective of country-specific trade dynamics.

3.3 The analytics

In this Section, I derive a relationship between the changes in the domestic nominal effective exchange rate and the fluctuations of the anchor currency vis-*à*-vis the currencies of the local country's trade partners.

The nominal effective exchange rate (NEER) of the domestic country (currency) j is defined as follows, where time subscripts have been dropped for clarity:

$$NEER_j = \prod_{i=1}^{N} (E_{i/j})^{w_i} \tag{3.3.1}$$

Where:

- N is the number of country j's main trade partners;
- $E_{i/j}$ is the bilateral exchange rate between currency i and currency j, defined here as the number of units of currency i per unit of currency j;
- w_i is the share of country i in country j's total trade, normalized so that: $\sum_{i=1}^{N} w_i = 1$.

Since the paper focuses on alternative peg regimes (hard peg and basket peg), let's denote by i_0 the anchor currency, that is the currency to which the domestic currency (j) is pegged. Noting that $E_{i/j} = E_{i/i_0}.E_{i_0/j}$ for any currency i, and using the relation $\sum_{i=1}^{N} w_i = 1$, Equation 3.3.1 yields:

$$NEER_j = E_{i_0/j} \cdot \prod_{i=1}^{N} (E_{i/i_0})^{w_i} \tag{3.3.2}$$

After some algebra I obtain the following relationship in which trade shares have been redefined:

$$\ln(NEER_j) = \ln(E_{i_0/j}) + (1 - w_{i_0}). \sum_{i=K+1}^{N} \phi_i \ln(E_{i/i_0}) \tag{3.3.3}$$

Where:

- K is the number of countries that share currency i_0, which is the currency to which the local currency j would be pegged. One could think of i_0 as being the euro and K the number of countries in the European union. K therefore needs not equal one. In the case of a peg to SDR, K equals zero as no country has SDR as currency.
- $w_{i_0} = \sum_{i=1}^{K} w_i$;
- $\phi_i = \frac{w_i}{1-w_{i_0}}$, and corresponds to the new trade shares of country i when one ignores the trade weights of anchor countries—countries which have i_0 as currency.

The month-to-month changes in the nominal effective exchange are therefore given by the following relationship: [7]

$$\Delta\ln(NEER_j) = \Delta\ln(E_{i_0/j}) + (1 - w_{i_0}). \sum_{i=K+1}^{N} \phi_i \Delta\ln(E_{i/i_0}) \tag{3.3.4}$$

Equation 3.3.4 is central to the analysis that will follow in the next Section. The first term in the right hand side of the equation is policy-related. Changing it indeed requires a policy action, namely an amendment to the institutional peg arrangement (e.g. through devaluation). This term can mistakenly be perceived as being the only term that affects the effective exchange rate of a currency under a fixed exchange rate regime. This would be equivalent to saying that the effective exchange rate of a pegged currency coincides with is nominal exchange rate. Equation 3.3.4 precisely highlights that this is a misperception. A country's effective exchange rate is in fact subject to fluctuations among major currencies—through the third currency phenomenon in the case of fixed exchange rate regimes. This channel is exogenous to the country and is represented by the second term of Equation

7. The equation assumes no month-to-month changes in trade shares as trade data is not available at monthly frequency. This is somewhat innocuous for the analysis as a country's trade shares are unlikely to change substantially within such a short time span. The trade shares (ϕ_i, w_{i_0}) in a given month are set at the corresponding annual figure. Although trade weights do not change on a monthly basis, their levels do affect the volatility of the effective exchange rate and are accounted for in the set-up (second term in the RHS).

3.3.4.

Under a fixed exchange rate regime, the fluctuations of the anchor vis-*à*-vis the currency of the domestic country's trade partners translates into changes in the nominal effective exchange rate of the domestic country to an extent that is decreasing with the trade share of the anchor country. In fact, as trade patterns shift away from the anchor country, the domestic country becomes more vulnerable to the behaviour of the anchor currency vis-*à*-vis the currencies of its other trading partners. In that context, a peg to a basket of currencies that is more reflective of the country's trade patterns, could insulate its nominal effective exchange rate from fluctuations in major currencies. To see this let's consider the following two extreme cases:

- $w_{i_0} = \sum_{i=1}^{K} w_i = 1$: The domestic country trades exclusively with the anchor country. Equation 3.3.4 suggests that the nominal effective exchange rate of the domestic currency in this case would be equal to $E_{i_0/j}$ which is constant in the absence of policy intervention, given the hard peg. This is intuitive given that the domestic country would not be exposed to the third currency phenomenon.
- $w_{i_0} = \sum_{i=1}^{N} w_i = 0$: The country does not trade at all with the anchor country, and yet has its currency pegged to that country's currency. The fluctuations of the "anchor currency" vis-*à*-vis currencies of the domestic country's trade partners are therefore fully pass-through to its effective exchange rate by the third currency phenomenon.

Pegging to a composite basket of main trading partners' currencies ensures in particular that the underlying hypothetical weight w_{i_0} would always be large, thus minimizing the exogenous term. In general, a weighted average of currencies would by construction be less volatile than a single currency as per an argument similar to that of portfolio diversification prominent in the finance literature.

3.4 Application: the WAEMU's nominal effective exchange rate

3.4.1 Data sources and computations

I use annual trade data for WAEMU countries, and monthly bilateral exchange rate data of trade partners for the period 1980M1-2010M12. The list of trade partners is compiled so as to reflect the imports origin and exports direction of individual WAEMU countries. [8] It includes fourteen countries of which six countries in the Euro area: Belgium, France, Germany, Italy, Netherlands, and Spain; Japan, U.K., U.S.; the BICs: China, Brazil, India; and two non-WAEMU African countries: Ghana and Nigeria.

The main trading partners of individual countries are obtained from the "IMF exchange rate facility". In the exchange rate facility, however, trade weights are updated only every 5 to 10 years. Although this is generally enough to capture the overall dynamics of trade patterns—existing studies on effective exchange rate typically rely on these weights—it is less appropriate for this study which emphasizes the role of trade patterns.

I therefore gather annual exports and imports data by trade partner for all individual WAEMU countries from the "IMF Direction of Trade Statistics". Countries data are then aggregate into union-wide data, from which regional trade weights are computed. These trade weights are used, together with bilateral exchange rate figures to evaluate Equation 3.3.4. This gives a time-series of monthly changes in the NEER from which the volatility is computed as the standard deviation of NEER changes over different sub-periods of interest. I consider sub-periods that are reflective of the evolution of the institutional CFA peg arrangement as described in Section 3.2.1. In particular one needs to distinguish pre and post devaluation episodes. In fact the first term of Equation 3.3.4 shifted dramatically upon a parity changes, which would distort the picture. Also, the introduction of the euro in 1999 was a significant step in the peg arrangement, and I split the sample accordingly. I also consider 2001 which represents the year from which the euro officially replaced the currencies of individual euro area countries in daily transactions. Finally, I consider the re-

8. Partners countries on the list cover on average three quarters of individual WAEMU countries trade.

cent global financial crisis' episode separately given the substantial volatility of exchange rates that resulted from financial shocks.

3.4.2 Counterfactual analysis

3.4.2.1 Description

I evaluate the volatility of the nominal effective exchange rate under two peg arrangements: the actual peg to the euro and the hypothetical peg to SDR. This corresponds to setting $i_0 \in \{Euro, SDR\}$ in Equation 3.3.4. I then perform a counterfactual experiment to gauge the role of shifting trade patterns on the volatility of the nominal effective exchange rate. I therefore re-compute the previous volatilities keeping trade weights at their 1980 level throughout the sample period.

3.4.2.2 Results

Table 3.II presents the monthly volatility of the nominal effective exchange rate under the current hard peg and under a hypothetical basket peg (SDR). The figures displayed are monthly standard deviations over the corresponding sub-periods. Note that annual volatility figures would be substantially higher. The sub-periods are set to match different phases of evolution of the CFA peg arrangement as explained above, except that I further split the past decade between the pre and post-crisis episodes, so as to highlight the structural break in volatility brought about by the recent global financial crisis. Results suggest that for any sub-periods prior to 2001, the nominal effective exchange rate of the CFA seems equally volatile under hard peg and SDR peg.[9] Formal tests of variance difference confirms that the volatilities under both peg regimes are not statistically different in any sub-periods prior to 2001. A test for the period from January 1980 to December 2000 as a whole yields a similar result. However, due to substantial shifts in the trade patterns over the past decade, the actual nominal effective exchange rate is nearly as twice as volatile under hard peg than

9. SDR peg yields a slightly higher NEER's volatility than the current hard peg. The difference, however, is not significant over the first two decades of the sample period.

Table 3.II: The volatility of the NEER under hard peg and SDR peg—using actual trade patterns

	Euro peg (1)	SDR peg (2)	Ratio (1/2)
Jan 1980-Dec. 1993	1.39	1.26	1.1
Fev 1994-Dec. 1998	1.27	1.10	1.2
Jan 1999-Dec 2000	1.68	1.46	1.1
Jan 2001-Dec 2007	0.91	0.43	2.1 ***
Jan 2008-Oct. 2010 (crisis)	2.03	0.92	2.2 ***

*** The volatility under the two peg arrangements are different at 1% significance level.

it would have been under SDR peg. This volatility differential is highly significant—at 1% significance level.

The previous result also holds when the post 2000 episode is further split into pre and post crisis episodes. This distinction brings an additional insight: the volatility of the effective exchange rate of the WAEMU doubled under both peg arrangement over the recent global financial crisis (2008-2010)—as uncertainty about the expected level of major currencies' exchange rate increases substantially. The main result of the first counterfactual is reverse in the second counterfactual where trade shares are kept at their 1980 level as SDR peg now leads to a substantially more volatile nominal effective exchange rate than hard peg over the last decade. The results remain the same in sub-periods prior to 2001—the two peg arrangements do not lead to significantly different volatilities of the effective exchange rate. [10]

I also run the experiments with imports weights separately and the difference between the two peg arrangements is even larger.

10. The results of the two counterfactual experiments are not very sensitive to the choice of sub-periods. In fact, the ratio of nominal effective exchange rate's volatility under hard peg to the volatility under SDR peg is increasing overtime, owing to the continuous shift in trade patterns.

Table 3.III: Counterfactual analysis: hard peg vs. SDR peg using 1980's trade patterns

	Euro peg (1)	SDR peg (2)	Ratio (1/2)
Jan 1980-Dec. 1993	0.90	1.13	0.8
Fev 1994-Dec. 1998	0.75	0.84	0.9
Jan 1999-Dec 2000	0.95	1.33	0.7
Jan 2001-Dec 2007	0.45	0.72	0.6 ***
Jan 2008-Oct. 2010 (crisis)	0.80	1.48	0.5 ***

*** The volatility under the two peg arrangements are different at 1% significance level.

3.5 Conclusion

Notwithstanding the fact that more flexible exchange rate regimes potentially increase countries' resilience to shocks, the so called fear of floating (Calvo and Reinhart (2002)) is still quite prominent among developing countries, and a non-trivial number of countries around the world still have their currency pegged *de jure* to a major currency. This paper attempts to answer the question whether or not trade patterns matter for the choice of the type of peg arrangement—unique currency peg vs. basket peg. In that context, it emphasizes a particular aspect of peg's choice: the volatility of the effective exchange rate. I show analytically that the volatility of the nominal effective exchange rate of the domestic currency—under peg—depends on the volatility of the anchor vis-*à*-vis currencies of the domestic country's trade partners.

To gauge the extent of this relationship, I consider a set of height African countries, members of the West African Economic and Monetary Union (WAEMU) which have their currency—the CFA franc—pegged to the French franc since the mid-40s and to the euro since its introduction in 1999. The paper uses monthly exchange rate data and annual trade data from 1980 to 2010. Computations suggest that the hard peg to the euro—French Franc—was marginally volatility-reducing compared to basket peg at the early stages of the peg arrangement as WAEMU countries traded mostly with France and other Euro area countries. However, given the substantial shifts in trade patterns that occured overtime, and especially over the past decade, pegging to SDR would have resulted to a substantially lower volatility of the nominal effective exchange rate of the CFA lately.

The results obtained in this paper suggest that policy makers should pay as much attention to the type of peg as to pegging *per se*, with a particular focus on trade patterns dynamics. The paper, however, does not derive an optimal peg for the WAEMU. Such exercise would not only account for exchange rate volatility, but also for the extent of imported inflation, the currency composition of countries' assets and liabilities, as well as institutional constraints faced by local policy makers.

This paper could be extended to examine the same question for other fixed exchange rate countries. Preliminary computations already suggest that CEMAC countries have witnessed substantial shifts in their trade patterns comparable to the WAEMU's. CEMAC countries also have their common currency pegged to the euro and it could be interesting to compare the volatility of the nominal effective exchange rate under the current hard peg to the volatility under a peg to a composite basket of currencies.

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Appendix I

Appendix to Chapter 1

I.1 Proof of Proposition 1.3.5.1

This proof uses the pricing equation of re-optimizing monopolistically competitive firms, the first order conditions of the consumer problem, along with some equilibrium conditions. As is the case for the standard New Keynesian Phillips Curve (NKPC), the result is obtained by a first order Taylor expansion around the deterministic steady state.

Let $\bar{X}$ denotes the value of the variable X in the deterministic steady state and x its deviation around that steady state.

The aggregate price in the market-service sector reads:

$$P_{s,t} = \left[(1-\theta_s){P^{\star}_{s,t}}^{1-\varepsilon_s} + \theta_s P_{s,t-1}^{1-\varepsilon_s}\right]^{\frac{1}{1-\varepsilon_s}}$$

where θ_s is the exogenous probability that a monopolistically competitive firm in the market-service sector does not re-optimize its price in a given period t, and ε_s is the constant elasticity of substitution among varieties produced in that sector. [1]

Dividing both sides of the previous equation by $P_{s,t}$ one gets:

$$\frac{P^{\star}_{s,t}}{P_{s,t}} = \left(\frac{1-\theta_s \Pi_{s,t}^{\varepsilon_s-1}}{1-\theta_s}\right)^{\frac{1}{1-\varepsilon_s}} \tag{I.1.1}$$

where $\Pi_{s,t} = \frac{P_{s,t}}{P_{s,t-1}}$ is the gross inflation rate in the market-service sector.

Recall from the text that firms in the market-service sector that have the opportunity to reset their price at date t do so according to the following pricing rule (see Equation

1. θ_s also corresponds to the fraction of firms that do not adjust their price in period t. I am implicitly considering the symmetric equilibrium here, which implies that all re-optimizing firms actually charge the same price, $P^{\star}_t$.

1.3.12):

$$P^{\star}_{s,t} = \left(\frac{\varepsilon_s}{\varepsilon_s - 1}\right) \frac{\mathbb{E}_t \sum_{i=0}^{\infty} (\beta\theta_s)^i MU_{s,t+i} \Psi_{s,t+i} P^{\varepsilon_s - 1}_{s,t+i} Y_{s,t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} (\beta\theta_s)^i MU_{s,t+i} P^{\varepsilon_s - 1}_{s,t+i} Y_{s,t+i}}. \tag{I.1.2}$$

Since I assume a linear technology in labor, the nominal marginal cost is not sector-specific and is simply equal to the nominal wage up to a constant, namely the labor productivity parameter: $\Psi_{s,t} = \Psi_t = W_t/A \quad \forall t$.

Now, the following relation holds from the consumer optimization problem, where MU is the marginal utility of consumption, and MRS is the marginal rate of substitution between consumption and leisure:

$$MRS_{s,t} = \Phi/MU_{s,t} = W_t/P_{s,t}$$

It follows that:

$$MU_{s,t+i}\Psi_{s,t+i} = \Phi P_{s,t+i}/A \quad \text{for all } i. \tag{I.1.3}$$

It is interesting to note that the numerator of $P^{\star}_{s,t}$ then has the same form as that one would get for $P^{\star}_{g,t}$ (which is standard). The difference between sectoral prices comes from the denominator. More precisely, because of the CES aggregate of services $C_S = \left[\gamma C_h^{\frac{\nu-1}{\nu}} + (1-\gamma) C_s^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}$, which accounts for household production, the marginal utility of consuming the market-services (MU_s) now depends on how much household-services the agent actually consumes. In fact, by chained derivation, $MU_s = \partial U/\partial C_s = (\partial U/\partial C_S)(\partial C_S/\partial C_s)$.

Now, taking into account the functional form of the utility, and combining the expression of $P^{\star}_{s,t}$ above with Equation I.1.1, one gets the following equation after some manipulations:

$$\frac{\varepsilon_s}{\varepsilon_s - 1} \frac{\Phi}{(1-\omega)(1-\gamma)} \frac{V_{1,t}}{V_{2,t}} = \left(\frac{1 - \theta_s \Pi^{\varepsilon_s - 1}_{s,t}}{1 - \theta_s}\right) \tag{I.1.4}$$

where V_1 and V_2 have the following recursive representation:

$$V_{1,t} = A^{-1} C_{s,t} + \beta\theta_s \mathbb{E}_t \left(\Pi^{\varepsilon_s}_{s,t+1} V_{1,t+1}\right)$$

and

$$V_{2,t} = \left(\frac{C_{s,t}}{C_{S,t}}\right)^{1-1/\nu} + \beta\theta_s\mathbb{E}_t\left(\Pi_{s,t+1}^{\varepsilon_s-1}V_{2,t+1}\right)$$

which admits the following linearization forms (after solving for $\bar{V}_1$ and $\bar{V}_2$):

$$v_{1,t} = (1-\beta\theta_s)c_{s,t} + \beta\theta_s\varepsilon_s\mathbb{E}_t(\pi_{s,t+1}) + \beta\theta_s\mathbb{E}_t(v_{1,t+1}) \tag{I.1.6a}$$

$$v_{2,t} = (1-1/\nu)(1-\beta\theta_s)\left(c_{s,t}-c_{S,t}\right) + \beta\theta_s(\varepsilon_s-1)\mathbb{E}_t(\pi_{s,t+1}) + \beta\theta_s\mathbb{E}_t(v_{2,t+1}). \tag{I.1.6b}$$

Recall that:

$$C_S = \left[\gamma C_h^{\frac{\nu-1}{\nu}} + (1-\gamma)C_s^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}} \Rightarrow c_{S,t} = \gamma\left(\bar{C}_h/\bar{C}_S\right)^{1-1/\nu}c_{h,t} + (1-\gamma)\left(\bar{C}_s/\bar{C}_S\right)^{1-1/\nu}c_{s,t}$$

where C_h is the amount of services which are produced at home.

After linearization, Equation I.1.4 becomes:

$$v_{1,t} - v_{2,t} = \frac{\theta_s}{1-\theta_s}\pi_{s,t}. \tag{I.1.7}$$

Iterating the above equation one step forward, and using Equations I.1.6a and I.1.6b to evaluate the expression $(v_{1,t} - v_{2,t})$, one obtains the following *"Augmented"* NKPC after some straightforward algebra:

$$\pi_{s,t} = \kappa_s y_{s,t} + (1-1/\nu)\kappa_s(y_{S,t} - y_{s,t}) + \beta\mathbb{E}_t(\pi_{s,t+1}), \quad \kappa_s = \frac{(1-\theta_s)(1-\beta\theta_s)}{\theta_s} \tag{I.1.8}$$

where I use the market clearing condition $c_s = y_s$ and define $y_S = c_S$.■

I.2 Reduced set of equations for the linearized model

$$c_{i,t} = \mathbb{E}_t c_{i,t+1} - (r_t - \mathbb{E}_t\pi_{i,t+1}), \quad i \in \{g,s\}$$

$$c_i = y_i \quad i \in \{g,h,s,S\}$$

$$\pi_{g,t} = \kappa_g y_{g,t} + \beta\mathbb{E}_t(\pi_{g,t+1}), \quad \kappa_i = (1-\theta_i)(1-\beta\theta_i)/\theta_i, i \in \{g,s\}$$

$$\pi_{s,t} = \kappa_s y_{s,t} + (1-1/\nu)\kappa_s(y_{S,t} - y_{s,t}) + \beta\mathbb{E}_t(\pi_{s,t+1})$$

$$r_t = \phi_\pi \pi_t + \phi_y y_t + \ln\xi_t$$

$$\ln\xi_t = \rho_r \ln\xi_{t-1} + \zeta_t$$

$$y_t = \chi y_{g,t} + (1-\chi) y_{s,t}$$

$$\pi_t = \chi \pi_{g,t} + (1-\chi) \pi_{s,t}$$

$$c_{S,t} = \gamma \left(\bar{C}_h/\bar{C}_S\right)^{1-1/\nu} c_{h,t} + (1-\gamma) \left(\bar{C}_s/\bar{C}_S\right)^{1-1/\nu} c_{s,t}$$

$$c_{h,t} = (1-\nu) c_{S,t}$$

$$w_t - p_{g,t} = c_{g,t}$$

I.3 Figures

I.3.1 IRF prices

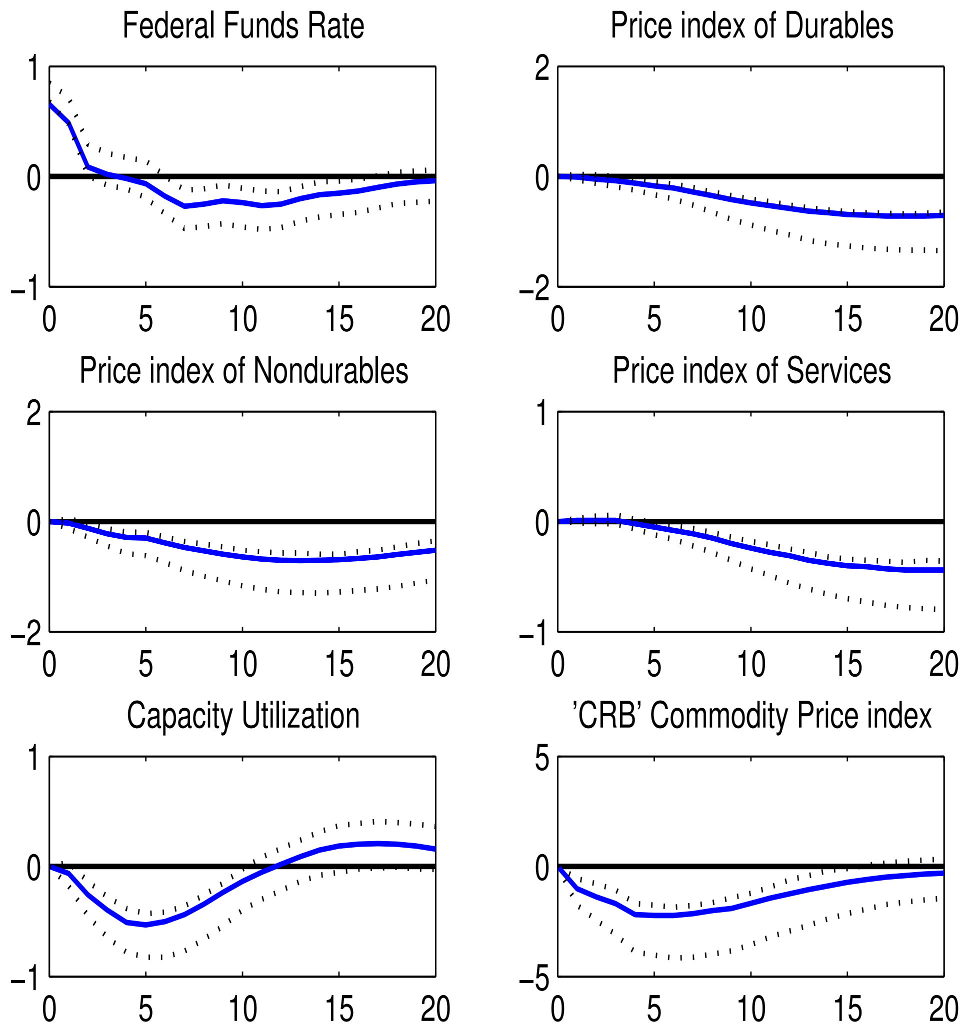


Figure I.1: Estimated responses of sectoral prices to a monetary policy tightening in a VAR model: services vs. nondurables

I.3.2 Simulation Results: Figures

Figure I.2: Responses of Real Sectoral Consumption to a 1% Interest-rate Cut.

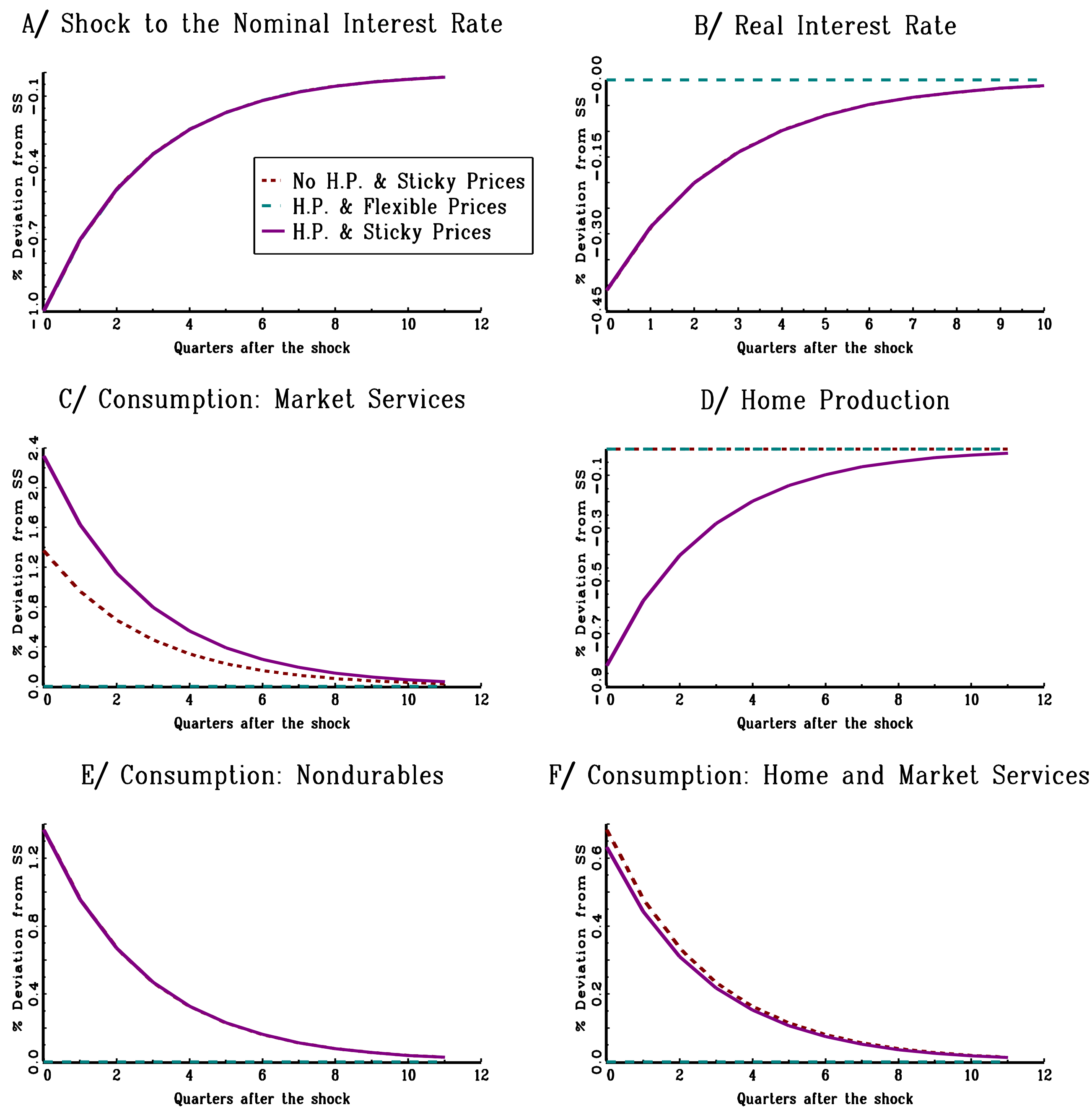
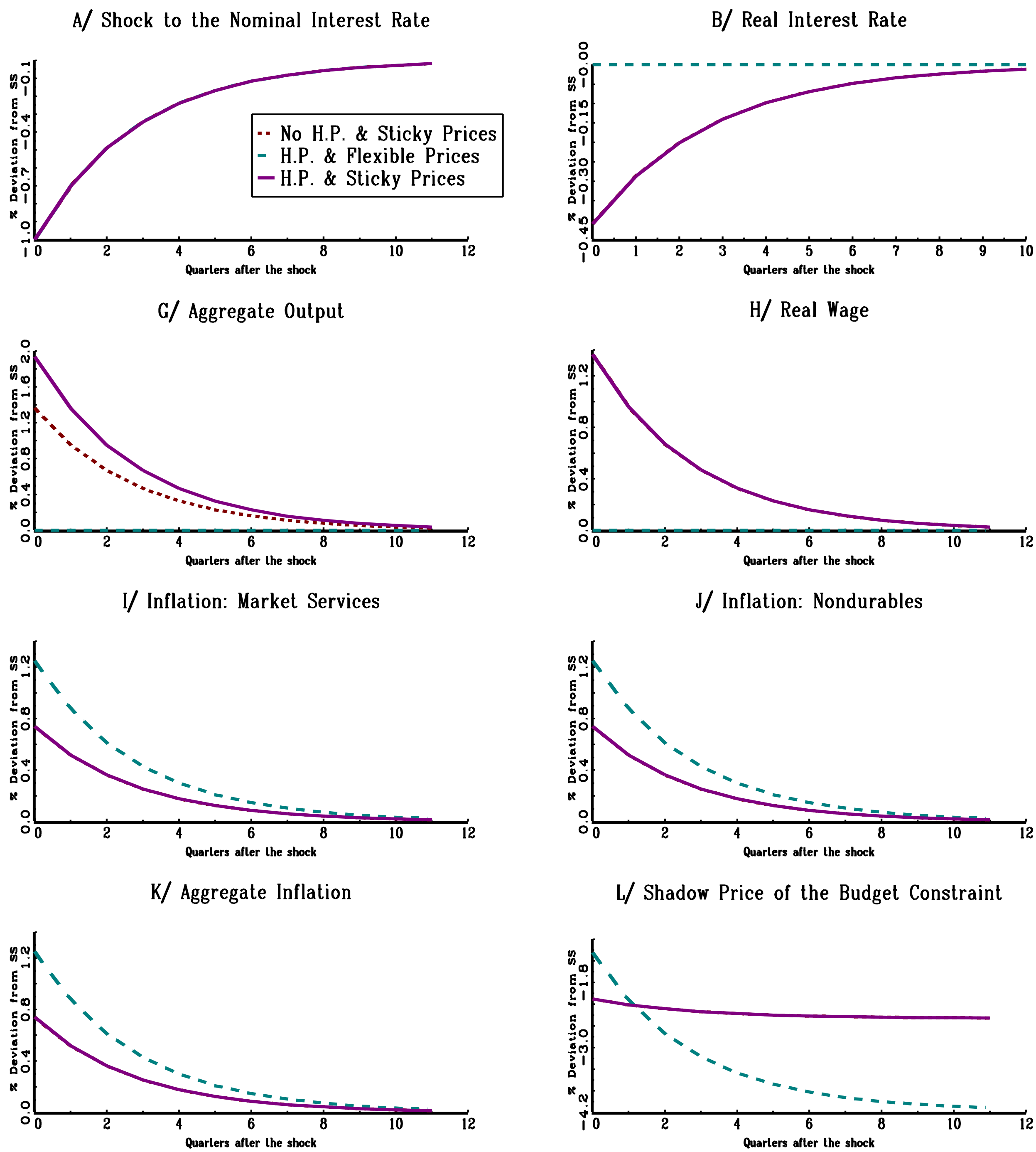


Figure I.3: Responses of Sectoral Inflation and Real Aggregates to a 1% Interest-rate Cut.



Appendix II

Appendix to Chapter 2

II.1 Data and sources

I construct a panel data set containing the following OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Turkey, United Kingdom, and the United States. Data are gathered from various sources including the OECD database (Annual Labor Force Statistics -Summary Statistics-, National Accounts for OECD countries - Main Aggregates and Detailed Tables -(sourceOECD, 2008)), the World Bank Development Indicators online, the Penn World Table, the 10-Sector Database (see Van Ark (1996)), and the National Accounts of individual countries. The panel is balanced and covers annual observations for the period 1970-2006. This makes a total of 771 observations for each variable.

Data is available for the total working-age (15-64) population (N), the total civilian labor force (L), as well as the number of persons employed (including self-employment) in three broad sectors of the economy: agriculture (L_a), industry (L_m) and services (L_s).

The sectors are defined by the International Standard Industrial Classification, revision 3 (ISIC II). Agriculture includes forestry, hunting and fishing (ISIC divisions 1-5). Industry corresponds to ISIC divisions 10-45 (mining, manufacturing, construction, electricity, water, and gas), and services to ISIC divisions 50-99 (wholesale and retail trade-including hotels and restaurants, transport, and government, financial, professional, and personal services such as education, health care, and real estate services).

Data on real aggregate output per capita are from The Penn World Table, version 6.2 (see Heston, Summers, and Aten (2006)). I collect data on sectoral real value added (a measure of real output at the sector level). To insure comparability across countries in the same spirit as PWT data, this measure is in constant $US and constant PPP (OECD base year).

Sectoral productivities are computed as sectoral valued added per persons employed: $A_i = Y_i/L_i, i = a, m, s$, where Y_i is the real output in sector i, and L_i is the number of persons working in that sector. Gross Domestic Product (Y) in the model is simply defined as the sum of value added across sectors.

II.2 Tables and Figures

Table II.I: Summary statistics on sectoral volatilities across OECD countries.

Country	**Average (level)**			**Average (Volatility)**											
	π_a	π_m	π_s	Y_a	Y_m	Y_s	Y	L_a	L_m	L_s	L	A_a	A_m	A_s	A
AUSTRALIA	0.06	0.27	0.67	13.15	2.76	1.41	1.51	3.83	3.04	1.35	1.41	14.85	3.47	1.65	1.99
AUSTRIA	0.09	0.36	0.55	3.53	2.46	1.17	1.49	3.38	2.16	1.71	1.11	4.77	3.25	2.00	1.51
BELGIUM	0.03	0.31	0.66	6.41	3.23	1.52	1.62	5.63	1.96	0.83	1.08	9.91	3.03	1.36	1.54
CANADA	0.05	0.25	0.70	5.67	3.59	1.09	1.83	2.64	2.93	0.90	1.31	5.51	2.62	0.73	1.08
DENMARK	0.06	0.29	0.65	7.98	3.26	1.53	1.80	4.23	3.44	2.16	1.62	8.54	3.49	2.63	1.63
FINLAND	0.11	0.31	0.58	6.31	3.33	1.59	2.18	3.55	2.91	1.64	1.84	7.26	3.30	1.03	1.60
FRANCE	0.07	0.31	0.62	6.51	1.69	0.95	1.33	0.50	1.30	0.57	0.71	6.70	1.14	0.69	0.69
GERMANY	0.04	0.40	0.56	6.74	2.88	1.09	1.48	5.59	3.82	2.18	2.82	9.03	3.82	1.71	2.42
GREECE	0.26	0.26	0.48	6.55	4.59	1.63	2.37	3.23	2.30	1.73	1.21	8.87	4.76	2.56	2.28
ITALY	0.11	0.35	0.54	4.03	2.76	1.16	1.62	2.48	1.26	1.30	0.86	4.71	3.24	1.48	1.52
JAPAN	0.09	0.34	0.58	4.20	3.31	1.16	1.68	1.55	1.43	0.59	0.60	4.38	2.76	1.17	1.42
KOREA	0.25	0.28	0.47	6.63	5.56	2.02	3.14	3.25	4.39	2.06	1.75	7.42	3.39	2.19	1.98
LUXEMBOURG	0.04	0.32	0.63	10.80	4.13	2.77	2.89	4.58	1.54	1.02	0.92	11.29	4.13	2.41	2.33
NETHERLANDS	0.04	0.27	0.68	4.59	2.08	1.23	1.38	4.29	2.82	1.97	1.62	6.19	3.21	2.26	1.83
NORWAY	0.07	0.27	0.66	5.80	2.77	1.29	1.34	3.63	2.26	1.46	1.34	7.55	3.40	1.40	1.65
PORTUGAL	0.21	0.34	0.45	6.27	4.09	2.68	2.52	8.27	4.12	4.37	2.48	12.63	4.73	4.54	3.05
SPAIN	0.14	0.33	0.52	6.25	2.38	1.09	1.39	2.48	2.86	1.90	1.66	6.37	2.01	1.36	0.87
SWEDEN	0.04	0.29	0.66	4.43	3.34	0.98	1.60	2.71	2.30	1.21	1.34	5.28	2.89	1.13	1.25
TURKEY	0.47	0.21	0.31	4.52	4.74	2.65	4.06	3.50	2.71	1.70	1.57	7.06	4.97	2.61	3.76
UNITED KINGDOM	0.02	0.32	0.65	6.39	2.73	1.29	1.62	3.54	2.92	1.07	1.34	6.74	3.36	1.30	1.55
UNITED STATES	0.03	0.27	0.70	8.28	3.82	1.21	1.87	4.11	2.95	0.82	1.24	11.42	2.53	0.92	0.83
Average	0.11	0.30	0.59	6.43	3.31	1.50	1.94	3.67	2.64	1.55	1.42	7.93	3.31	1.77	1.75

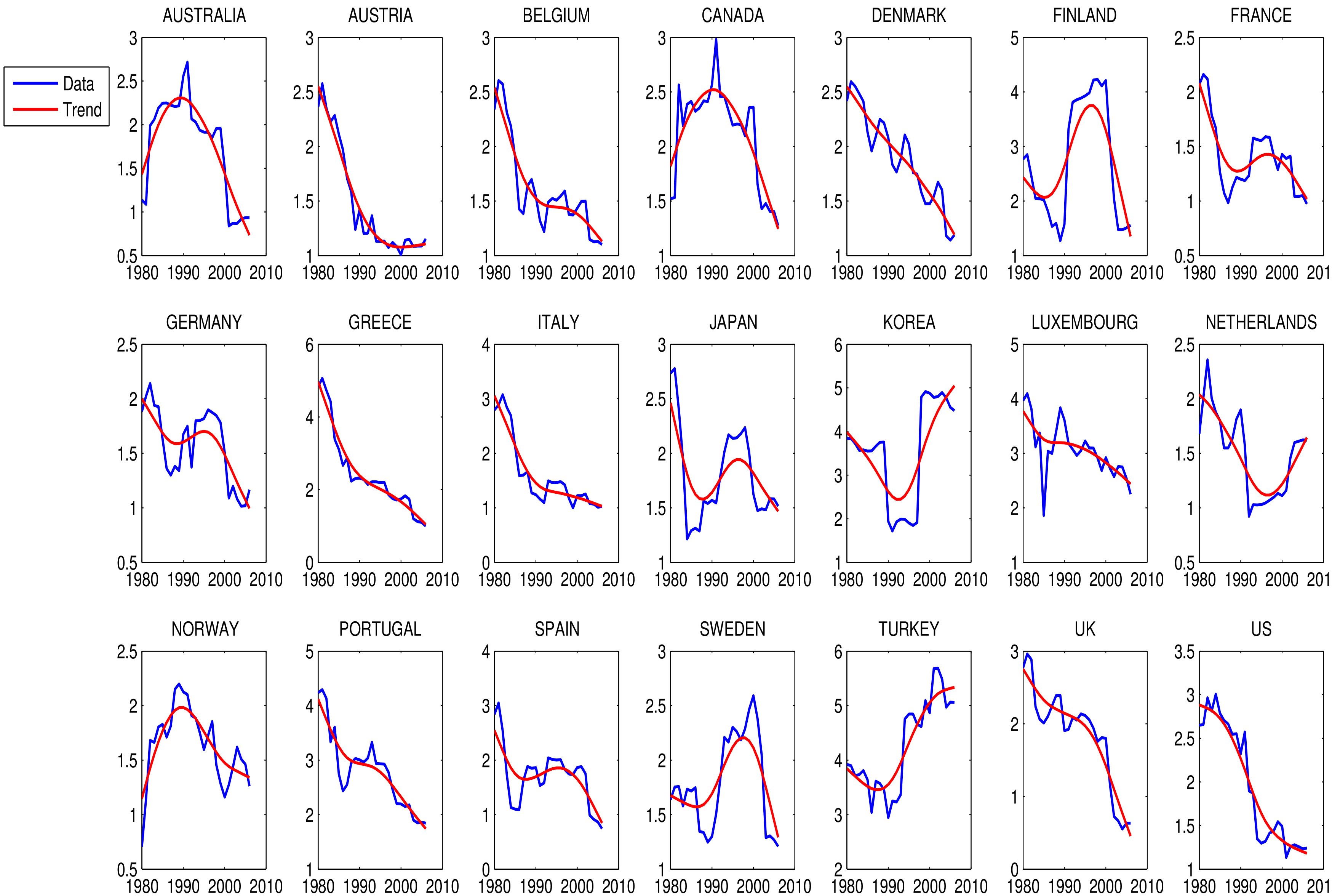


Figure II.1: GDP per Capita and Aggregate Volatility Across Countries.

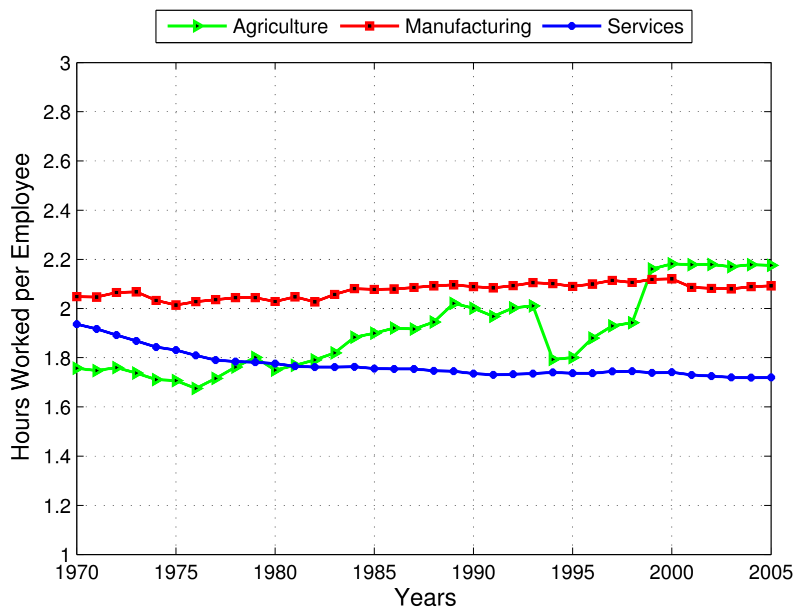


Figure II.2: Sectoral Annual Hours Worked per Person Engaged in the US (in thousands).