European University Institute

Department of Economics

Financial Constraints, Financial Shocks, and Business Cycle Accounting

Massimiliano Rimarchi

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

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CONTENTS

Part I

Introduction

Abstract

This thesis features three closely related chapters investigating the role of the investment wedge in affecting macroeconomic fluctuations. The first chapter shows that the Business Cycle Accounting (BCA) methodology is sensitive to the specification of households' preferences in identifying the role of the investment wedge. A poor performance of the investment wedge and of the financial frictions it represents, such as the one BCA finds on 2007-2010 US data and other past events, is compatible with a simulated recession fully driven by financial factors and financial accelerator mechanisms when preferences are not correctly specified in the BCA tool. The second chapter investigates the conditions under which a shock to the risk premium paid by entrepreneurs on bank funds, i.e. a shock to the investment wedge, is able to generate a pro-cyclical response of aggregate consumption. The analysis shows that a minimum degree of nominal stickiness a-la-Calvo and non-separable household's preferences of the GHH type, are sufficient conditions for solving the problem of countercyclicality of consumption in the presence of financial shocks. The third chapter is an application of the BCA toolkit to the Swedish boom-bust cycle of the late 1980s. The efficiency wedge plays an essential role in explaining the cycle while the investment wedge plays a minor role, adding to the persistence of the recession. Calibrating a BGG model to Sweden according to the findings of the BCA shows that financial deregulation reforms in Sweden did not affect the vulnerability of the economy to the recessionary shock.

Introduction[1]

The three chapters of this thesis explore the role of financial constraints and financial shocks in driving business cycle fluctuations. They study such role essentially combining two analytical tools: the financial accelerator DSGE model, as in Gertler et al. (2003), and the Business Cycle Accounting toolkit, as in Chari et al.(2007a). The first (and most recent) chapter explores a key substantive finding of the Business Cycle Accounting Literature: the measured investment wedge, the distortion that enters between the inter-temporal marginal rate of substitution in consumption and the rate of return on capital, plays a tertiary role with respect to either distortions in the efficiency of production and labor market distortions in accounting for business cycle dynamics; in addition it often appears to improve during recessions and worsen during recovery phases. First, the chapter shows that such "poor" performance of the investment wedge is also found when applying the BCA toolkit to the US data of the recent (2007-2010) financial crisis. Then it illustrates how those dynamics of the measured investment wedge are broadly compatible with the ones that BCA finds over a simulated recession triggered by an adverse risk premium shock within a financial accelerator economy a la Gertler et al. (2003), provided that in the data generating economy standard separable preferences are replaced with their GHH[2] specification. The chapter discusses how the imperfect mapping of preferences between the BCA toolkit and the data generating economy can mislead the BCA toolkit into measuring a composite investment (euler) distortion which reflects not only the structural (financial) distortions of the economy but also the endogenous dynamics of hours worked. The latter prevail over the contribution of the risk premium and determine a countercyclical reaction of the measured investment wedge when the economy is hit by a risk premium disturbance. When the same exercise is applied over financial recession generated by an underlying economy with standard separable preferences, matching those of the BCA toolkit, the measured investment wedge appears to explain most of the economic fluctuation and plays a markedly procyclical role, worsening during the recession and improving during booms. An inspection of the inter-temporal equilibrium conditions of the BCA toolkit and the underlying economy illustrates that the measured investment wedge captures a euler distortion which is only driven by the procyclical dynamics of the risk premium.

The second chapter explores the transmission of financial risk premium shocks within

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[1]The final draft of this thesis has benefited from several useful comments by Prof. Marco Maffezzoli (Bocconi University) and Dr. Oreste Tristani (European Central Bank).

[2]Non-separable preferences over consumption and leisure introduced by Greenwood Hercowitz and Huffman (1988)

a Gertler et al. (2003) financial accelerator framework. Such shocks represent sudden increase in the spread entrepreneurs are charged over the riskless rate when borrowing funds from the financial intermediary. Little attention, if any, has been paid to the conditions under which consumption co-moves with the other main macro-economic variables when the economy gets hit by a risk premium shock. We introduce a risk premium shock in a basic New-Keynesian version of the BGG financial accelerator model, only featuring Calvo (1983) nominal rigidities and investment adjustment costs, and investigate the conditions under which a pro-cyclical response of consumption can be obtained in such a basic framework. Following the interpretation of the financial shock given in Christiano et al. (2009) as a shock to the demand of capital, the present work contributes to bridging the credit crunch literature to the type of analysis on consumption comovement and investment-specific shocks developed, among others, in Justiniano et al. (2010) and Furlanetto and Seneca (2010). We find that the preferences introduced by Greenwood et al. (1988) (hereafter GHH preferences) generate the comovement of consumption, with output hours worked investment and equity prices, when combined with Calvo-type nominal rigidities. The latter turn out to be an essential device. A minimum degree of price stickiness, equal to three quarters in the benchmark calibration, and non-separable preferences of the GHH type are sufficient for obtaining consumption comovement following a risk premium shock.

The third chapter (the first to be written) applies the Business Cycle Accounting toolkit to two episodes of the Swedish business cycle: the credit boom period of years 1986-1990, that followed the implementation of financial liberalization measures, and the economic recession of the early 1990s. BCA finds a pattern of improvement of the investment wedge between the second half of 1987 and the beginning of 1990, contemporaneous to the main expansion of corporate lending figures reported in the literature. This result seems to suggest that, if any, financial deregulation had a small positive impact on firms' investment financing constraints. The findings on the pattern of realized wedges and on output decomposition for the recession years suggest that: i) distortions to efficiency of production play a crucial role in shaping the recession pattern and turn out to be the only driving force of the recovery phase; ii) distortions captured by the investment wedge made the recession only slightly deeper but sensibly contributed to increase its persistence. In the second part of the chapter the results of the BCA application on financial liberalization effects are used to calibrate to Sweden a Bernanke et al. (1998) economy. The same BCA-measured TFP series of the Swedish recession is fed into two different calibrations of the model, for mimicking both the environments of pre and post financial liberalization. Modeling the easing of the financial constraint as a 10% fall in the share of resources devoted to monitoring costs turns out

to generate no material difference in the way the macroeconomic variables respond to the recessionary productivity shock, suggesting that the measures of financial liberalization did not affect the vulnerability of the Swedish economy.

Part II

Financial constraints, financial shocks and Business Cycle Accounting

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CHAPTER 1

WHICH ROLE FOR THE INVESTMENT WEDGE DURING FINANCIAL CRISES? BUSINESS CYCLE ACCOUNTING AND CREDIT CONSTRAINTS

1.1 Introduction

Business Cycle Accounting (BCA hereafter) augments a standard one-sector growth model with stochastic variables that enter the model's equilibrium as *reduced form* distortions, altering the outcome of agents' optimal decisions. The variables included in the benchmark procedure, named *wedges* because of their distorting role, are the *efficiency wedge,*the *labor wedge,*the *investment wedge* and *government spending wedge.*

Since its introduction, in Chari et al. (2007a), the BCA methodology has been applied to several different economic recession episodes as a useful device for identifying the nature of the most relevant economic distortions driving economic fluctuations. Its own authors propose the BCA method as a new tool for understanding which economic frictions and mechanisms are to be considered the most promising ones for successfully modelling the business cycles in DSGE frameworks.

A substantive finding across several of the BCA applications on historical recession episodes is that the measured investment wedge, the shock that enters between the intertemporal marginal rate of substitution in consumption and the rate of return on capital, plays a tertiary role with respect to either the efficiency wedge and the labor wedge in accounting for business cycle dynamics. In addition, as Chari et al. (2007a) find on the data of the US Great Depression, the investment wedge often appears to improve during recessions and worsen during recovery phases. Based on their findings and their equivalence results, which map models of firms' financial constraints a la Bernanke et al. (1998) and Carlstrom and Fuerst (1997) into a BCA economy appropriately modified with an investment wedge, Chari et al. (2007a) claim that financial frictions as modelled in those seminal contributions are not promising avenues for studying business cycles.

In the first part of this paper we apply the BCA toolkit to the US data of the 2007-2010[1]

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[1]The Business Cycle Dating Committee, at National Bureau of Economic Research, marks the beginning of the recession in December 2007 and its trough in June 2009.

financial crisis and find that the "poor" performance of the investment wedge is confirmed. BCA assigns a crucial role to both production efficiency and labor market type of distortions (wedges) in shaping and explaining the recession of 2007-2010 and finds a tertiary and countercyclical contribution of economic frictions and shocks propagating through the investment wedge. The investment wedge is the one displaying the lowest relative volatility (with respect to observed output) and follows a trend of improvement from the quarter marking the beginning of the recession up until the last quarter of 2010, our latest available observation of the US business cycle. By 2010q4 the corresponding ad-valorem tax on investment decreases by approximately 5% of its 2007q4 value.

In the second part of this paper we show that the "poor" performance of the investment wedge can be reconciled with the recessionary dynamics generated by a risk premium shock within a financial accelerator economy a la Bernanke et al. (1998) and and Gertler et al. (2003) provided that standard separable households' preferences are replaced by their GHH[2] specification. We show that under the assumption of imperfect matching between the preferences of the data generating economy (non-separable GHH) and those of the BCA toolkit (log-separable), the investment wedge can be driven by two factors: the structural distortions of the underlying economy and the endogenous fluctuations due to the mismatch in preferences. The endogeous fall of hours worked,following a risk premium shock, enters the euler condition of the underlying economy under the GHH specification and mislead the standard BCA toolkit into estimating a composite investment wedge which reacts countercyclically to the structural financial shock, i.e. it falls during the downturn and increases during the upturn.

Absent the mismatch in preferences, i.e. assuming an underlying economy with financial accelerator and standard separable preferences, the investment wedge measured by BCA maps into the risk premium of the underlying economy and follows the typical procyclical dynamics of the latter, increasing (worsening) during recessions and falling (improving) during booms.

We simulate data from a model economy featuring a financial accelerator mechanism in which the only fundamental source of disturbance stems from 1-standard deviation shocks to the risk premium entrepreneurs have to pay in order to borrow funds from the banking sector. Our economy is therefore free from any distortions of the production process (efficiency wedge) and features a distortion of the labor market, due to the assumption of price nominal rigidities, which fluctuates endogenously following the financial disturbance. On the simu-

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[2]Non-separable preferences over consumption and leisure introduced by Greenwood Hercowitz and Huffman (1988)

lated macro-economic data we then apply the wedges estimation and output decomposition exercises of the BCA methodology. In particular we simulate two different specifications of the financial accelerator model economy, which differ for the type of preferences households have over consumption and hours worked[3]. The findings of the BCA methodology on the two simulated financial recessions lead to particularly different conclusions on the role of the investment wedge:

- On the financial recession simulated using GHH type of preferences the BCA methodology assigns an expansionary (counter-cyclical) role to the investment wedge and finds that its contribution within the output decomposition exercise is the least relevant. The volatility of the investment wedge, over the 20 periods of the episode, is in fact only one third the volatility of the output series. All the examined macro-economic variables are driven in an opposite (expansionary) direction with respect to their observed path over the recession episode. In particular the correlation of the output predicted by the investment-wedge model with actual output turns out to be -77%. The most important contribution is by far the one of the labor wedge, which worsens and then recovers capturing the endogeous counter-cyclical dynamics of the monopolistic price mark-up triggered by the financial shock.

- On the recession generated by the financial accelerator model with standard separable preferences, BCA assigns a recessionary (procyclical) role to the investment wedge and finds that the latter materially outperforms the other wedges in explaining the output dynamics during the episode. The volatility of the investment wedge, over the 20 periods of the recession-recovery, is approximately 1,2 times larger than the volatility of the output series. All the examined macro-economic variables are driven through a recession-recovery path which corresponds to their observed path over the recession episode. In particular the correlation of the output predicted by the investment-wedge model with actual output turns out to be 96%. The labor wedge plays a secondary procyclical role also in this case worsening and then recovering according to the endogenous dynamics of the price-markup of the underlying economy.

The mismatch of preferences between the data generating economy and the BCA toolkit affects as well the measurement of the labor wedge, although it does not determine a change

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[3]As shown in Rimarchi (2011), GHH preferences within a financial accelerator economy with sticky prices guarantee that following an adverse risk premium shock consumption reacts procyclically (falls), comoving with the other main macroeconomic variables. Under standard separable households' preferences all macro variables but consumption fall on impact of a risk premium shock.

in the sign of its contribution. In both simulated recession episodes labor distortions worsen during the downturn and improve during the recovery, following the countercyclical dynamics of the price-markup triggered by the credit-crunch shock. In the recession simulated using standard separable preferences the labor wedge plays a markedly reduced role. BCA measures the labor wedge in a straightforward residual way, using the data series and the static labor/leisure first order condition. Consumption enters linearly the labor/leisure condition of the BCA toolkit while it is absent from the corresponding condition of the underlying economy, when preferences in the latter take on the GHH specification. With an imperfect matching between the preferences of the data generating economy (non-separable GHH) and those of the BCA toolkit (standard separable), the labor wedge measured by the BCA toolkit is therefore a composite distortion arising from two sources: the fluctuations of the monopolistic price markup distortion and the fluctuations of aggregate consumption. Since the measurement of the labor wedge does not require solving and estimating the BCA toolkit, we can compute the "actual" labor wedge using the GHH type of labor market equilibrium underlying the simulated data. Comparing actual and measured labor wedges shows that the mismatch in preferences leads BCA to overestimating the recessionary contribution of the labor wedge.

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1.2 Business Cycle Accounting

1.2.1 The BCA benchmark economy

The prototype model used by Chari et al. (2007a) is a standard neoclassical dynamic growth model augmented with four stochastic variables, respectively called: *efficiency wedge, labor wedge, investment wedge* and *government wedge.* Each of the wedges enters a different equilibrium condition of the economy, as described in the following sections.

Household's problem

The representative household maximizes expected utility over per capita consumption (c_t) and labor (l_t):

$$\max_{c_t, l_t, x_t} \sum_{t=0}^{\infty} \sum_{s_t} \beta^t \pi_t(s^t) U(c_t(s^t), l_t(s^t)) N_t \tag{1.1}$$

subject to the budget constraint:

$$c_t + [1 + \tau_{xt}(s^t)]x_t(s^t) = [1 - \tau_{lt}(s^t)]w_t(s^t)l_t(s^t) + r_t(s^t)k_t(s^{t-1}) + T_t(s^t) \tag{1.2}$$

and the law of motion of capital:

$$(1 + g_n)k_{t+1} = (1 - \delta)k_t + x_t. \tag{1.3}$$

Here $s^t = (s_0, ..., s_t)$ denotes the history of events up to and including period t , occurring with probability $\pi_t(s^t)$. β is the discount factor, N_t is the population, x_t and k_t are per capita investment and per capita capital stock respectively, δ is the constant depreciation rate of capital, r_t and w_t are the rental rate of capital and the real wage , T_t are lump-sum transfers to the household, and g_n is the constant growth rate of population. $(\mathbf{1 + \tau}_{xt})$ and $(\mathbf{1 - \tau}_{lt})$,in turn the *investment wedge* and the *labor wedge*, act in the model as time-varying taxes on investment purchases and on labor income.

Firm's problem

The representative firm optimally chooses labor (l_t) and capital (k_t) so as to maximize:

$$\max_{k_t, l_t} A_t(s^t)F(k_t(s^{t-1}), (1 + g_z)^t l_t(s^t)) - w_t(s^t)l_t(s^t) - r_t(s^t)k_t(s^{t-1}) \tag{1.4}$$

where $(1 + g_z)$ is the constant growth rate of labor-augmenting technological progress. Note that the *efficiency wedge,* $\mathbf{A}_t$, takes the form of a time-varying Total Factor Productivity term.

Equilibrium

Once the aggregate budget constraint is taken into account, one can easily solve for the optimality problems and characterize the model's equilibrium as follows (where for simplicity the history notation s_t is dropped):

$$c_t + x_t + g_t = y_t \tag{1.5}$$

$$y_t = A_t F(k_t, (1 + g_z)^t l_t) \tag{1.6}$$

$$-\frac{U_{lt}}{U_{ct}} = (1 - \tau_{lt})A_t(1 + g_z)^t F_{lt} \tag{1.7}$$

$$U_{ct}(1 + \tau_{xt}) = \beta E_t U_{ct+1}[A_{t+1}F_{kt+1} + (1 - \delta)(1 + \tau_{xt+1})] \tag{1.8}$$

where the *government wedge* g_t is a simple time varying government consumption term "distorting" the aggregate budget constraint.

Interpretation of the wedges

By distorting the optimality conditions of the prototype model the wedges provide a measure of different broad categories of frictions at work in the economy. The labor wedge, for instance, invalidates the intra-temporal equivalence between the household's marginal rate of substitution between labor and leisure, on one hand , and the marginal product of labor on the other. As clarified in Chari et al. (2007b) the stochastic wedges are not meant to capture the effects of "primitive shocks" on macroeconomic aggregates, such as for example monetary shocks, preferences shocks and financial market shocks. The wedge of the BCA methodology measures the extent to which a whole range of unidentified primitive shocks and frictions manifest themselves through the distortion of the optimality condition they are associated to.

The *investment wedge*, discussed more in detail in the present paper, captures all shocks and distortions affecting the optimal inter-temporal condition (1.8). The latter is meant to represent the equilibrium outcome of the inter-temporal choices of both households and firms. It can be distorted by different sorts of *economic frictions* such as, for instance, liquidity constraints of households and investment financing frictions of firms.

The multiplicity of explanations to which each of the wedges is open to determines the richness of the BCA methodology. In Chari et al. (2007a), as well as in previous work, the authors provide proof of important *equivalence results*: broad classes of detailed quantitative models of the business cycle, featuring complex friction mechanisms and primitive shocks, are shown to result in equilibrium allocations equivalent to the ones reached by a prototype growth model appropriately modified with one or more wedges. As far as financial frictions are concerned, Chari et al. (2007a) show that models à la Bernanke-Gertler-Gilchrist (1998) and Carlstrom and Fuerst (1997) are equivalent to a prototype economy modified with an investment wedge while models with inputs financing frictions can result in equilibrium allocations equivalent to the ones of a prototype economy appropriately augmented with an efficiency wedge. [4]

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[4]The equivalence results are not limited to detailed business cycle models including financial frictions. In Chari et al. (2007a) one can find two additional equivalence results: a detailed model economy with international borrowing and lending is reproduced by a prototype model augmented with a government consumption wedge, while a detailed economy with sticky wages and monetary shocks is shown to be equivalent to a prototype economy modified with a labor wedge. In the same work several other equivalence results are cited.

1.2.2 The accounting procedure: model solution and estimation

The possibility of identifying one or more broad classes of business cycle detailed models, behind each of the wedges, makes the benchmark BCA model a relevant laboratory economy to be used for at least two types of exercise:

- measuring the patterns of *actual realization* of the wedges during relevant business cycle episodes, like boom-bust periods or periods of economic reform.

- running *counterfactual simulations* of wedges-driven model economies where a single wedge (a combination of wedges) is allowed to vary across time according to its measured historical realization, while the remaining wedges are shut down to constant values. This *decomposition* exercise allows the researcher to obtain a clear picture of what would have been the behavior of the macroeconomic aggregates during a business cycle episode if only one specific distortion (a set of specific distortions) had been at work in the economy. A comparison with historical time series eventually sheds light on which distortions are crucial in driving the business cycle episode, or at least play a dominant role in shaping it.

By construction, the *government wedge,* (g_t) the *efficiency wedge* (A_t) and the *labor wedge,* $(1 - \tau_{lt})$ can be measured by simply combining the appropriate macroeconomic time series according to static optimality conditions of the benchmark BCA model, once functional forms and parameter values have been chosen.

The measurement of the investment wedge $(\frac{1}{1+\tau_{xt}})$, though, is not equally straightforward. The investment wedge enters the dynamic first-order condition (1.8) and, as a consequence, depends on the policy functions of the benchmark model equilibrium. The computation of the latter, in turn, requires the specification of a stochastic process for the wedges upon which households form their expectations when taking their optimal decisions.

We follow Chari et al. (2007a) and use two fundamental assumptions concerning the stochastic structure of the model:

1. A realization of the four wedges uniquely uncover event $s_t = (\log A_t, \tau_{lt}, \tau_{xt}, \log g_t)$, i.e. there is a one-to-one mapping between the wedges and the stochastic event.

2. The four wedges follow a VAR(1) process defined by: $s_{t+1} = P_0 + P s_t + Q \varepsilon_{t+1}$

The disturbances ε_t are i.i.d. and follow a Normal distribution with zero mean and variance-covariance matrix V.[5] The parameters that enter matrices $P0, P$ and Q are es-

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[5]In order to ensure semiposidefiniteness of the latter we estimate the lower triangular matrix Q which is such that $V = QQ'$.

timated using a Maximum Likelihood procedure. Once the model's equilibrium is log-linearized around its steady-state, an expression for k_{t+1} can be found in terms of the five states of the benchmark economy (k_t and the four wedges) using the method of undetermined coefficients: the latter expression and the VAR(1) assumed for the wedges allow rewriting the model in State-Space form and applying the Kalman Filter for the construction of the likelihood function.

1.3 BCA applied to the 2007-2010 US Financial Crisis

The beginning of the recession is identified, according to NBER analysis, in the last quarter of 2007. This justifies the choice of the latter as the period used for normalizing all variables to unity in our graphic analysis (see Figure 1.1). Per-capita output falls continuously in the period 2007:q4-2009:q2, reaching a peak fall of 7.5 % of its initial value. Hours worked reach a peak 10% fall in 2010:q1 and then show only weak signs of recovery. Consumption falls steadily and reaches a 10% fall at the end of 2009. Investment, unsurprisingly the most volatile series during the recession, falls by approximately 17.5% of its 2007:q4 value already at the beginning of 2009.

1.3.1 Calibration

The calibration of the BCA follows the one in Chari et al. (2007a). Production function takes on Cobb-Douglas form $F(k_t, l_t) = k_t^\theta l_t^{1-\theta}$ while households' instantaneous utility is of log-utility type $U(c_t, l_t) = \log c_t + \psi \log(1 - l_t)$. The capital share is set to $\theta = 0.35$ while the time allocation parameter is set to $\psi = 2.24$. The capital depreciation rate δ and the discount factor β are such that, on an annualized basis, depreciation is 4.64% and the rate of time preference is 3%. Annual growth rate of population is set to $g_n = 0.015$ to match an average 1.5% population growth rate. The labor-augmenting technological progress parameter is set to $g_z = 0.016$ to match an annual growth of per capita GDP of 1.6%.

Table 1: Annualized Parameter Values - Benchmark Economy

Parameter	Value
θ	0.35
δ	0.0464
β	0.9722
ψ	2.24
g_n	0.015
g_z	0.016

1.3.2 Accounting and Decomposition Results

The estimated actual path of the wedges as well as their individual role in the exercises of output decomposition provide a broad picture that Chari et al. (2007a) have already found on US data of 1929-1939 Great Depression episode and the 1982 recession. Distortions to efficiency of production and distortions of the labor market play, in different ways, a crucial role in shaping the dynamics of US output, hours worked and investment during the business cycle episode. The dynamics of the investment wedge, instead, do not square at all with the recession-recovery path of the main macroeconomic aggregates, as one would expect to be the case during episodes of financial crisis and recessions triggered by disruptions in financial and inter-bank funding markets .

According to our findings for the period 2007:q4-2010:q4 the steep worsening of labor distortions seems to be behind the protracted fall in hours worked. The recovery of the efficiency wedge, which starts already at the end of 2008, is in line with the recovery path of both output and investment. The distortions that manifest themselves as an investment wedge steadily improve during the period, leading to a cumulative 5% fall in the investment tax $\tau_{x,t}$ measuring the wedge (See Figure 1.2).

The fit of the output series predicted by the BCA model driven by one wedge (Y_W) to the output series observed in the data (Y_D) is measured by the following statistics:

$$corr(Y_W, Y_D) \cdot \frac{std(Y_W)}{std(Y_D)} \qquad (1.9)$$

This measure indicates whether the simulated variable is moving to the correct direction as well as whether its generated fluctuation is large enough.

The predictions of the BCA model when only one wedge is allowed to operate in the economy show that:

- The historical path of each of the three macroeconomic variables examined lies within the predictions given by a model economy where only either labor market distortions or

production efficiency distortions are operating. In particular we find that labor market distortions would have driven all variables in a deeper and more protracted recession while distortions to efficiency of production would have determined smaller and less protracted declines (see Figure 1.3).

- A model economy featuring only investment distortions, would have driven all macro-economic variables along a wrong expansionary path, as shown in Figure 1.4. Figure 1.5 shows the counterfactual contribution of the investment wedge by plotting a model economy where all wedges except the investment wedge are operating: when the effect of the latter is missing all the examined variables take on paths much closer to the one historically observed.

A measure of the correlation between historically observed US output and the output series generated by each of the BCA models used for decomposition confirms the results shown by the graphical analysis. For the period 2007:q4-2010:q4, the output generated by a labor-wedge-alone economy and an efficiency-wedge-alone economy is correlated, respectively, at 84% and 59% with actual output. The corresponding coefficients of fit are at 1.33 and 0.5. The correlation between historical output and the output simulated by a model only driven by distortions to investment is -73%. The coefficient of fit of the output predicted by the investment wedge model is -0.24.

1.4 BCA on two simulated financial recessions

Based on their findings on US data of different economic recession episodes, Chari et al. (2007a) argue that the investment wedge contributes very little to explaining business cycle fluctuations for two main reasons: (i) the wedge is found to account for only a very small part of the movements in the main macroeconomic series during the 1982 recession; (ii) the wedge drives output and the other main macro-economic variables in opposite directions with respect to the ones actually observed during the Great Depression episode. Using their equivalence results which map the financial accelerator type of financial friction into the investment wedge of the BCA tool-model, Chari and coauthors look at the financial constraints mechanisms pioneered by Bernanke et. al (1998) as a non promising avenue for modelling economic recessions.

In this section we show that such "poor" performance of the investment wedge in BCA can be reconciled with the recessionary dynamics generated by the simulation of a risk premium shock within a financial accelerator economy a la Bernanke et al. (1998) and and Gertler et al. (2003) where households have GHH type of preferences over consumption

and hours worked. To provide some insight on the role of complementarity in preferences in determining the BCA-estimated performance of the investment wedge we do the same simulation and BCA application exercises using a version of the Financial Accelerator model economy characterized by more standard log-separable preferences.

1.4.1 The model

The model is a version of the Bernanke et al. (1998) financial accelerator, very close to the versions found in Dib and Christensen (2008) and Gertler et al. (2003). The only rigidities at work are: nominal price stickiness, capital adjustment costs and the financial friction embedded in the accelerator mechanism.

There are six types of agents in the model: households, entrepreneurs, capital producers, monopolistically competitive retailers, a monetary policy authority and a financial intermediary. Entrepreneurs produce wholesale goods by means of a standard Cobb-Douglas technology. In order to purchase capital entrepreneurs borrow from a financial intermediary that converts households' deposits into loans. Capital producers produce new capital , using consumable goods and non-depreciated old capital, and are subject to quadratic capital adjustment costs. Retailers buy non-differentiated wholesale goods from entrepreneurs, at their marginal cost, and differentiate them into different varieties that are sold on a monopolistically competitive market. The monetary authority sets nominal interest rates following a standard Taylor feedback rule. The financial intermediary is at the heart of the BGG financial accelerator mechanism: being unable to observe entrepreneurial outcomes, it has to devote resources for monitoring borrowers. Costly monitoring results in borrowers being charged with a finance premium which is an increasing function of entrepreneurial leverage, i.e. it increases with the ratio between entrepreneurial expenditure for new capital and entrepreneurial own wealth. The risk premium is modelled here in a reduced form[6] and its exogenous component, i.e. the financial shock in the model, follows an autoregressive process of order1.

1.4.1.1 Wholesale goods producers (entrepreneurs)

Entrepreneurs produce non-differentiated wholesale goods, using a standard Cobb-Douglas production technology, which are sold on a competitive market to retailers at a price equal to the marginal cost. Labor and Capital to be employed in production are chosen according to the following cost minimization problem:

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[6]The microfoundations of the BGG risk premium can be found in , for example, in Bernanke et al. (1999), Gilchrist et al. (2003), Meier-Mueller (2008) and Christiano et al. (2009).

$$min_{H_t,K_t} \qquad w_t L_t + z_t K_t \tag{1.10}$$

$$\text{s.t.} Y_t = L_t^{(1-\alpha)} K_t^{\alpha}$$

The first order conditions are:

$$w_t = (1-\alpha) mc_t \frac{Y_t}{H_t} \tag{1.11}$$

$$z_t = \alpha \cdot mc_t \frac{Y_t}{K_t} \tag{1.12}$$

The resulting expression for the real marginal cost is:

$$mc_t = \frac{w_t^{(1-\alpha)} z_t^{(\alpha)}}{\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}} \tag{1.13}$$

Entrepreneurs are risk-neutral agents and have a finite planning horizon: with probability v_t they survive period t and hence remain in business. The resulting expected survival period is given by $1/(1-v_t)$. The assumption of the finite planning horizon is necessary to make sure that entrepreneurial own wealth, accumulated through time, is never enough to fully finance the purchases of capital K_{t+1} for next period production. For this reason capital purchased in period t at price Q_t has to be financed by both wealth N_{t+1} and bank loans D_t, as follows:

$$Q_t K_{t+1} - N_{t+1} = D_t \tag{1.14}$$

Entrepreneurial wealth N_{t+1} is the end-of-period equity of the business, i.e. the realized value of the capital investment net of the costs of debt repayment to the bank. At the end of each period t entrepreneurs have to sell the unused capital to capital producers and repay the debt to the financial intermediary.

The BGG financial friction is microfounded using an asymmetry of information type of argument in the one-period contract between the borrower (entrepreneur) and the lender (bank). When purchasing capital for production the entrepreneur is hit by an idiosyncratic shock (risk) whose realization is unobservable to the lender. To cope with the misreporting incentives that arise in the borrower's behavior, the financial intermediary has to implement a costly monitoring activity and consequently charges a risk premium over the riskless cost

of funds, the latter being the interest rate that households receive on their bank deposits. As shown in detail in Bernanke et al. (1998) and in Gilchrist et al. (2003), the optimal financial contract entails an endogenous risk premium which is an increasing function of the leverage ratio $(\frac{Q_t K_{t+1}}{N_{t+1}})$ featured by the borrower's business project, i.e.:

$$E_t R_{t+1}^K = E_t \frac{R_t^D \cdot rp(\frac{Q_t K_{t+1}}{N_{t+1}})}{\pi_{t+1}}. \tag{1.15}$$

The expected cost $E_t R_{t+1}^K$ of bank loans, for the entrepreneur, equals the riskless return on bank deposits requested by households augmented by a gross premium $rp(\frac{Q_t K_{t+1}}{N_{t+1}})$ which is assumed to have the following properties:

$$rp(\frac{Q_t K_{t+1}}{N_{t+1}}) : rp'(.) > 0 \text{ and } rp(1) = 1. \tag{1.16}$$

Intuitively the risk premium charged, because of moral-hazard concerns, is higher the lower (higher) the entrepreneur's stake in the project (the leverage of the project) and is absent when the capital investment project is fully financed by entrepreneurial wealth, i.e. when the leverage ratio is unity[7].

When deciding about the amount of capital K_{t+1} to be purchased for next period production the entrepreneur has to target an expected return on the investment which covers the expected costs of bank funds. The former is an increasing function of the expected marginal productivity of capital (z_{t+1}) and the expected resale price of the non depreciated capital, as follows:

$$E_t R_{t+1}^K = E_t \left[\frac{z_{t+1} + (1-\delta)q_{t+1}}{q_t} \right]. \tag{1.17}$$

The condition determining the optimal demand for K_{t+1} equalizes expected return and expected borrowing costs as follows:

$$E_t \left[\frac{z_{t+1} + (1-\delta)q_{t+1}}{q_t} \right] = E_t \frac{R_t^D \cdot rp(\frac{Q_t K_{t+1}}{N_{t+1}})}{\pi_{t+1}}. \tag{1.18}$$

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[7]The latter scenario corresponds to a fully internally financed operation which, due to the previsouly mentioned finite planning horizon assumption, is never occurring at equilibrium. In other words, the BGG framework is such that entrepreneurs always need external finance and, consequently, always pay a cost of funds higher than the riskless rate on bank deposits.

Entrepreneurial net-wealth, in aggregate terms, evolves according to a firm equity component V_t and a transfer component G_t :

$$N_{t+1} = v_t V_t + (1 - v_t)G_t \tag{1.19}$$

The former is given by the realized value of the return on the purchase of capital, net of the debt repayment contracted upon in period $(t-1)$:

$$V_t = R_t^K Q_{t-1} K_t - E_{t-1}(R_t^K)(Q_{t-1}K_t - N_t) \tag{1.20}$$

The transfer component G_t represents "seed money" that the fraction $(1 - v_t)$ of exiting entrepreneurs leave to newly entering entrepreneurs[8] before consuming whatever else is left. The number of exiting entrepreneurs is always balanced by the number of start-ups; this, combined with the fact that exiting entrepreneurs have larger accumulated wealth than start-ups, ensures that a larger exiting fraction is reflected in a lower value of aggregate entrepreneurial wealth.

1.4.1.2 Capital Producers

Capital producers use final goods, purchased from retailers combined with undepreciated (old) capital, to produce new capital goods that add to the capital stock. Producing and selling an amount $Q_t I_t$ of capital goods implies bearing the cost of I_t units of goods augmented with a quadratic capital adjustment cost, according to the following profit maximization problem:

$$\max_{I_t} E_t \left[Q_t I_t - I_t - \frac{\chi}{2}(\frac{I_t}{K_t} - \delta)^2 K_t \right] \tag{1.21}$$

The optimal choice of investment, which defines a standard Tobin's Q relation, is:

$$E_t \left[Q_t - 1 - \chi(\frac{I_t}{K_t} - \delta) \right] = 0 \tag{1.22}$$

Aggregate capital evolves according to a standard law of motion:

$$K_{t+1} = I_t + (1 - \delta)K_t \tag{1.23}$$

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[8]The "seed money" component of aggregate net-worth does not appear in the log-linear approximation of the net-worth evolution condition in Appendix 5. For the same modelling choice see also Dib and Christensen (2008) and De Graeve (2007).

1.4.1.3   Retailers

Retailers purchase wholesale goods from entrepreneurs, at their marginal costs, differentiate them, and sell them on a monopolistically competitive market.

The price stickiness assumed here is of the Calvo (1983) type: with probability θ_p the firm does not receive the signal allowing her to optimally reset the price[9]. When she gets the chance to reoptimize prices the firm chooses the optimal price $p_t^*(h)$ by solving the following profit maximization problem:

$$\max_{p_t^*(h)} E_t \left[\sum_{k=0}^{\infty} (\beta\phi_p)^{t+k} \lambda_{t+k} \Phi_{t+k}(h) \right] \tag{1.24}$$

where the nominal profit function is:

$$\Phi_t(h) = \left[p_t^*(h) - MC_t(h) \right] Y_t(h) \tag{1.25}$$

and the demand function is :

$$Y_t(h) = \int \left(\frac{p_t^*(h)}{P_t} \right)^{-\theta_p} Y_t = \int \left(\frac{p_t^*(h)}{P_t} \right)^{-\theta_p} (C_t + I_t) \tag{1.26}$$

The first order condition of this problem is:

$$P_t^*(f) = \frac{\theta_p}{\theta_p - 1} \frac{E_t \sum_{k=0}^{\infty} (\beta\phi_p)^k \lambda_{t+k} MC_{t+k}(h) D_{t+k}(h)}{E_t \sum_{k=0}^{\infty} (\beta\phi_p)^{t+k} \lambda_{t+k} D_{t+k}(h)} \tag{1.27}$$

The price stickiness of the Calvo (1983) type is such that the final product price evolves according to:

$$P_t^{1-\theta_p} = \phi_p (\pi P_{t-1})^{1-\theta_p} + (1-\phi_p) P_t^{*1-\theta_p}. \tag{1.28}$$

Combining the log-linear expressions for the optimal price and the evolution of aggregate prices yields the well known New-Keynesian Phillips curve, expressing present inflation as a function of current real marginal cost and expected inflation:

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[9] The resulting price duration is given by: $\dfrac{1}{1-\theta_p}$

$$\pi_t = \beta \pi_{t+1} + \frac{(1 - \beta \theta_p)(1 - \theta_p)}{\theta_p} mc_t. \tag{1.29}$$

1.4.1.4 Households

The representative household chooses sequences for consumption, hours worked, and bank deposits $\{C_t, H_t, D_t\}_{t=0}^{\infty}$ in order to maximize her expected life-time utility function:

$$U_0 = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(C_t, H_t) \right\} \tag{1.30}$$

subject to the sequence of budget constraints (in real consumables terms):

$$C_t + \frac{D_t}{P_t} \leq \frac{W_t}{P_t} H_t + \frac{R_{t-1}}{\pi_t} D_{t-1} + \frac{T_t}{P_t} + \frac{\Omega_t}{P_t} \tag{1.31}$$

where C_t is consumption of final good, D_t is nominal deposit bearing gross nominal riskless interest rate R_t, T_t are nominal lump sum transfers/taxes from the Government and Ω_t are nominal monopolistic profits derived from households' ownership of intermediate goods producing firms.

We adopt two specifications of the instantaneous utility function. Our baseline is the GHH polar case of the non-separable preferences introduced by Jaimovich and Rebelo (2009):

$$U(C_t, H_t) = \frac{\left(C_t - \chi H_t^{(1+\sigma_L)} X_t \right)^{(1-\sigma)}}{(1 - \sigma)}$$

where: $X_t = C_t^{\omega} X_{t-1}^{(1-\omega)}$

This family of preferences is such that when $\omega = 1$ one obtains the preferences introduced by King, Plosser and Rebelo ((?)), and when instead $\omega = 0$ one obtains the preferences suggested by Greenwood et al. (1988).

Our standard log-separable preferences specification is the common one:

$$U(C_t, H_t) = \log C_t - \chi \frac{N_t^{(1+\sigma_L)}}{1 + \sigma_L} \tag{1.32}$$

Households have monopolistic power in the labor market and therefore set their own wages. A continuum of different labor types indexed by $j \in [0, 1]$ is assumed to exist; labor employed by firm i is assumed to be an index given by:

$$H_t(i) \equiv \left[\int_0^1 H_t(i,j)^{\frac{\theta_w-1}{\theta_w}} \right]^{\frac{\theta_w}{\theta_w-1}}$$

where θ_w is a parameter denoting the substitution elasticity among labor varieties.

Let $W_t(j)$ denote the nominal wage set by households for $j-type$ of labor, for all $j \in [0,1]$. Optimal demand for $j-type$ of labor, aggregating the cost minimization result of each and every firm i, is given by:

$$H_t(j) = \left(\frac{W_t(j)}{W_t} \right)^{-\theta_w} H_t \tag{1.33}$$

for all $j \in [0,1]$.

$H_t = \int_0^1 H_t(i)$ represents total hours worked, across firms, in the economy, while W_t is an aggregate nominal wage index given by:

$$W_t \equiv \left[\int_0^1 W_t(j)^{1-\theta_w} \right]^{\frac{1}{1-\theta_w}} \tag{1.34}$$

Nominal wages are sticky a-la Calvo (1983), in that a fraction ϕ_w of households is not allowed to optimally reset her own wage in each period t. The resulting average duration of wage contracts, in such a framework, is notably given by $1/(1-\phi_w)$.

When setting her own optimal wage W_t^* household j maximizes (1.30) subject to both the budget constraint (1.31) and the optimal demand (1.33) for her own variety of labor service. The FOC are given by:

$$\sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ H_{t+k}(j) \left[\frac{W_t^*}{P_{t+k}} MU_{C,t+k} + \mu_w MU_{H,t+k}(j) \right] \right\} = 0 \tag{1.35}$$

where MU_C and MU_H are the marginal utility of consumption and hours respectively and where $\mu_w = \frac{\theta_w}{\theta_w-1}$ is the desired (steady-state) markup of the real wage. (1.35) can be rewritten as:

$$\sum_{k=0}^{\infty} (\beta\phi_w)^k E_t \left\{ H_{t+k}(j) MU_{C,t+k} \left(\frac{W_t^*}{P_{t+k}} - \mu_w MRS_{t+k} \right) \right\} = 0 \tag{1.36}$$

where $MRS_{t+k} \equiv -\frac{MU_{H,t+k}}{MU_{C,t+k}}$ is the marginal rate of substitution between hours worked and consumption. As can be inferred by looking at (1.36), when households are fully free to optimally reset their wages in each period t, i.e. when $\phi_w = 0$, they do so by setting:

$$\frac{W_t^*}{P_t} = \frac{W_t}{P_t} = \mu_w MRS_t \tag{1.37}$$

For this reason the constant wage markup μ_w is usually defined a "desired" wage markup in the economy. By combining a log-linear version of (1.36) with an expression for the Calvo (1983) type evolution of wages[10] one obtains the commonly used log-liner New Keynesian Phillips curve for wage inflation:

$$\pi_t^w = \beta \pi_{t+1}^w - \kappa_w \mu_w \tag{1.38}$$

where $\kappa_w \equiv \frac{(1-\phi_w)(1-\beta\phi_w)}{\phi_w(1+\theta_w\sigma_L)}$.

1.4.1.5 Equilibrium

The economy's resource constraint is:

$$Y_t = C_t + I_t \tag{1.39}$$

Notice that, as in most of the BGG related literature, the above constraint disregards the amount of (lost) resources devoted to the payment of monitoring costs.

1.4.1.6 Monetary policy

The benchmark Taylor Rule is a feedback rule responding to deviations of the gross nominal inflation rate from its steady-state value and allowing for some degree of inertia.

$$\frac{R_t}{R} = (\frac{\pi_t}{\pi})^{\rho_\pi(1-\rho_R)}(\frac{R_{t-1}}{R})^{\rho_R} \tag{1.40}$$

1.4.1.7 Risk premium shock

Within the financial accelerator framework pioneered in Bernanke et al. (1998) several papers have introduced autoregressive shocks aimed at representing sources of disturbance directly linked to the functioning of financial (intermediation) markets.

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[10]Given the probabilistic structure of the Calvo wage rigidity mechanism aggregate wage indeax in the economy, in each period t, evolves according to: $W_t = \left[\phi_w W_{t-1}^{(1-\theta_w)} + (1-\phi_w)W_t^{*(1-\theta_w)}\right]^{\frac{1}{1-\theta_w}}$

After the 2007-2008 world financial crisis, in particular, several papers have examined the macroeconomic impact of *credit crunch* shocks. The breakdown of the money markets and inter-bank markets, that occurred in the summer of 2007 and in the fall of 2008, manifested itself primarily as a jump in financial spreads to unusually high levels, reflecting banks' perceptions of risk and liquidity conditions. The resulting collapse of funding opportunities, for banks, translated into a severe worsening of both price and quantity conditions of bank credit supply to both households and firms.

The risk premium shock (erp_t) is assumed to enter the log-linear version of (1.18) as follows[11]:

$$rp_t = \Psi(k_{t+1} + q_t - n_{t+1}) + erp_t \qquad (1.41)$$

In (1.41) parameter Ψ is the elasticity of the endogenous external finance premium to deviations from steady-state of the firm's leverage ratio. The credit supply shock follows an AR(1) process:

$$erp_t = \rho_{erp}erp_{t-1} + \epsilon_{erp,t} \qquad (1.42)$$

A shock to the risk premium acts as a shifter on the demand for new capital and can in this respect be interpreted as a form of investment-specific shock. In particular, a sudden rise in erp_t makes the funds necessary for purchasing K_{t+1} more costly and hence impact on condition (1.18): a higher expected cost of funds is such that only entrepreneurial projects with a sufficiently higher expected returns on capital will be actually implemented by entrepreneurs. The suddenly higher share of profits that entrepreneurs have to devote to debt repayment implies a fall in the demand for capital and, consequently, falling investment and falling relative price of investment goods (Q_t).

1.4.1.8   Calibration

The model is calibrated quarterly and log-linearised around its non-stochastic steady-state. In appendices C1 and C2 the steady-state and log-linear conditions are reported, respectively. For $\omega = 1$ households preferences take on a standard separable specification while for $\omega = 0$ preferences are non-separable of the GHH type.

Most of the parametersare calibrated to identical values across the two different specifications for households' preferences. The households' time discount factor is set to 0.9928,

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[11]See also Cantore and Maurin (2008) and Freystatter (2010).

so as to have an annual real interest rate of approximately 3%. The depreciation rate of physical capital δ is set to 0.025 and the capital share in production α is set to 0.35, as standard in the literature. In the benchmark model $\sigma_C = 2$. Desired mark-ups are set to 20%, as standard in New-Keynesian literature, by fixing the market power parameter θ_p to 6. Hours worked at steady-state are set to 1/3 by calibrating the utility weight parameter $\varkappa$.

The price stickiness parameter ϕ_p equals 0.75, so as to have an approximate duration of price contracts of 4 quarters. ϕ_w is set to 0 so as to guarantee flexible wages. The parameter χ ruling capital adjustment costs is set to the very low value of 0.1, so as to minimize the role played by capital adjustment costs in the simulations of risk premium shocks. The inverse elasticity of labor supply σ_L is set to 1, implying a benchmark elasticity of labor supply equal to unity.

As far as the financial accelerator parameters are concerned, the steady-state survival rate of entrepreneurs v is set to 0.9728, the leverage ratio k/n is set to 2 and the steady-state gross external finance risk premium is set to 1.0025, corresponding to an annual spread of 200 basis points. The latter are values taken from Bernanke et al. (**??**). The elasticity of the risk premium to leverage Ψ is set to 0.04, as estimated in Gilchrist and Zakrajšek (2009).

Monetary policy response to inflation ρ_π is calibrated to 1.5, a common value in the New-Keynesian literature, and features a mild degree of inertia ($\rho_R = 0.4$) in its benchmark calibration.

The persistence ρ_{e_rp} of the external finance risk premium shock is set to 0.75 in both specifications of the model, as found in Gilchrist et al. (2009).The standard deviation of the risk premium shock changes across the two model specifications in order to guarantee recessionary responses of investment not too dissimilar in magnitude. It is equal to 0.01 in the model with GHH preferences and approximately three times smaller in the specification of the model featuring standard separable preferences.

1.4.2 Accounting results for two counterfactual recessions

Figure 1.6 plots a 20 quarters recessionary episode taken from the dataset which we generated by simulating a financial accelerator economy featuring GHH type of households' preferences. In such a model economy shocks to the risk premium are the only fundamental source of disturbance allowed to operate. The choice of GHH preferences in a financial accelerator model economy makes sure that in response to a financial risk premium shock all macroeconomic variables are driven into a recession. Investment, unsurprisingly the most

volatile, reaches a 25% peak fall 11 periods after the start of the recession. Hours worked fall by 15% with respect to their initial value while output and consumption fall by 8% and 7% respectively. For illustrative purposes we label this recession as *counterfactual 1*.

Figure 1.7 reports the same 20 quarters recessionary episode generated by simulating a financial accelerator model economy only differing from the previous one for its standard separable specification of households' preferences. The response of the economy to the underlying fundamental risk premium disturbances is such that all macroeconomic variables are driven into a recession with the exception of aggregate consumption. While investment falls by approximately 40%,11 periods after the start of the recession, hours worked fall by 8% and output by 5%. Consumption behaves counter-cyclically, reaching a 5% increase from its initial value right at the trough of the recession. We label this recession episode as *counterfactual 2*.

Both recessions have been simulated by assuming an exogenous constant value of Public Spending.

The BCA methodology provides materially different results when applied to the two different recession episodes.

Figure 1.8 plots simulated output and the estimated path of the wedges for the recession characterized by comovement of all the macro-economic variables examined (*Counterfactual 1*). BCA finds an almost time invariant contribution of the investment wedge. The volatility of the latter, over the 20 periods of the episode, is approximately one third the volatility of the output series. BCA also finds that the tax on investment goods τ_{xt} tends to move in opposite directions with respect to output, i.e. the distortions that manifest themselves through the investment wedge improve when output levels decline and worsen when output levels increase. The correlation between the investment wedge and the output series is -38% if measured over the quarters of the recession episode, and -55% if measured over the whole estimation sample.

The efficiency wedge displays the lowest volatility over the recession episode and, as such, seems to correctly account for the absence of TFP type of distortions in the underlying data generating process (model). The movements of simulated output seem to be fully captured by the dynamics of the labor wedge, whose volatility relative to output is larger than 2 and whose correlation with output is slightly less than 100%.

The predictions of the BCA model when only one wedge is allowed to operate in the economy, reported in Figure 1.9 and Figure 1.10,confirm the results:

- The distortions channeled through the investment wedge would have missed the move-

ments of output, hours worked and investment during the *Counterfactual 1* recession episode, driving each of the series in an opposite (i.e. expansionary) direction. The correlation of the output predicted by the investment-wedge model with actual output is -62%. The coefficient of fit measures -0.11.

- The labor wedge plays a dominant role in predicting all macro-economic variables examined. The predicted series for output, hours worked and investment almost perfectly mimic the dynamics of the actual recession-recovery path. Output predicted with the labor-wedge model is correlated at 99% with actual output along the 20 quarters of the recession episode. The coefficient of fit measures 1.17.

- The predictions of the efficiency-wedge driven economy lead to negligible business cycle movements for all macro-economic series considered in the exercise.

Figure 1.11 plots simulated output and estimated path of the wedges for the recession characterized by counter-cyclical behavior of consumption (*Counterfactual 2*). On this episode BCA finds a clearly predominant role of the distortions that manifest themselves through the investment wedge. The volatility of the latter, relative to output, is twice as large the one of the labor wedge and equals1.21. The relative volatility of the efficiency wedge, as it was the case for the recession simulated under *Counterfactual 1*, is very close to zero, reflecting the neutral role played by TFP type of distortions during the recession episode. The correlation between the investment wedge and simulated output is, unlike the case of *Counterfactual 1,* positive and very close to 100%.

The exercise of output decomposition, reported in Figure 1.12 and 1.13, shows that:

- The investment wedge can account for almost 100% of the drop in output that the simulated economy experiences after 11 quarters from the start of the recession. The correlation between output predicted by the investment wedge and simulated output is equal to 96%. The coefficient of fit measures 0.81. In addition, the BCA model in which all distortions but the investment wedge are at work almost fully misses the recession-recovery path which all simulated macro-economic series display.

- Distortions represented by the labor wedge are able to explain less than 50% of the drop in simulated output and generate an output series whose correlation with actual output is 53%. The coefficient of fit measures 0.20.

1.5   Misspecified BCA preferences and the investment wedge.

In this section we inspect the mapping between the data generating model economy and the standard BCA toolkit and provide some insight about the implications that GHH preferences in the underlying economy have on the measurement of the investment wedge, when the economy is subject to risk premium shocks.

The standard version of the BCA toolkit, the one we applied on the data of the US 2007-2010 recession and that Chari et al. (2007a) apply to the US Great Depression episode, is a wedge-augmented growth model with standard separable preferences and no adjustment costs.

When the data generating process is a financial accelerator economy with standard separable preferences, the corresponding inter-temporal equilibrium conditions are:

$$\lambda_t^{BCA} - \lambda_{t+1}^{BCA} - \frac{mpk_{ss}}{RK_{ss}} \cdot mpk_{t+1} = \left[\frac{1-\delta}{\bar{R}} \tau_{x,t+1} - \frac{1}{1+\tau_x} \tau_{x,t} \right] \tag{1.43}$$

$$\lambda_t^{SEP} - \lambda_{t+1}^{SEP} - \frac{mpk_{ss}}{RK_{ss}} mpk_{t+1} = \frac{(1-\delta)}{RK_{ss}} q_{t+1} - q_t - rp_t \tag{1.44}$$

where (**??**) is the log-linear version of condition (**??**), and (1.44) is the log-linear equivalent of (**??**)

Log-separable preferences in both the BCA toolkit and the underlying economy guarantee that:

$$\lambda_t^{SEP} = \lambda_t^{BCA} = -c_t \tag{1.45}$$

Under these assumptions the investment wedge of the BCA toolkit, the term in square brackets in condition (**??**), capture the dynamics of two "distortions" characterizing the underlying economy: i) the investment adjustment costs, which are responsible for the variations in the price of installed capital q_t; ii) the financial risk premium rp_t, which varies endogenously as a function of entrepreneurial leverage and is subject to exogenous shocks.

As illustrated in Chari et al. (2007a) and as can be seen by comparing conditions (1.43) and (1.44), if investment adjustment costs were the only distortion entering the inter-temporal equilibrium condition (1.44) of the underlying economy, a standard BCA toolkit with no investment adjustment costs would estimate an investment wedge $\tau_{x,t}$ which increases during booms and decreases during recessions. Our low calibration of the adjustment costs parameter sets to a minimum the contribution of the adjustment costs.

The right hand side of condition (1.44), which is the distortion estimated by the investment wedge, is therefore driven in our simulated financial accelerator economy by the

countercyclical dynamics of the risk premium rp_t: the resulting estimated wedge is, as reported in Figure 1.11, a tax on investment that increases during the recession and decreases during the boom.

When the data generating process is a financial accelerator economy with GHH preferences, the inter-temporal equilibrium condition is:

$$\lambda_t^{GHH} - \lambda_{t+1}^{GHH} - \frac{mpk_{ss}}{RK_{ss}} mpk_{t+1} = \frac{(1-\delta)}{RK_{ss}} q_{t+1} - q_t - rp_t \tag{1.46}$$

Under the GHH assumption for preferences condition (1.45) is no longer verified. We have that:

$$\lambda_t^{GHH} = -(1+\alpha_1) \cdot c_t + \alpha_2 \cdot h_t \tag{1.47}$$

where coefficients $\alpha_1 > 0$ and $\alpha_2 > 0$ depend on structural parameters and steady-state values.

Comparing conditions (1.43) and (1.46) one can see that the investment wedge estimated by the standard BCA toolkit is lead to capture not only the structural frictions due to investment adjustment costs and financial intermediation costs but also the endogenous fluctuations of consumption and hours worked which result from the imperfect mapping with the preferences of the underlying economy. Our simulations show that the endogenous contribution of consumption and hours to the composite distortion captured by the BCA toolkit as an investment wedge, due to non-zero coefficients α_1 and α_2, drives the wedge in a procyclical response to the risk premium shock. As a result, when applied to an underlying economy with GHH preferences and risk premium shocks, BCA estimates a tax on investment that falls during the recession and increases during booms, as documented by Figure 1.8.

As mentioned, the contribution of the endogenous fluctuations in consumption and hours to the composite distortion of the euler condition is a function of the parameters 1 and 2, and ultimately a function of steady-state values and structural parameters among which the labor supply elasticity and the degree of complementarity between consumption and hours worked. Non-reported simulations confirm that the reaction of the composite euler distortion is more procyclical the larger the degree of complementarity between consumption and hours and less procyclical the larger the labor supply elasticity. For values of these two parameters well inside the ranges commonly adopted in the literature the dynamics of the composite euler distortion captured by the BCA investment wedge do not change their sign. The mismatch of preferences between the data generating economy and the BCA toolkit affects

as well the measurement of the labor wedge, although it does not determine a change in the sign of its contribution. In both simulated recession episodes labor distortions worsen during the downturn and improve during the recovery, following the countercyclical dynamics of the price-markup triggered by the credit-crunch shock. In the recession simulated using standard separable preferences the labor wedge plays a markedly reduced role. The data generating economy with GHH specification of preferences is a world in which the labor supply decision is independent from the level of wealth, i.e. consumption does not enter the labor-leisure first order condition. The BCA measures the labor wedge in a straightforward residual way, using the data series and the static labor-leisure first order condition which applies to its standard separable specification of preferences. The corresponding labor market equilibria are[12]:

$$h_t = w_t - Pmarkup_t \tag{1.48}$$

$$h_t + c_t = w_t + dev(1 - \tau_{l,t}) \tag{1.49}$$

Comparing conditions (1.48) and (1.49), one can see that while the "actual" labor wedge operating in the underlying economy is the monopolistic price markup entering between hours worked and the real wage, the residual tax on labor income computed by the BCA toolkit is also a linear function of the fluctuations in aggregate consumption. The fact that the measurement of the labor wedge does not require solving the BCA model and estimating the wedges allows us to use the data series generated by the GHH specification of financial accelerator economy to compute the actual labor wedge and compare it to the measured labor wedge. Figure 1.14 shows that, due to the mismatch in preferences, the standard BCA toolkit tends to overestimate the procyclical contribution of the labor wedge to the recessionary dynamics of a financial accelerator economy hit by an adverse risk premium shock.

1.6 Conclusion

We explore a key substantive finding of the Business Cycle Accounting Literature: the measured investment wedge, the distortion that enters between the inter-temporal marginal rate of substitution in consumption and the rate of return on capital, plays a tertiary role with respect to either distortions in efficiency of production and labor market distortions in accounting for business cycle dynamics; in addition it often appears to improve during

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[12]Assuming a unit elasticity of labor supply.

recessions and worsen during recovery phases. We show that such "poor" performance of the investment wedge is also found when applying the BCA toolkit to the US data of the recent (2007-2010) financial crisis. Then we illustrate how those dynamics of the measured investment wedge are broadly compatible with the ones that BCA ...nds over a simulated recession triggered by an adverse risk premium shock within a financial accelerator economy a la Gertler et al. (2003), provided that in the data generating economy standard separable preferences are replaced with their GHH12 specification. We discuss how the imperfect mapping of preferences between the BCA toolkit and the data generating economy can mislead the BCA toolkit into measuring a composite investment (euler) distortion which re‡ects not only the structural (financial) distortions of the economy but also the endogenous dynamics of hours worked. The latter prevail over the contribution of the risk premium and determine a countercyclical reaction of the measured investment wedge when the economy is hit by a risk premium disturbance. When the same exercise is applied over a financial recession generated by an underlying economy with standard separable preferences, matching those of the BCA toolkit, the measured investment wedge appears to explain most of the economic fluctuation and plays a markedly procyclical role, worsening during the recession and improving during booms. An inspection of the inter-temporal equilibrium conditions of the BCA toolkit and the underlying economy illustrates that the measured investment wedge captures a euler distortion which is only driven by the procyclical dynamics of the risk premium.

1.7   Figures and Tables

TABLE 1 Properties of the Wedges: US 1977:q1-2010:q4

A. Summary Statistics	Std Dev / Y	*Cross Correl Wedge / Output*				
Wedges		-2	-1	0	1	2
Efficiency	**0.61**	0.57	0.69	**0.77**	0.61	0.42
Labor	**1.15**	0.53	0.68	**0.74**	0.62	0.44
Investment	**0.17**	-0.19	0.05	**0.41**	0.50	0.52
Government Cons	**1.16**	-0.52	-0.51	**-0.39**	-0.25	-0.03
A. Cross Correlations		*Cross Correl X / Y*				
Wedges (X,Y)		-2	-1	0	1	2
Efficiency - Labor		0.66	0.46	0.17	0.51	0.61
Efficiency - Investment		0.26	0.40	0.41	-0.16	-0.37
Efficiency - Government		-0.17	-0.29	-0.44	-0.52	-0.41
Labor - Investment		0.50	0.25	-0.01	-0.06	-0.05
Labor - Government		-0.03	-0.24	-0.28	-0.32	-0.44
Investment - Government		0.53	0.52	0.40	0.16	0.13

TABLE 2 Properties of the Output Components: US 1977:q1-2010:q4

A. Summary Statistics	Std Dev / Y	*Cross Correl Wedge / Output*				
Wedges		-2	-1	0	1	2
Efficiency	**1.13**	0.57	0.69	**0.77**	0.61	0.41
Labor	**0.88**	0.44	0.58	**0.62**	0.53	0.38
Investment	**0.15**	-0.24	-0.03	**0.29**	0.39	0.45
Government Cons	**0.43**	-0.73	-0.88	**-0.93**	-0.74	-0.48
A. Cross Correlations		*Cross Correl X / Y*				
Wedges (X,Y)		-2	-1	0	1	2
Efficiency - Labor		0.67	0.40	0.02	0.43	0.58
Efficiency - Investment		0.14	0.26	0.28	-0.24	-0.42
Efficiency - Government		-0.47	-0.64	-0.83	-0.71	-0.49
Labor - Investment		0.19	0.55	0.99	0.49	0.11
Labor - Government		0.41	0.10	-0.17	-0.00	-0.06
Investment - Government		-0.39	-0.55	-0.55	-0.54	-0.51
C. 2007:q4-2010q4:		*Cross Correl Wedge / Output*				
Efficiency				59%		
Labor				84%		
Investment				-73%		

TABLE 5 Properties of the Wedges: Recession with separable preferences

A. Summary Statistics	Std Dev / Y	*Cross Correl Wedge / Output*				
Wedges		-2	-1	0	1	2
Labor	**0.44**	0.14	0.05	**-0.11**	-0.81	-0.44
Investment	**1.13**	0.07	0.37	**0.95**	0.51	0.11
B. Cross Correlations		*Cross Correl X / Y*				
Wedges (X,Y)		-2	-1	0	1	2
Labor - Investment		0.21	0.01	-0.34	-0.87	-0.52

TABLE 6 Properties of the Output Components: Recession with Separable Preferences

Full Sample						
A. Summary Statistics	Std Dev / Y	*Cross Correl Wedge / Output*				
Wedges		-2	-1	0	1	2
Labor	**0.40**	0.20	0.27	**0.71**	-0.38	-0.35
Investment	**0.72**	0.04	0.35	**0.95**	0.53	0.14
B. Cross Correlations		*Cross Correl X / Y*				
Wedges (X,Y)		-2	-1	0	1	2
Labor - Investment		-0.40	-0.72	-0.90	-0.25	0.19
Recession Episode						
C. Summary Statistics		*Cross Correl Wedge / Output*				
Wedges						
Labor				**0.53**		
Investment				**0.96**		

TABLE 7 Properties of the Wedges: Recession with GHH preferences

A. Summary Statistics	Std Dev / Y	*Cross Correl Wedge / Output*				
Wedges		-2	-1	0	1	2
Labor	**2.44**	0.05	0.17	**0.98**	-0.01	-0.11
Investment	**0.32**	-0.26	-0.23	**-0.55**	0.61	0.48
A. Cross Correlations		*Cross Correl X / Y*				
Wedges (X,Y)		-2	-1	0	1	2
Efficiency - Labor		-0.05	-0.15	-0.96	-0.11	0.06
Efficiency - Investment		-0.41	-0.41	0.68	0.34	0.31
Efficiency - Government		-0.15	-0.26	-0.94	-0.03	0.15
Labor - Investment		0.42	0.50	-0.69	-0.24	-0.24
Labor - Government		0.05	0.17	0.98	-0.01	-0.11
Investment - Government		-0.26	-0.23	-0.55	0.61	0.48

TABLE 8 Properties of the Output Components: Recession with GHH preferences

Full Sample						
A. Summary Statistics	Std Deviation	*Cross Correl Wedge / Output at lag*				
Wedges	relative to Output	-2	-1	0	1	2
Labor	**1.18**	0.01	0.15	**1.00**	0.08	-0.05
Investment	**0.17**	-0.19	-0.21	**-0.77**	0.43	0.37
B. Cross Correlations		*Cross Correl X / Y at lag*				
Wedges (X,Y)		-2	-1	0	1	2
Labor - Investment		-0.30	-0.21	0.80	0.41	0.28
Recession Episode						
C. Summary Statistics		*Cross Correl Wedge / Output at lag*				
Wedges		-2	-1	0	1	2
Labor				0.99		
Investment				-0.62		
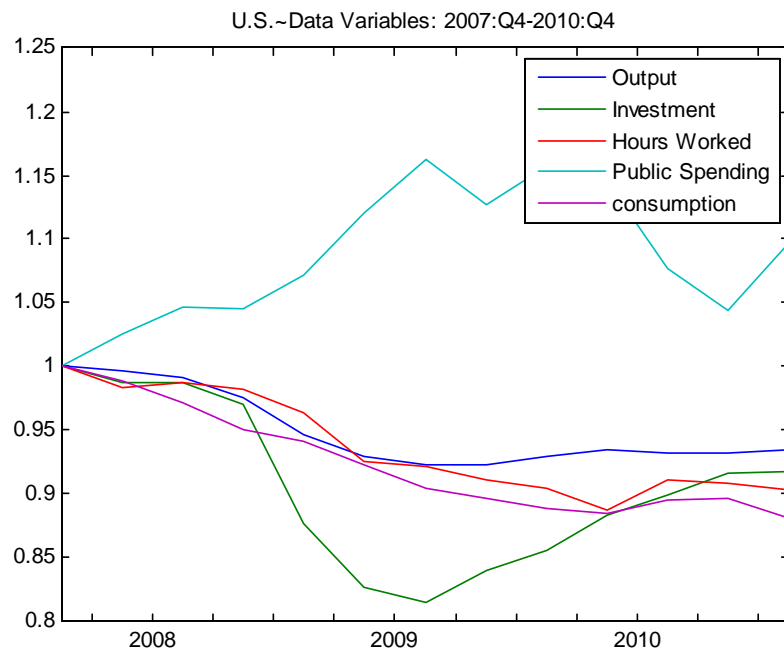
Figure 1.1: The recession episode of 2007-2010. Per capita variables. 2007:q4=1
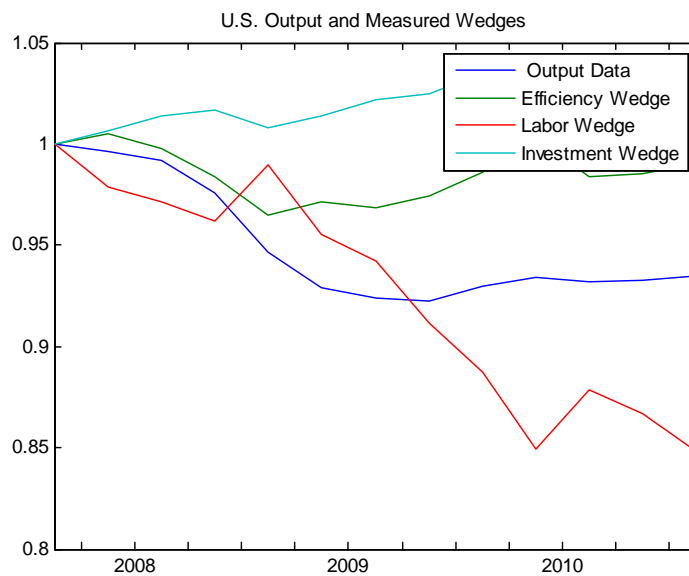
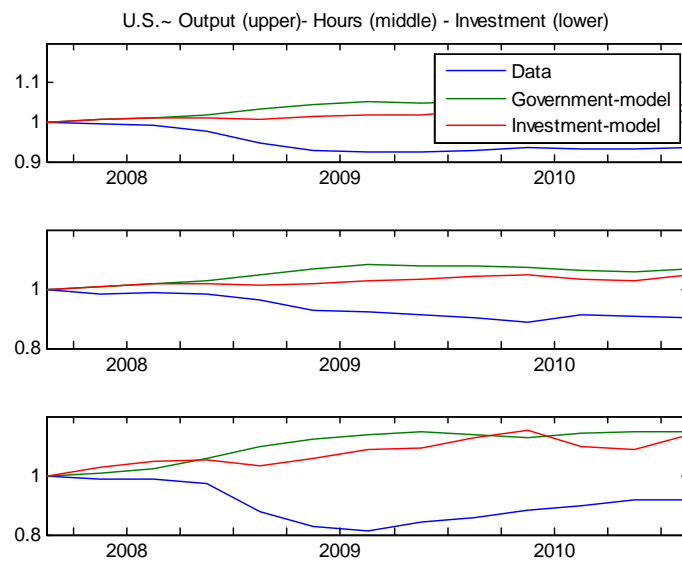Figure 1.2: The recession episode of 2007-2010. Output and measured wedges: 2007:q4=1.

Figure 1.3: The recession episode of 2007-2010. Data variables and 1-wedge-economy variables. 2007:q4=1
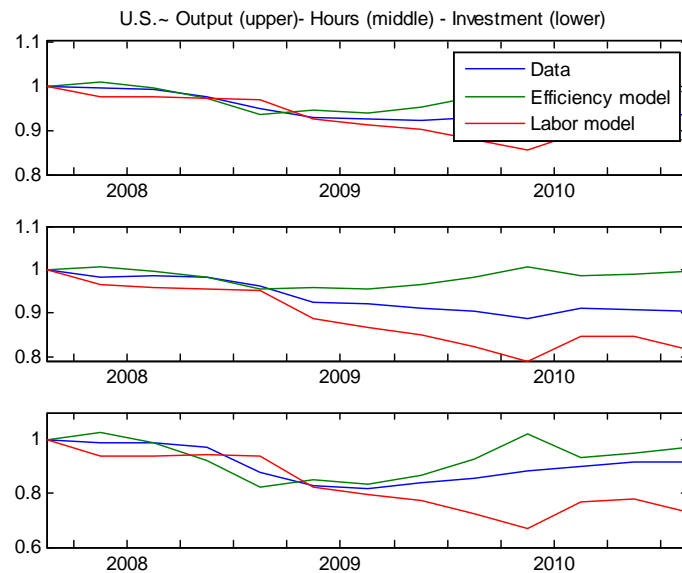

Figure 1.4: The recession episode of 2007-2010. Data variables and 1-wedge-economy variables. 2007:q4=1
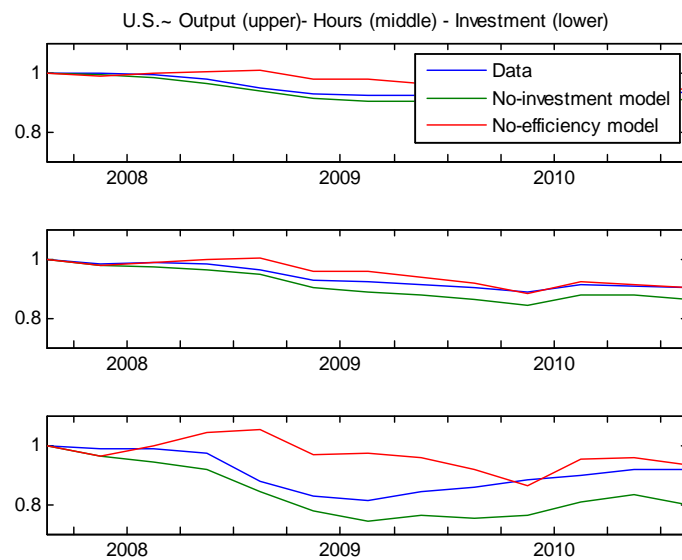
Figure 1.5: The recession episode of 2007-2010. Data variables and 2-wedges-economy variables. 2007:q4=1
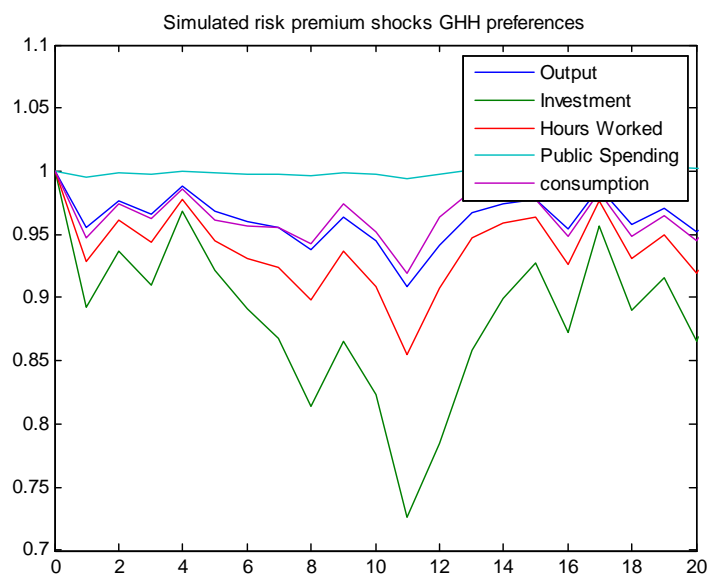

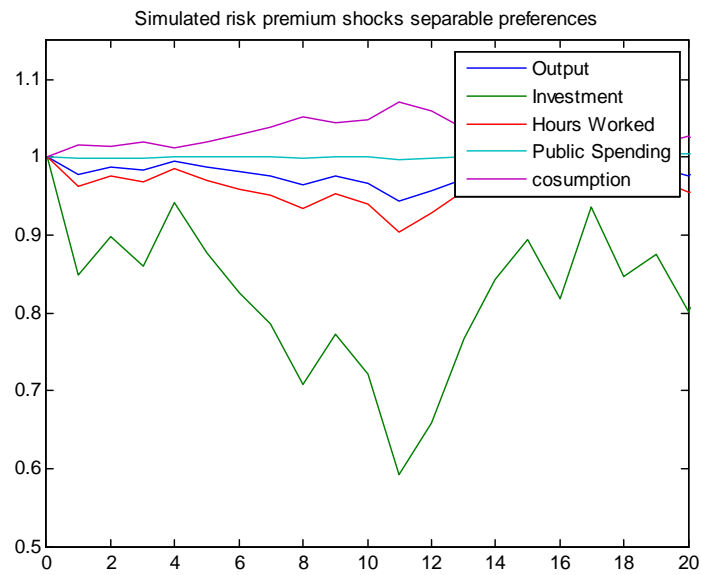Figure 1.6: Counterfactual 1. risk-premium shock, GHH preferences.

Figure 1.7: Counterfactual 2: risk-premium shock, standard separable preferences.
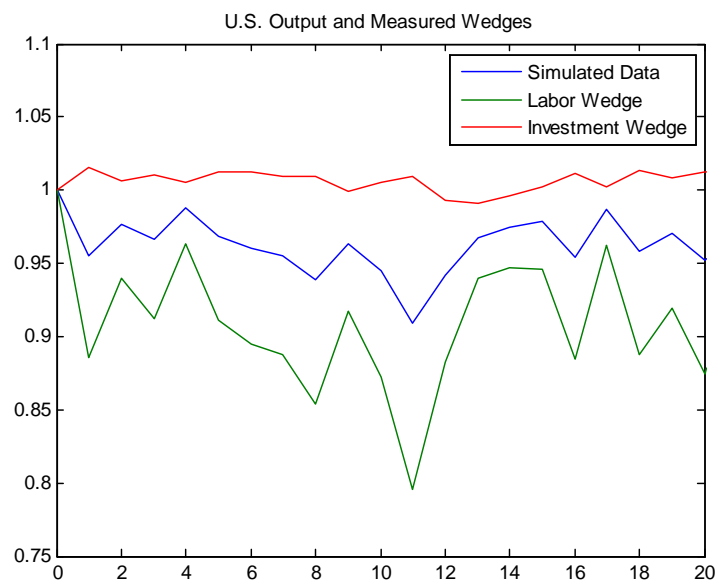

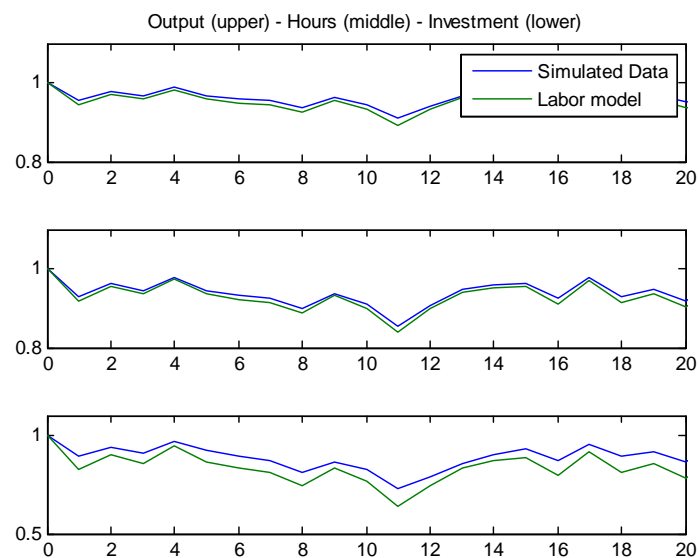Figure 1.8: Simulated Recession 1: Output and measured wedges

Figure 1.9: Simulated Recession 1: Data variables and 1-wedge-economy variables.
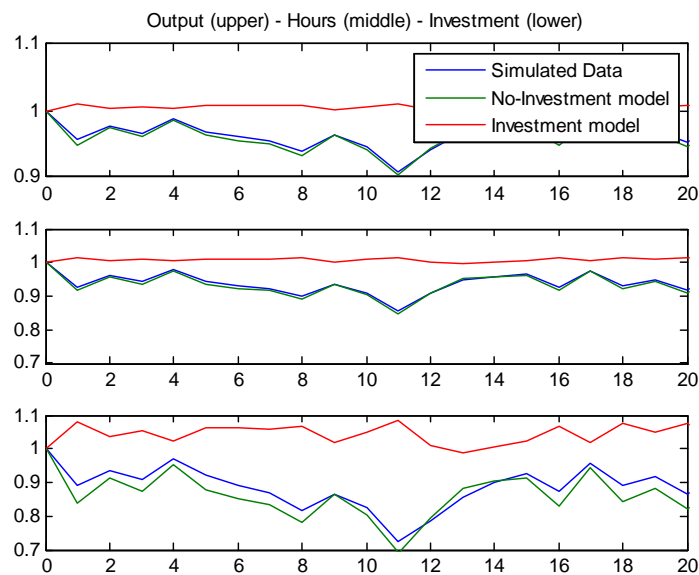

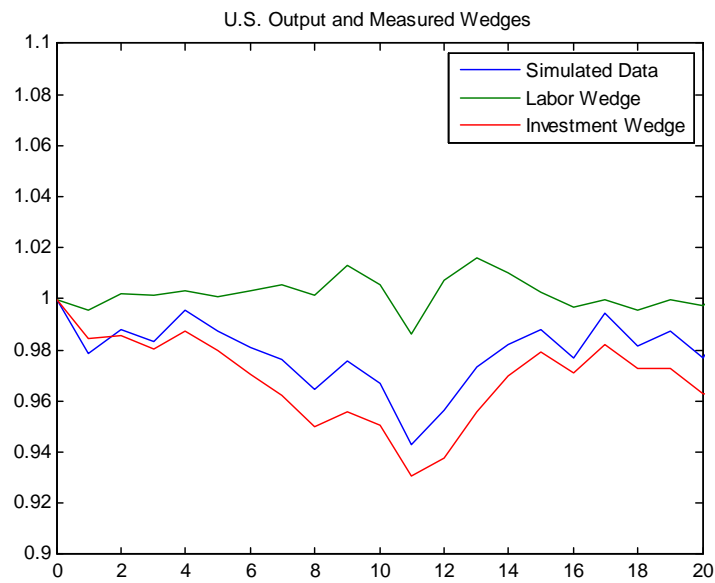Figure 1.10: Simulated Recession 1: Data variables and 1-wedge-economy variables.

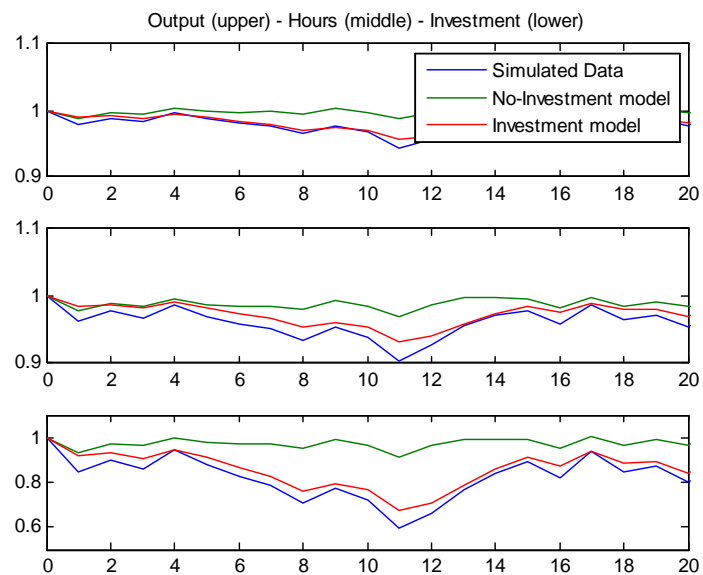Figure 1.11: Simulated Recession 2: Output and measured wedges

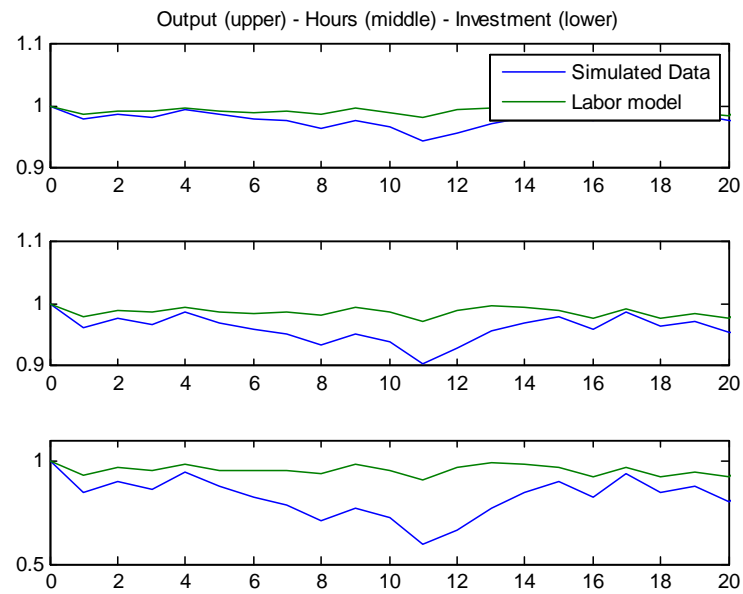Figure 1.12: Simulated Recession 2: Data variables and 1-wedge-economy variables.

Figure 1.13: Simulated Recession 2: Data variables and 1-wedge-economy variables.
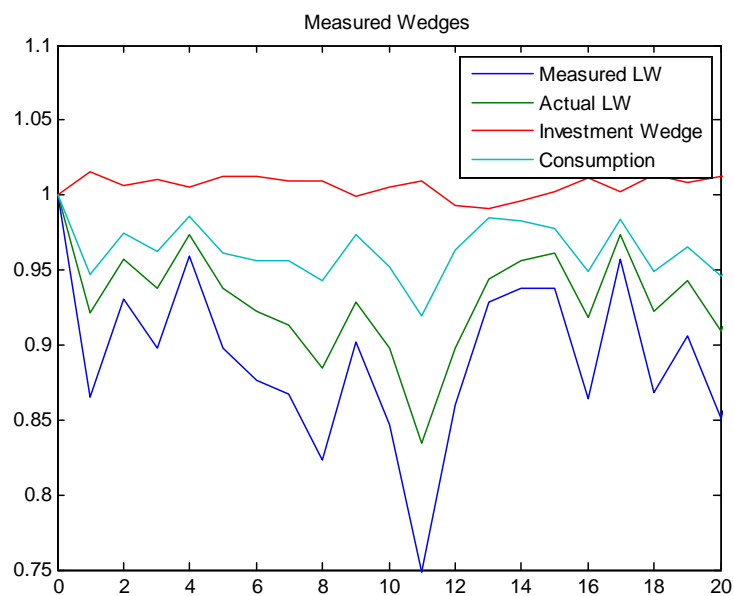

Figure 1.14: Measured Labour Wedge Vs. Actual Labour Wedge

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1.8 Appendices

1.8.1 Appendix 1: steady-state

Steady-state gross inflation rate is set to $\pi = 1$. Steady-state gross risk premium is $rp = 1.0075$.

From condition3.32 one has:

$$R = \pi/\beta = 1/\beta = RR \tag{1.50}$$

Capital evolution law 3.21 is such that at steady-state:

$$I = \delta K \tag{1.51}$$

Replacing the former in the Tobin's Q equation 3.20 provides the price of capital at steady-state:

$$Q = 1 \tag{1.52}$$

From condition **??** one has:

$$R^K = RR \cdot rp \tag{1.53}$$

From definition **??** one has that steady-state marginal product of capital is:

$$z = R^K - 1 + \delta \tag{1.54}$$

Pricing 3.25 at steady-state is such that real marginal cost is pinned down as follows:

$$mc = \frac{1}{\mu_p} = \frac{\theta_p - 1}{\theta_p} \tag{1.55}$$

Wage setting at steady-state is such that:

$$\frac{w}{MRS} = \mu_w = \frac{\theta_w}{\theta_w - 1} \tag{1.56}$$

Steady-state **??** determines:

$$\frac{K}{Y} = \frac{\alpha}{z} \cdot mc \tag{1.57}$$

From 3.39:

$$\frac{C}{Y} = 1 - \delta\frac{K}{Y} \tag{1.58}$$

Real wage **??** is :

$$w = mc(1-\alpha)\frac{Y}{H} \tag{1.59}$$

Imposing $H = 1/3$ at steady-state one can obtain the resulting weigh of hours worked in the utility function:

$$\chi^{GHH} = \chi^{GALI} = \frac{w}{\mu_w H^{(\sigma_L)}} \tag{1.60}$$

$$\chi^{STD} = \frac{w}{\mu_w H^{(\sigma_L)}C} \tag{1.61}$$

1.8.2 Appendix 2: log-linear model

$$x_t = \omega c_t + (1 - \omega)x_{t-1} \tag{1.62}$$

$$SEP : \lambda_t = -x_t \tag{1.63}$$

$$GHH : \lambda_t = D_2 h_t + D_3 c_t$$

$$SEP : w_t - (\sigma_L h_t + x_t) = wmp_t \tag{1.64}$$

$$GHH : w_t - (\sigma_L h_t) = wmp_t$$

$$rr_t = r_t - E_t \pi_{t+1} \tag{1.65}$$

$$0 = \lambda_{t+1} - \lambda_t + rr_t \tag{1.66}$$

$$w_t = y_t + mc_t - h_t \tag{1.67}$$

$$z_t = y_t + mc_t - k_{t-1} \tag{1.68}$$

$$y_t = (1 - \alpha)h_t + \alpha k_{t-1} \tag{1.69}$$

$$y_t = \frac{c}{y}c_t + \frac{i}{y}i_t \tag{1.70}$$

$$k_t = (1 - \delta)k_{t-1} + \delta i_t \tag{1.71}$$

$$q_t = \chi(i_t - k_{t-1}) \tag{1.72}$$

$$d_t = \frac{k}{d}(q_t + k_t) - \frac{n}{d}n_t \tag{1.73}$$

$$rp_t = \Phi(q_t + k_t - n_t) \tag{1.74}$$

$$r_t^K = \frac{z}{R^K} \cdot z_t + \frac{(1-\delta)}{R^K} q_t - q_{t-1} \tag{1.75}$$

$$r_{t+1}^K = rp_t + rr_t \tag{1.76}$$

$$\pi_t = \beta\pi_{t+1} + \kappa mc_t \tag{1.77}$$

$$\frac{n_t}{vR^K} = \frac{k}{n}r_t^K - (\frac{k}{n} - 1)(rp_{t-1} + rr_{t-1}) + n_{t-1} \tag{1.78}$$

$$r_t = (1 - \rho_R)\rho_\pi\pi_t + \rho_R r_{t-1} \tag{1.79}$$

where:

$$D_1 = \frac{\chi}{C}\frac{N^{(1+\sigma_L)}}{(1+\sigma_L)} = \frac{(1-\alpha)MC}{\mu_W(1+\sigma_L)}$$

(the second equality above coming from the definition of χ^{GHH})

$$D_2 = \sigma_C\frac{D_1}{1-D_1}(1+\sigma_L)$$

$$D_3 = -\sigma_C\frac{1}{1-D_1}$$

CHAPTER 2

RISK PREMIUM SHOCKS AND CONSUMPTION

2.1 Introduction

Financial risk premium shocks, within a Bernanke et al. (1998) financial accelerator framework (hereafter BGG), represent sudden increase in the spread entrepreneurs are charged over the riskless rate when borrowing funds from the financial intermediary. Such shocks were at first introduced in order to explore, from a theoretical perspective, the transmission channels onto the real economy of disruptions in financial intermediation mechanisms, such adverse credit supply shocks and credit-crunch episodes. Since the unfolding of the 2007-2009 global financial turmoil and economic recession several papers have shown renewed interest in risk premium shocks and have adopted them, within different frameworks, to attempt matching the decline in economic activity empirically observed in the affected economies.

Little attention, if any, has been paid to the conditions under which consumption comoves with the other main macro-economic variables when the economy gets hit by a *credit-crunch* shock. In models which are very similar to the one discussed in this paper, Dedola-Lombardo (2010), Cantore-Maurin (2008) and Freystatter (2010) obtain a positive response of consumption following an adverse risk premium shock that makes output, hours worked, investment, inflation and equity prices all fall on impact. In Merola (2010) and in Dib et al. (2008) the response of consumption to the recessionary risk premium shock is not reported.

In contemporaneous work, Gilchrist and Zakrajšek (2010) provide VAR type of evidence on the recessionary response of consumption, together with all the main other macro-economic aggregates, to an orthogonal financial (bank) bond premium shock estimated using observable secondary market prices of bonds issued by U.S. financial institutions. The financial bond shock is interpreted by the authors as an exogenous variation in the risk attitude of financial intermediaries such as the ones that typically precede sudden shifts in the cost of credit to households and firms, i.e. credit-crunch events. Calibrated to match the VAR-estimated impulse-responses, a DSGE model embedding the financial accelerator mechanism fully accounts for the dynamics of the U.S. economy during the 2007-2009 downturn.[1]

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[1] In similar recent work Christiano et al. (**?**) and Gilchrist et al. (2009) show that allowing for unobservable

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The DSGE model in Gilchrist and Zakrajšek (2010) features a large array of frictions and rigidities in the spirit of Christiano et al. (2005) and Smet and Wouters (2007); according to the authors the mildly recessionary (pro-cyclical) response of consumption to the risk premium shock is guaranteed in the model by combining non-separable households' preferences with habit in consumption.

We introduce a risk premium shock in a basic New-Keynesian version of the BGG financial accelerator model, only featuring Calvo (1983) nominal rigidities and quadratic capital adjustment costs, and investigate the conditions under which a pro-cyclical response of consumption can be obtained in such a basic framework. Following the interpretation of the financial shock given in Christiano et al. (?) as a shock to the demand of capital, the present work contributes to bridging the credit crunch literature to the type of analysis on consumption comovement and investment-specific shocks developed, among others, in Justiniano et al. (2010) and Furlanetto and Seneca (2010).

We find that the preferences introduced by Greenwood et al. (1988) (hereafter GHH preferences) generate the comovement of consumption, with output hours worked investment and equity prices, when combined with Calvo-type nominal rigidities. The latter turn out to be an essential device. A minimum degree of price stickiness, equal to three quarters in the benchmark calibration, and non-seprable preferences of the GHH type are sufficient for obtaining consumption comovement following a risk premium shock. In addition we find that complementarity between consumption and hours worked, that reach a maximum degree in the GHH preferences as illustrated in Monacelli and Perotti (2008), is the feature driving the result of consumption comovement. The lack of wealth effects on labor supply, the feature for which GHH preferences have recently found wide-spread use in DSGE modelling, does not play a significant role.

2.2 The model

The model is a version of the Bernanke et al. (1998) financial accelerator, as simplified in Dib and Christensen (2008). The only rigidities at work are: nominal price stickiness, capital adjustment costs and the financial friction embedded in the accelerator mechanism.

There are six types of agents in the model: households, entrepreneurs, capital producers, monopolistically competitive retailers, a monetary policy authority and a financial intermediary. Entrepreneurs produce wholesale goods by means of a standard Cobb-Douglas technology. They borrow from the financial intermediary that converts households' deposits

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shocks to the efficiency of credit itermediation process can account for a sunstantial fraction of the variability in investment and output in U.S. historical data.

into loans for new capital goods purchasing. Capital producers produce new capital, using consumable goods and non-depreciated old capital, and are subject to quadratic capital adjustment costs. Retailers buy non-differentiated wholesale goods from entrepreneurs, at their marginal cost, and differentiate them into different varieties that are sold on a monopolistically competitive market. The monetary authority sets nominal interest rates following a standard Taylor feedback rule. The financial intermediary is at the heart of the BGG financial accelerator mechanism: being unable to observe entrepreneurial outcomes, she has to devote resources for monitoring borrowers and, consequently, charges borrowers with a finance premium which is an increasing function of entrepreneurial leverage. The risk premium is modelled here in a reduced form[2] and its exogenous component follows an autoregressive process.

2.2.1 Wholesale goods producers (entrepreneurs)

Entrepreneurs produce non-differentiated wholesale goods, using a standard Cobb-Douglas production technology, which are sold on a competitive market to retailers at a price equal to the marginal cost. Labor and Capital to be employed in production are chosen according to the following cost minimization problem:

$$min_{H_t,K_t} \qquad w_t L_t + z_t K_t \tag{2.1}$$

$$\text{s.t.} Y_t = L_t^{(1-\alpha)} K_t^{\alpha}$$

The first order conditions are:

$$w_t = (1-\alpha) mc_t \frac{Y_t}{H_t} \tag{2.2}$$

$$z_t = \alpha \cdot mc_t \frac{Y_t}{K_t} \tag{2.3}$$

The resulting expression for the real marginal cost is:

$$mc_t = \frac{w_t^{(1-\alpha)} z_t^{(\alpha)}}{\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}} \tag{2.4}$$

---

[2]The microfoundations of the BGG risk premium can be found in , for example, in Bernanke et al. (1999), Gilchrist et al. (2003), Meier-Mueller (2008) and Christiano et al. (2009).

Entrepreneurs are risk-neutral agents and have a finite planning horizon: with probability v_t they survive period t and hence remain in business. The resulting expected survival period is given by $1/(1 - v_t)$. The assumption of the finite planning horizon is necessary to make sure that entrepreneurial own wealth, accumulated through time, is never enough to fully finance the purchases of capital K_{t+1} for next period production. For this reason capital purchased in period t at price Q_t has to be financed by both wealth N_{t+1} and bank loans D_t, as follows:

$$Q_t K_{t+1} - N_{t+1} = D_t \tag{2.5}$$

Entrepreneurial wealth N_{t+1} is the end-of-period equity of the business, i.e. the realized value of the capital investment net of the costs of debt repayment to the bank. At the end of each period t entrepreneurs have to sell the unused capital to capital producers and repay the debt to the financial intermediary.

The BGG financial friction is microfounded using an asymmetry of information type of argument in the one-period contract between the borrower (entrepreneur) and the lender (bank). When purchasing capital for production the entrepreneur is hit by an idiosyncratic shock (risk) whose realization is unobservable to the lender. To cope with the misreporting incentives that arise in the borrower's behavior, the financial intermediary has to implement a costly monitoring activity and consequently charges a risk premium over the riskless cost of funds, the latter being the interest rate that households receive on their bank deposits. As shown in detail in Bernanke et al. (1998) and in Gilchrist et al. (2003), the optimal financial contract entails an endogenous risk premium which is an increasing function of the leverage ratio $(\frac{Q_t K_{t+1}}{N_{t+1}})$ featured by the borrower's business project, i.e.:

$$E_t R_{t+1}^K = E_t \frac{R_t^D \cdot rp(\frac{Q_t K_{t+1}}{N_{t+1}})}{\pi_{t+1}}. \tag{2.6}$$

The expected cost $E_t R_{t+1}^K$ of bank loans, for the entrepreneur, equals the riskless return on bank deposits requested by households augmented by a gross premium $rp(\frac{Q_t K_{t+1}}{N_{t+1}})$ which is assumed to have the following properties:

$$rp(\frac{Q_t K_{t+1}}{N_{t+1}}) : rp'(.) > 0 \text{ and } rp(1) = 1. \tag{2.7}$$

Intuitively the risk premium charged, because of moral-hazard concerns, is higher the lower (higher) the entrepreneur's stake in the project (the leverage of the project) and is absent when the capital investment project is fully financed by entrepreneurial wealth, i.e. when the leverage ratio is unity[3].

When deciding about the amount of capital K_{t+1} to be purchased for next period production the entrepreneur has to target an expected return on the investment which covers the expected costs of bank funds. The former is an increasing function of the expected marginal productivity of capital (z_{t+1}) and the expected resale price of the non depreciated capital, as follows:

$$E_t R_{t+1}^K = E_t \left[\frac{z_{t+1} + (1-\delta)q_{t+1}}{q_t} \right]. \tag{2.8}$$

The condition determining the optimal demand for K_{t+1} equalizes expected return and expected borrowing costs as follows:

$$E_t \left[\frac{z_{t+1} + (1-\delta)q_{t+1}}{q_t} \right] = E_t \frac{R_t^D \cdot rp(\frac{Q_t K_{t+1}}{N_{t+1}})}{\pi_{t+1}}. \tag{2.9}$$

Entrepreneurial net-wealth, in aggregate terms, evolves according to a firm equity component V_t and a transfer component G_t :

$$N_{t+1} = v_t V_t + (1 - v_t)G_t \tag{2.10}$$

The former is given by the realized value of the return on the purchase of capital, net of the debt repayment contracted upon in period $(t-1)$:

$$V_t = R_t^K Q_{t-1}K_t - E_{t-1}(R_t^K)(Q_{t-1}K_t - N_t) \tag{2.11}$$

The transfer component G_t represents seeds money that the fraction $(1 - v_t)$ of exiting entrepreneurs leave to newly entering entrepreneurs. The number of exiting entrepreneurs is always balanced by the number of start-ups; this, combined with the fact that exiting entrepreneurs have larger accumulated wealth than start-ups, ensures that a larger exiting fraction is reflected in a lower value of aggregate entrepreneurial wealth.

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[3]The latter scenario corresponds to a fully internally financed operation which, due to the previsouly mentioned finite planning horizon assumption, is never occurring at equilibrium. In other words, the BGG framework is such that entrepreneurs always need external finance and, consequently, always pay a cost of funds higher than the riskless rate on bank deposits.

2.2.2 Capital Producers

Capital producers use final goods, purchased from retailers combined with undepreciated (old) capital, to produce new capital goods that add to the capital stock. Producing and selling an amount $Q_t I_t$ of capital goods implies bearing the cost of I_t units of goods augmented with a quadratic capital adjustment cost, according to the following profit maximization problem:

$$\max_{I_t} E_t \left[Q_t I_t - I_t - \frac{\chi}{2} (\frac{I_t}{K_t} - \delta)^2 K_t \right] \tag{2.12}$$

The optimal choice of investment, which defines a standard Tobin's Q relation, is:

$$E_t \left[Q_t - 1 - \chi(\frac{I_t}{K_t} - \delta) \right] = 0 \tag{2.13}$$

Aggregate capital evolves according to a standard law of motion:

$$K_{t+1} = I_t + (1 - \delta)K_t \tag{2.14}$$

2.2.3 Retailers

Retailers purchase wholesale goods from entrepreneurs, at their marginal costs, differentiate them, and sell them on a monopolistically competitive market.

The price stickiness assumed here is of the Calvo (1983) type: with probability θ_p the firm does not receive the signal allowing her to optimally reset the price[4]. When she gets the chance to reoptimize prices the firm chooses the optimal price $p_t^*(h)$ by solving the following profit maximization problem:

$$\max_{p_t^*(h)} E_t \left[\sum_{k=0}^{\infty} (\beta \phi_p)^{t+k} \lambda_{t+k} \Phi_{t+k}(h) \right] \tag{2.15}$$

where the nominal profit function is:

$$\Phi_t(h) = [p_t^*(h) - MC_t(h)] Y_t(h) \tag{2.16}$$

and the demand function is :

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[4]The resulting price duration is given by: $\dfrac{1}{1 - \theta_p}$

$$Y_t(h) = \int \left(\frac{p_t^*(h)}{P_t} \right)^{-\theta_p} Y_t = \int \left(\frac{p_t^*(h)}{P_t} \right)^{-\theta_p} (C_t + I_t) \tag{2.17}$$

The first order condition of this problem is:

$$P_t^*(f) = \frac{\theta_p}{\theta_p - 1} \frac{E_t \displaystyle\sum_{k=0}^{\infty} (\beta\phi_p)^k \lambda_{t+k} MC_{t+k}(h) D_{t+k}(h)}{E_t \displaystyle\sum_{k=0}^{\infty} (\beta\phi_p)^{t+k} \lambda_{t+k} D_{t+k}(h)} \tag{2.18}$$

The price stickiness of the Calvo type is such that the final product price evolves according to:

$$P_t^{1-\theta_p} = \phi_p (\pi P_{t-1})^{1-\theta_p} + (1 - \phi_p) P_t^{*1-\theta_p}. \tag{2.19}$$

Combining the log-linear expressions for the optimal price and the evolution of aggregate prices yields the well known New-Keynesian Phillips curve, expressing present inflation as a function of current real marginal cost and expected inflation:

$$\pi_t = \beta\pi_{t+1} + \frac{(1 - \beta\theta_p)(1 - \theta_p)}{\theta_p} mc_t. \tag{2.20}$$

2.2.4 Households

The representative household chooses sequences for consumption, hours worked, and bank deposits $\{C_t, H_t, D_t\}_{t=0}^{\infty}$ in order to maximize her expected life-time utility function:

$$U_0 = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(C_t, H_t) \right\} \tag{2.21}$$

subject to the sequence of budget constraints (in real consumables terms):

$$C_t + \frac{D_t}{P_t} \le \frac{W_t}{P_t} H_t + \frac{RR_{t-1}}{\pi_t} D_{t-1} + \frac{T_t}{P_t} + \frac{\Omega_t}{P_t} \tag{2.22}$$

where C_t is consumption of final good, D_t is nominal deposit bearing gross nominal riskless interest rate R_t, T_t are nominal lump sum transfers/taxes from the Government and Ω_t are nominal monopolistic profits derived from households' ownership of intermediate goods producing firms.

We adopt two specifications of the instantaneous utility function. Our baseline is the GHH polar case of the non-separable preferences introduced by Jaimovich and Rebelo (2009):

$$U(C_t, H_t) = \frac{\left(C_t - \chi H_t^{(1+\sigma_L)} X_t\right)^{(1-\sigma)}}{(1-\sigma)}$$

where: $X_t = C_t^\omega X_{t-1}^{(1-\omega)}$

This family of preferences is such that when $\omega = 1$ one obtains the preferences introduced by King, Plosser and Rebelo ((**?**)), and when instead $\omega = 0$ one obtains the preferences suggested by Greenwood et al. (1988).

Our standard log-separable preferences specification is the polar case of the family of separable preferences itroduced by Gali (2010):

$$U(C_t, H_t) = \Theta_t \log C_t - \chi \frac{N_t^{(1+\sigma_L)}}{1 + \sigma_L} \tag{2.23}$$

with $\Theta_t = C_t / X_t$ and $X_t = C_t^\omega X_{t-1}^{(1-\omega)}$

For $\omega = 1$ $X_t = C_t$ and preferences are equivalent to the standard log-separable preferences employed, for instance, in Smets and Wouters (2007).For $\omega = 0$ X_t is a constant term and preferences are such that consumption and hours are separable but consumption does not appear in the expression of the household's marginal rate of substitution, i.e. there isn't any wealth effect on the supply of labor.

The first order conditions of the problem, for both family of preferences, are reported in Appendix 3.

Households have monopolistic power in the labor market and therefore set their own wages. A continuum of different labor types indexed by $j \in [0,1]$ is assumed to exist; labor employed by firm i is assumed to be an index given by:

$$H_t(i) \equiv \left[\int_0^1 H_t(i,j)^{\frac{\theta_w-1}{\theta_w}}\right]^{\frac{\theta_w}{\theta_w-1}}$$

where θ_w is a parameter denoting the substitution elasticity among labor varieties.

Let $W_t(j)$ denote the nominal wage set by households for $j - type$ of labor, for all $j \in [0,1]$. Optimal demand for $j - type$ of labor, aggregating the cost minimization result of each and every firm i, is given by:

$$H_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\theta_w} H_t \tag{2.24}$$

for all $j \in [0,1]$.

$H_t = \int_0^1 H_t(i)$ represents total hours worked, across firms, in the economy, while W_t is an aggregate nominal wage index given by:

$$W_t \equiv \left[\int_0^1 W_t(j)^{1-\theta_w}\right]^{\frac{1}{1-\theta_w}} \tag{2.25}$$

Nominal wages are sticky a-la Calvo (1983), in that a fraction ϕ_w of households is not allowed to optimally reset her own wage in each period t. The resulting average duration of wage contracts, in such a framework, is notably given by $1/(1 - \phi_w)$.

When setting her own optimal wage W_t^* household j maximizes 2.21 subject to both the budget constraint 2.22 and the optimal demand 2.24 for her own variety of labor service. The FOC are given by:

$$\sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ H_{t+k}(j) \left[\frac{W_t^*}{P_{t+k}} MU_{C,t+k} + \mu_w MU_{H,t+k}(j) \right] \right\} = 0 \tag{2.26}$$

where MU_C and MU_H are the marginal utility of consumption and hours respectively and where $\mu_w = \frac{\theta_w}{\theta_w - 1}$ is the desired (steady-state) markup of the real wage. 2.26 can be rewritten as:

$$\sum_{k=0}^{\infty} (\beta\phi_w)^k E_t \left\{ H_{t+k}(j) MU_{C,t+k} \left(\frac{W_t^*}{P_{t+k}} - \mu_w MRS_{t+k} \right) \right\} = 0 \tag{2.27}$$

where $MRS_{t+k} \equiv -\frac{MU_{H,t+k}}{MU_{C,t+k}}$ is the marginal rate of substitution between hours worked and consumption. As can be inferred by looking at 2.27, when households are fully free to optimally reset their wages in each period t, i.e. when $\phi_w = 0$, they do so by setting:

$$\frac{W_t^*}{P_t} = \frac{W_t}{P_t} = \mu_w MRS_t \tag{2.28}$$

For this reason the constant wage markup μ_w is usually defined a "desired" wage markup in the economy. By combining a log-linear version of 2.27 with an expression for the Calvo-

type evolution of wages[5] one obtains the commonly used log-liner New Keynesian Phillips curve for wage inflation:

$$\pi_t^w = \beta \pi_{t+1}^w - \kappa_w \mu_w \tag{2.29}$$

where $\kappa_w \equiv \frac{(1-\phi_w)(1-\beta\phi_w)}{\phi_w(1+\theta_w\sigma_L)}$.

2.2.5 Equilibrium

The economy's resource constraint is:

$$Y_t = C_t + I_t \tag{2.30}$$

Notice that, as in most of the BGG-related literature, the above constraint disregards the amount of (lost) resources devoted to the payment of monitoring costs.

2.2.6 Monetary policy

The benchmark Taylor Rule is a feedback rule responding to deviations of the gross nominal inflation rate from its steady-state value and allowing for some degree of inertia.

$$\frac{R_t}{R} = (\frac{\pi_t}{\pi})^{\rho_\pi(1-\rho_R)}(\frac{R_{t-1}}{R})^{\rho_R} \tag{2.31}$$

2.2.7 Risk premium shock

Since the introduction of the Bernanke et al. (1998) financial accelerator framework, several papers have introduced, within the common setting, autoregressive shocks aimed at representing exogenous sources of disturbance directly linked to the functioning of the financial (intermediation) markets.

After the 2007-2008 world financial crisis, in particular, several papers have examined the macroeconomic impact of *credit crunch* shock. The paralysis of the money markets and inter-bank markets, that occurred in the summer of 2007 and in the fall of 2008, manifested itself primarily as a jump in the spread to unusually high levels, reflecting banks' perceptions of risk and liquidity conditions. The resulting collapse of funding opportunities, for banks, translated into a severe worsening of both price and quantity conditions of bank credit supply to households and firms.

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[5]Given the probabilistic structure of the Calvo wage rigidity mechanism aggregate wage indeax in the economy, in each period t, evolves according to: $W_t = \left[\phi_w W_{t-1}^{(1-\theta_w)} + (1-\phi_w)W_t^{*(1-\theta_w)}\right]^{\frac{1}{1-\theta_w}}$

The risk premium shock (erp_t) is assumed to enter the log-linear version of 2.9 as follows[6]:

$$rp_t = \Psi(k_{t+1} + q_t - n_{t+1}) + erp_t \tag{2.32}$$

In 2.32 parameter Ψ is the elasticity of the endogenous external finance premium to deviations from steady-state of the firm's leverage ratio. The credit supply shock follows an AR(1) process as follows:

$$erp_t = \rho_{erp} erp_{t-1} + \epsilon_{erp,t} \tag{2.33}$$

A shock to the risk premium acts as a shifter on the demand for new capital and can in this respect be interpreted as a form of investment-specific shock. In particular, a sudden rise in erp_t makes the funds necessary for purchasing K_{t+1} more costly and hence impact on condition 2.9: a higher expected cost of funds is such that only entrepreneurial projects with a sufficiently higher expected returns on capital will be actually implemented by entrepreneurs. The suddenly higher share of profits that entrepreneurs have to devote to debt repayment implies a fall in the demand for capital and, consequently, a fall in investment and in the relative price Q_t of investment goods.

2.2.8 Calibration

The model is calibrated quarterly, log-linearised around its non-stochastic steady-state, and solved numerically. In appendices A and B the steady-state and log-linear conditions are reported, respectively.

The households' time discount factor is set to 0.9928, so as to have an annual real interest rate of approximately 3%. The depreciation rate of physical capital δ is set to 0.025 and the capital share in production α is set to 0.35, as standard in the literature. In the benchmark version of the model utility is logarithmic ($\sigma_C = 1$). Desired mark-ups are set to 20%, as standard in New-Keynesian literature, by fixing the market power parameter θ_p to 6. Hours worked at steady-state are set to 1/3 by calibrating the utility weight parameter $\varkappa$.

The sticky prices version of the model assumes that the Calvo parameter ϕ_p equals 0.75, so as to have an approximate duration of price contracts of 4 quarters. A duration of 4 quarters is also assumed in the sticky wages version of the model, where $\phi_w = 0.75$. The parameter χ ruling capital adjustment costs is set to 0.5. The inverse elasticity of labor supply σ_L is set to 1, implying a benchmark elasticity of labor supply equal to unity.

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[6]See also Cantore and Maurin (2008) and Freystatter (2010).

As far as the financial accelerator parameters are concerned, the steady-state survival rate of entrepreneurs v is set to 0.9728, the leverage ratio k/n is set to 2 and the steady-state gross external finance risk premium is set to 1.0025, corresponding to an annual spread of 200 basis points. The latter are values taken from BGG **??**. The elasticity of the risk premium to leverage Ψ is set to 0.04, as estimated in Gilchrist and Zakrajšek **??** .

Monetary policy response to inflation ρ_π is calibrated to 1.5, a common value in the literature, and features no inertia ($\rho_R = 0$) in its benchmark calibration.

The benchmark $^{(*)}$ persistence ρ_{e_rp} of the external finance risk premium shock is set to 0.75, as found in Gilchrist et al. (2009)

parameter	flex	sticky
β : time discount	0.9928	-
α : K share	0.35	-
δ : K depreciation rate	.025	-
θ_p, θ_w : price elasticity of demand	6	-
σ_C : risk aversion	2	-
σ_L : inv. elasticity labor supply	1	-
χ : K adjustment costs	0.5	-
ϕ_p : Calvo price stickiness	0.0001	$0; 0.68; 0.75^{(*)}; 0.9$
v : entrepreneur survival prob	0.9728	-
Ψ : elasticity premium to leverage	0.04	-
k/n : firms leverage ratio	2	-
ρ_R : Taylor rule inertia	$0^{(*)}; 0.4; 0.8$	-
ρ_π : Taylor rule on inflation	1.5	-
ρ_{e_rp} : risk premium persistence	$0; 0.4^{(*)}; 0.8$	-

2.3 The response of consumption

2.3.1 Flexible prices

The flexible prices and wages scenario sheds light on the transmission of the shock discussed here as well as on the specific features of GHH preferences. We discuss the impact of the risk premium shock by focusing on the labor market. When prices and wages are flexible the labor market equilibrium, under standard separable and GHH preferences respectively, requires that:

$$MPL_t \left(\underset{(-)}{H_t} \right) = \mu_P MRS_t \left(\underset{(+)}{C_t}, \underset{(-)}{H_t} \right) : STD\ SEP \tag{2.34}$$

$$MPL_t \left(\underset{(-)}{H_t} \right) = \mu_P MRS_t \left(\underset{(-)}{H_t} \right) : GHH \tag{2.35}$$

The mark-up (μ_P) drives a wedge between the marginal product of labor and the marginal rate of substitution between consumption and leisure.

Figure 2.1 shows impulse-response functions generated by a one standard deviation adverse (increase) shock in the risk premium for external finance. The behavior, on impact, of hours output and wages differ substantially across preferences specification, highlighting the role played by the different labor market equilibrium conditions.

The sudden increase in the cost of external finance discourages investment by increasing the effective price of new capital for entrepreneurs. The demand for capital goods falls, dragging the price of capital (Q) down. The falling return on investment, reinforced by falling capital price, leads households to shift resources away from bank deposits (i.e. investment) towards consumption.

Under standard separable preferences, as can be seen from condition 2.34, the rise in consumption causes a leftward shift in the labor supply curve which is in turn responsible for the fall in hours worked, along with falling output and an impact increase in real wage. Under GHH preferences there is no wealth effect on the labor supply. Hours worked do not move on impact since no shift of the labor supply schedule occurs. Output and real wages are consequently unchanged in the period of the shock. Only as the capital stock starts falling, as a consequence of falling investment, does the marginal productivity of labor gets negatively affected causing hours worked and output to fall. In a scenario of prices and wages flexibility, consumption is even less procyclical under GHH preferences, than under standard separable ones, because the inter-temporal allocation mechanism is not at all counteracted by negative wealth effects on labor supply.

2.3.2 Sticky prices

Having outlined the different dynamics generated by the two different class of preferences in a simple flexible prices economy, we now introduce sticky prices according to the probabilistic framework first introduced by Calvo (1983). As discussed in Justiniano et al. (2010)

and Furlanetto-Seneca (2010) the introduction of sticky prices modifies the labor market equilibrium conditions by introducing a time-varying price markup term $(\mu_{P,t})$, as follows:

$$MPL_t\left(\underset{(-)}{H_t}\right) = \mu_{P,t}MRS_t\left(\underset{(+)}{C_t},\underset{(-)}{H_t}\right) : STD\ SEP \tag{2.36}$$

$$MPL_t\left(\underset{(-)}{H_t}\right) = \mu_{P,t}MRS_t\left(\underset{(-)}{H_t}\right) : GHH \tag{2.37}$$

Figure 2.2 shows impulse-response functions generated by a one standard deviation adverse (increase) shock in the risk premium in an economy with sticky prices. As soon as the risk premium shock hits the economy, demand for new capital and for investment fall. The fall in demand for goods implies a leftward shift in the labor demand of those retailers who cannot reoptimize the price of their product and therefore have to meet the new lower demand by decreasing production.

Under both types of preferences a fall in the real marginal cost, which drives inflation down, stands for a rise in the price markup. As the labor demand schedule shifts leftward, because of price stickiness, hours worked fall along the labor supply schedule and the real wage falls.

Under standard separable preferences the fall in the real wage is smaller than under GHH preferences. As already mentioned GHH preferences do not generate any shift in the labor supply schedule when the inter-temporal allocation of consumption changes: for a given leftward shift in the labor demand curve wages fall by more.

Notice that standard separable preferences are such that consumption and hours worked are substitutes: the leftward shift in labor demand due to price stickiness does not guarantee impact comovement of consumption. Under GHH preferences, instead, consumption and hours worked are complements: with falling hours worked along the labor supply schedule, marginal utility of consumption falls (marginal utility of consumption is increasing in hours worked). For the equilibrium to be restored consumption has to fall.

Figure 2.3 suggests that for consumption to comove along with other macro variables, a minimum degree of nominal price stickiness is necessary. A calibration of the Calvo price stickiness parameter corresponding to an average price contract duration shorter than three quarters, does not generate consumption comovement as instead is the case for the benchmark duration of four quarters as well for any duration longer than benchmark. Figure 2.4 shows that even implausibly high levels of price stickiness cannot guarantee consumption comovement if GHH preferences are replaced with standard separable ones.

2.3.3 Adding wage stickiness

Nominal wage stickiness of the Calvo-type, as the only nominal rigidity in the economy, is able to generate consumption comovement when households' preferences feature consumption/hours complementarity, as is the case under GHH specification. When nominal wages are sufficiently sticky (i.e. $\phi_w = 0.75$), as can be seen in Figure 2.5, a leftward shift in the labor supply schedule implies falling hours worked and increasing equilibrium real wages on impact: GHH preferences, alike standard separable preferences, engineer comovement of consumption. Introducing wage stickiness, in a framework of sticky prices and standard separable preferences (simulations are not reported here) sheds light on the role of wage mark-up in dampening, without though reverting, the impact rise of consumption, following the risk premium shock. Labor market condition (??) features a wedge term μ_t which no longer varies only as a function of the price mark-up but represents the combined effect of equilibrium price and wage mark-ups in the economy. As long as the wage mark-up is countercyclical in the economy, i.e. it increases when output and hours worked fall, wage stickiness weakens the tight relationship between consumption and hours which prevents comovement in the absence of GHH preferences. Notice also that when both prices and nominal wages are sticky real wage is less volatile. As such, it implies less volatile real marginal costs, less volatile inflation rate and therefore translates into a less expansionary monetary policy. The latter contributes to dampening the impact rise in consumption.

2.3.4 Complementarity vs. wealth effects

In the previous paragraphs we have shown that GHH preferences are able to generate consumption comovement, following an external finance premium shock, in a model economy where the only rigidities are monopolistic competition and nominal price (and/or wage) stickiness.

Discussing the transmission of the risk premium shock, we have also highlighted the two most relevant features of GHH preferences, namely the absence of a wealth effect on labor supply and the complementarity of consumption and hours worked.

To assess which of the two features is a necessary condition for consumption to comove after a risk premium shock one can consider again the Gali (2010) family of households' preferences represented by specification (2.23) above, which combine separability (i.e. non-complementarity) between consumption and hours with a parameterized wealth effect on labor supply.

Figure 2.6 shows the impulse-response functions generated by a one standard deviation

adverse (increase) shock in the risk premium in an economy with sticky prices and wages. The response of consumption under Gali (2010) separable preferences with no zero wealth effect on labor supply shows that separability rather than the absence of wealth effects on labor supply is the mechanism preventing comovement of consumption following credit crunch types of shocks. The behavior of consumption under standard separable preferences and under Gali preferences with no wealth effect on labor supply shows that the latter feature actually acts against consumption comovement.

2.3.5 Robustness

We found nominal rigidities and consumption/hours complementarity in households' preferences to be two sufficient conditions for consumption to comove with other key macroeconomic variables following an adverse risk premium shock. This section explores the sensitivity of that result to changes in the values assigned to some crucial parameters in the model.

Figure 2.7 and Figure 2.8 show that the procyclicality of consumption is undermined by very low values of the inter-temporal elasticity of substitution parameter σ_C, and by implausibly large values of the monetary policy response to inflation's deviations from steady-state ($\rho_\pi = 3$). Parameter σ_C directly affects the degree of complementarity between consumption and hours worked in households' preferences, while the Central Bank's aggressiveness in targeting inflation is responsible for dampening the countercyclicality of price (and wage) markups and hence the real effects of nominal rigidities.

Our benchmark calibration of inertia in the monetary policy rule ($\rho_\pi = 0.4$) approaches the lower bound of generally accepted empirical estimates, and it is chosen for illustrative purposes. The absence of inertia in monetary policy, indirectly acting as increased aggressiveness in inflation targeting, mutes the result of consumption procyclicality, without though reverting it. Higher values of the inertia parameter, closer to most of empirical estimates, reinforce the co-movement result (see Figure 2.9). The consumption comovement result can be obtained as well when adopting a more realistic Taylor-type monetary policy rule, which responds with a pretty large degree of inertia to both inflation and output's deviations, with $\rho_\pi = 1.25$ $\rho_r = 0.7$ and $\rho_y = 0.26$, as estimated in Gali and Rabanal ((2005)) (see Figure 2.10).

Unreported simulations show that values of the inter-temporal elasticity of labor supply well below the ones usually adopted in macroeconomic models can undo the procyclical response of consumption. A very flat labour supply curve reduces in fact the equilibrium

variations in hours worked for a given shift of the labour demand schedule. The persistence of the risk premium shock does not impact materially on procyclicality of consumption.

2.4 Conclusions

This paper embeds an external finance premium shock in a traditional financial accelerator framework and discusses a few conditions under which comovement of consumption can be obtained. In particular, a pretty standard New-Keynesian framework only featuring capital adjustment costs and calvo nominal stickiness, in either prices or wages, is able to generate comovement of consumption when GHH type of households' preferences are introduced.

The latter differ from standard separable preferences in two respects: i) consumption and hours worked are complements (non-separable) to a maximum extent (see Monacelli-Perotti (2008)); ii) the labor supply choice is not affected by the level of wealth, i.e. there are no wealth effects on labor supply. Complementarity turns out to be the necessary mechanism to obtain comovement of consumption along the recessionary financial shock. This is shown by simulating the model under a family of separable preferences, introduced in Gali (2010), allowing for the parameterization of the wealth effect on labor supply. When the latter is switched off, in the presence of separability between consumption and hours, consumption comovement cannot be obtained.

A minimum degree of price or wage stickiness is required for consumption to comove following a risk premium shock: in the benchmark calibration no price contract duration shorter than three quarters is able to deliver consumption comovement. The result is robust to the degree of inertia of the monetary policy (Taylor) rule and to the degree of persistence of the risk premium shock.

As it is the case of the investment-specific shock, documented in Furlanetto-Seneca (2010), the large degree of complementarity of GHH preferences, combined with nominal stickiness, generates consumption comovement in absence of any additional model rigidities, such has habit formation and variable capital utilization.

This result contributes to reconciling the renewed interest in credit crunch (financial) type of shocks with empirical evidence on the dynamics of U.S. consumption following an external finance risk premium shock, as documented in Gilchrist et al. (2009), and on the behavior of U.S. consumption during the recent financial turmoil, analyzed in Lee et al. (2010).

The present analysis adds to the work already done on the issue of consumption comovement following investment-specific shocks and government spending shocks, respectively in Furlanetto-Seneca (2010) and Monacelli-Perotti (2008), thus enriching the explanatory potential of standard New-Keynesian DSGE models extended with non-separable preferences.
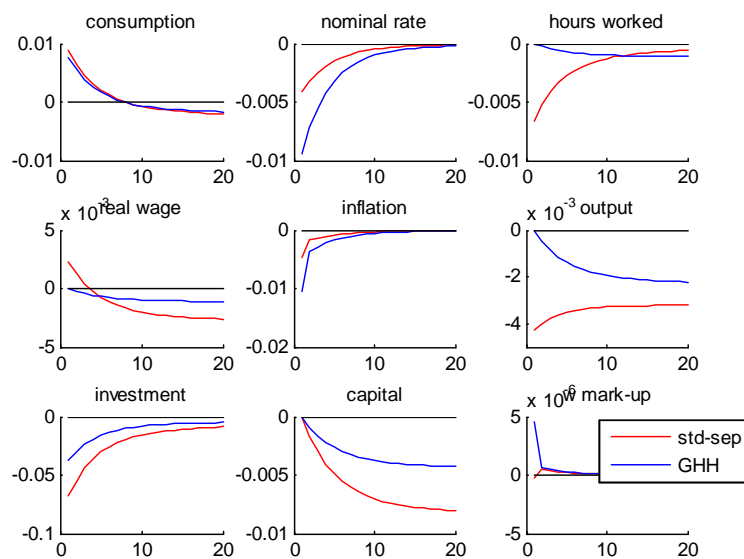
2.5 Figures

Figure 2.1: IRF's one standard deviation adverse shock to the risk premium. Flexible Prices, separable (solid) vs. GHH (dashed) preferences.
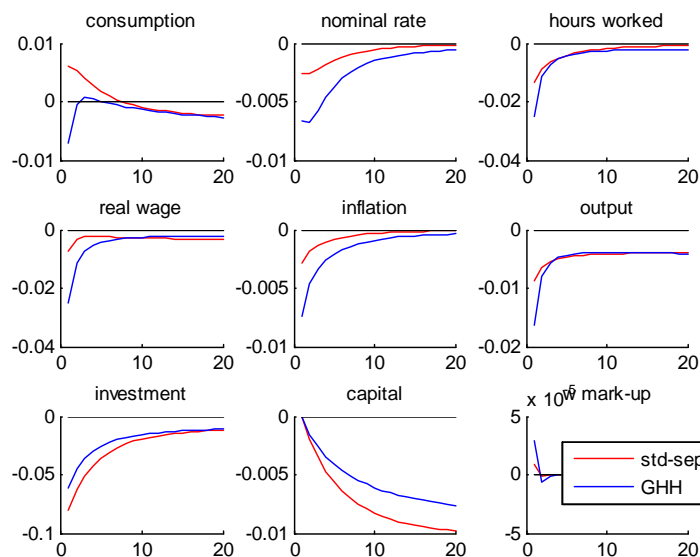

Figure 2.2: IRF's one standard deviation adverse shock to the risk premium. Sticky Prices, separable (solid) vs. GHH (dashed) preferences.
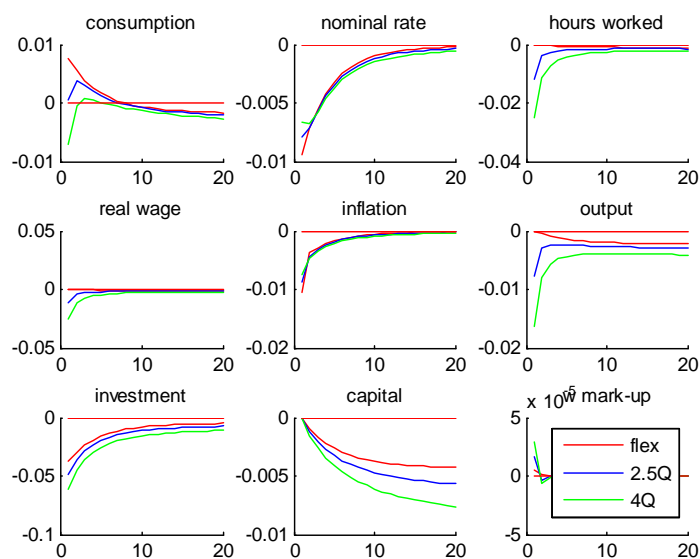
Figure 2.3: IRF's one standard deviation adverse shock to the risk premium. GHH preferences. Different degrees of price stickiness.
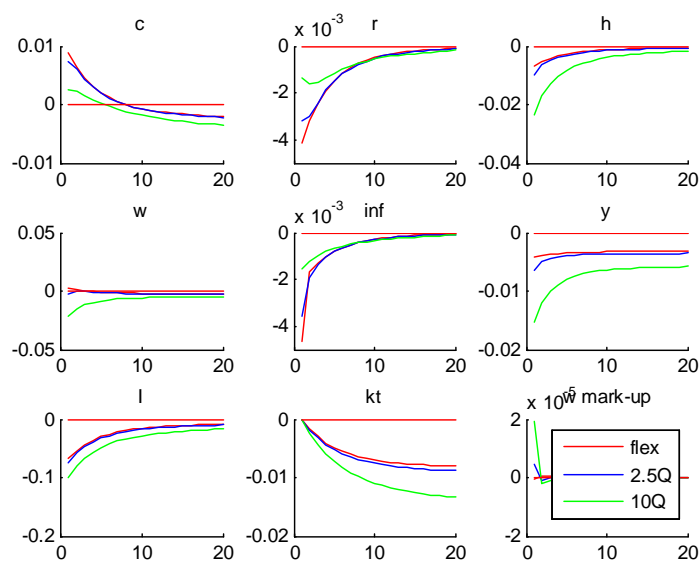

Figure 2.4: IRF's one standard deviation adverse shock to the risk premium. Standard Separable Preferences, different degrees of wage stickiness
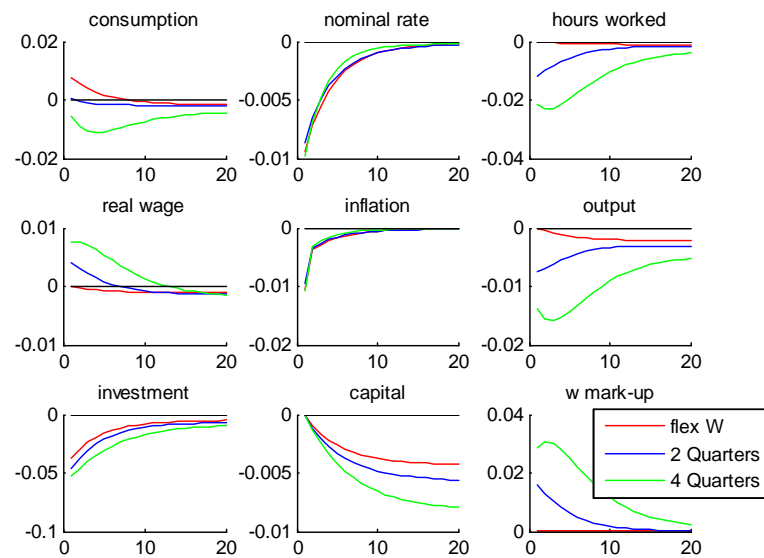
Figure 2.5: IRF's one standard deviation adverse shock to the risk premium. GHH preferences, different degrees of wage stickiness.
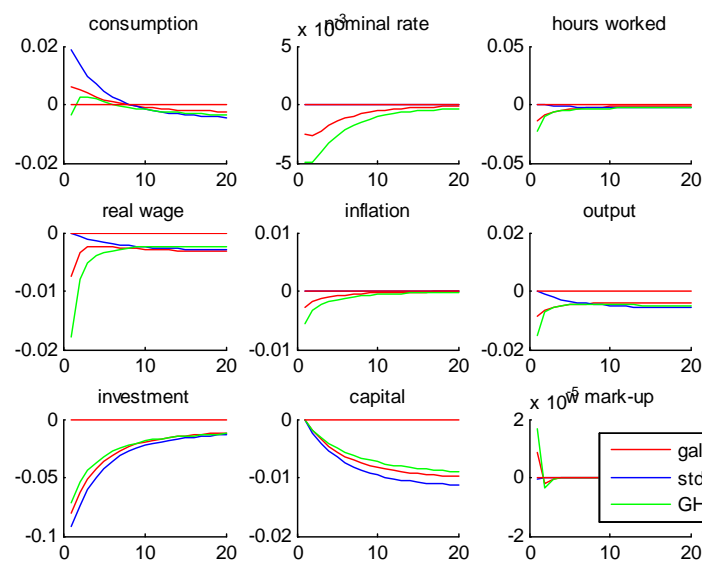

Figure 2.6: IRF's one standard deviation adverse shock to the risk premium. Sticky Prices, Complementarity Vs. Zero Wealth Effect
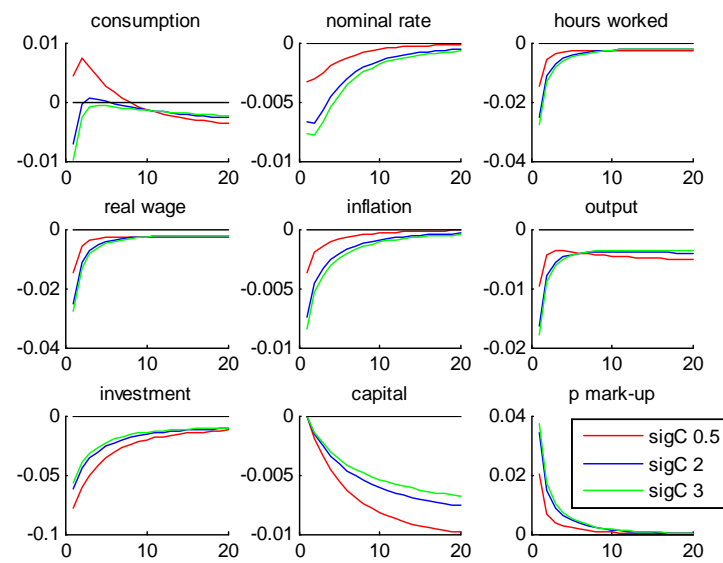
Figure 2.7: IRF's one standard deviation adverse shock to the risk premium. GHH preferences, different degrees of complementarity.

Figure 2.8: Sensitivity of consumption comovement to different degrees of inflation targeting

Figure 2.9: Sensitivity of consumption comovement to different degrees of monetary policy inertia

Figure 2.10: Risk Premium shock with GHH preferences and an estimated monetary policy rule for the US, as in Gali and Rabanal (2005) ($\rho_\pi = 1.25$, $\rho_y = 0.26$ and $\rho_r = 0.7$).

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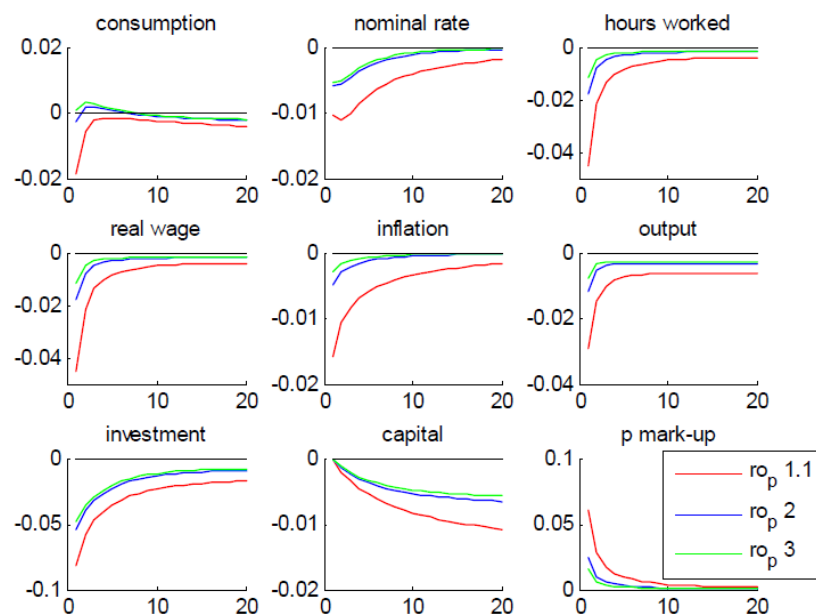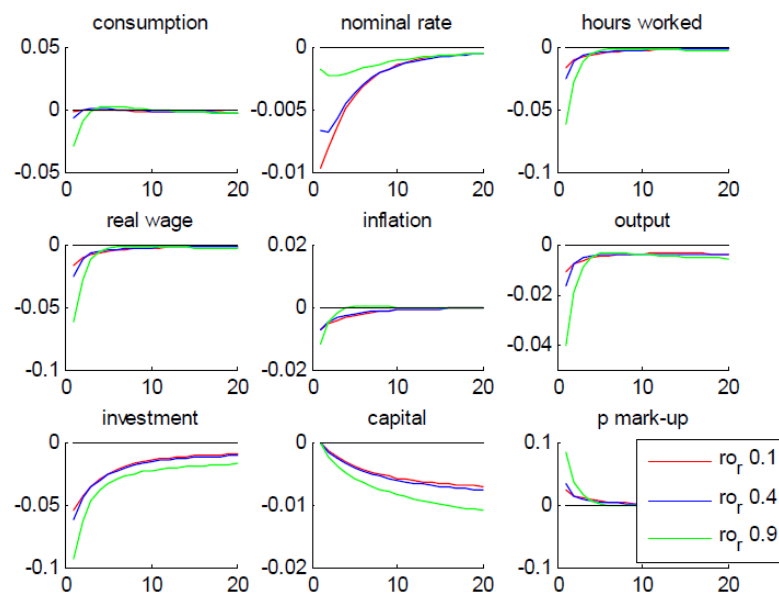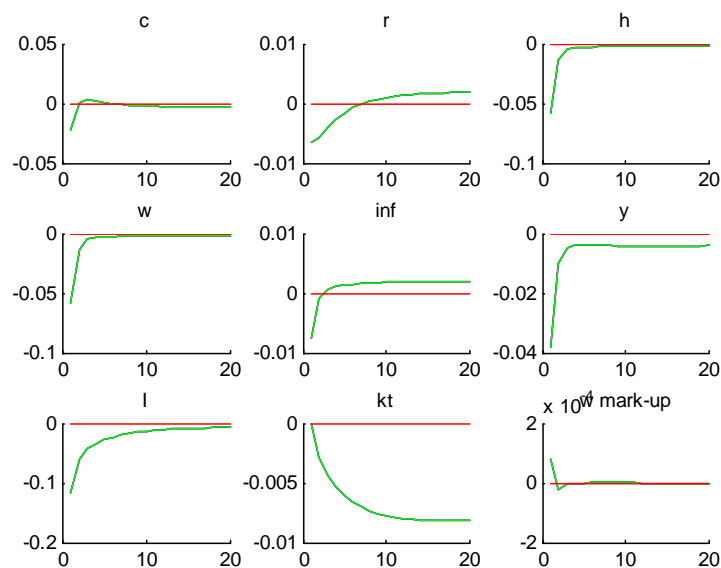
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2.6 Appendix

2.6.1 Appendix 3: First Order Conditions

$$MU_{C,t}^{GHH} = \left(C_t - \chi H_t^{(1+\sigma_L)} \right)^{-\sigma_C} \tag{2.38}$$

$$MU_{H,t}^{GHH} = - \left(C_t - \chi H_t^{(1+\sigma_L)} \right)^{-\sigma_C} \chi(1+\sigma_L)H^{(\sigma_L)} \tag{2.39}$$

$$MRS_t^{GHH} = -\frac{MU_{H,t}^{GHH}}{MU_{C,t}^{GHH}} = (1+\sigma_L)\chi H^{(\sigma_L)} \tag{2.40}$$

$$MU_{C,t}^{SEP} = \Theta_t/C_t \tag{2.41}$$

$$MU_{H,t}^{SEP} = -\chi H^{(\sigma_L)} \tag{2.42}$$

$$MRS_t^{SEP} = \frac{\chi H_t^{(\sigma_L)}}{\Theta_t}C_t \tag{2.43}$$

where $\Theta_t = C_t/X_t$ and $X_t = C_t^\omega X_{t-1}^{(1-\omega)}$

2.6.2   Appendix 4: steady-state

Steady-state gross inflation rate is set to $\pi = 1$. Steady-state gross risk premium is $rp = 1.0075$.

From condition3.32 one has:

$$R = \pi/\beta = 1/\beta = RR \tag{2.44}$$

Capital evolution law 3.21 is such that at steady-state:

$$I = \delta K \tag{2.45}$$

Replacing the former in the Tobin's Q equation 3.20 provides the price of capital at steady-state:

$$Q = 1 \tag{2.46}$$

From condition **??** one has:

$$R^K = RR \cdot rp \tag{2.47}$$

From definition **??** one has that steady-state marginal product of capital is:

$$z = R^K - 1 + \delta \tag{2.48}$$

Pricing 3.25 at steady-state is such that real marginal cost is pinned down as follows:

$$mc = \frac{1}{\mu_p} = \frac{\theta_p - 1}{\theta_p} \tag{2.49}$$

Wage setting at steady-state is such that:

$$\frac{w}{MRS} = \mu_w = \frac{\theta_w}{\theta_w - 1} \tag{2.50}$$

Steady-state **??** determines:

$$\frac{K}{Y} = \frac{\alpha}{z} \cdot mc \tag{2.51}$$

From 3.39:

$$\frac{C}{Y} = 1 - \delta\frac{K}{Y} \tag{2.52}$$

Real wage **??** is :

$$w = mc(1 - \alpha)\frac{Y}{H} \tag{2.53}$$

Imposing $H = 1/3$ at steady-state one can obtain the resulting weigh of hours worked in the utility function:

$$\chi^{GHH} = \chi^{GALI} = \frac{w}{\mu_w H^{(\sigma_L)}} \tag{2.54}$$

$$\chi^{STD} = \frac{w}{\mu_w H^{(\sigma_L)}C} \tag{2.55}$$

2.6.3 Appendix 5: log-linear model

$$x_t = \omega c_t + (1 - \omega)x_{t-1} \tag{2.56}$$

$$SEP : \lambda_t = -x_t \tag{2.57}$$

$$GHH : \lambda_t = D_2 h_t + D_3 c_t$$

$$SEP : w_t - (\sigma_L h_t + x_t) = wmp_t \tag{2.58}$$

$$GHH : w_t - (\sigma_L h_t) = wmp_t$$

$$rr_t = r_t - E_t \pi_{t+1} \tag{2.59}$$

$$0 = \lambda_{t+1} - \lambda_t + rr_t \tag{2.60}$$

$$w_t = y_t + mc_t - h_t \tag{2.61}$$

$$z_t = y_t + mc_t - k_{t-1} \tag{2.62}$$

$$y_t = (1 - \alpha)h_t + \alpha k_{t-1} \tag{2.63}$$

$$y_t = \frac{c}{y}c_t + \frac{i}{y}i_t \tag{2.64}$$

$$k_t = (1 - \delta)k_{t-1} + \delta i_t \tag{2.65}$$

$$q_t = \chi(i_t - k_{t-1}) \tag{2.66}$$

$$d_t = \frac{k}{d}(q_t + k_t) - \frac{n}{d}n_t \tag{2.67}$$

$$rp_t = \Phi(q_t + k_t - n_t) \tag{2.68}$$

$$r_t^K = \frac{z}{R^K} \cdot z_t + \frac{(1-\delta)}{R^K} q_t - q_{t-1} \tag{2.69}$$

$$r_{t+1}^K = rp_t + rr_t \tag{2.70}$$

$$\pi_t = \beta\pi_{t+1} + \kappa mc_t \tag{2.71}$$

$$\frac{n_t}{vR^K} = \frac{k}{n}r_t^K - (\frac{k}{n} - 1)(rp_{t-1} + rr_{t-1}) + n_{t-1} + v_t \tag{2.72}$$

$$r_t = (1 - \rho_R)\rho_\pi\pi_t + \rho_R r_{t-1} \tag{2.73}$$

where:

$$D_1 = \frac{\chi}{C}\frac{N^{(1+\sigma_L)}}{(1+\sigma_L)} = \frac{(1-\alpha)MC}{\mu_W(1+\sigma_L)}$$

(the second equality above coming from the definition of χ^{GHH})

$$D_2 = \sigma_C\frac{D_1}{1 - D_1}(1 + \sigma_L)$$

$$D_3 = -\sigma_C\frac{1}{1 - D_1}$$

CHAPTER 3

FINANCIAL LIBERALIZATION, CREDIT BOOM AND RECESSION: A BUSINESS CYCLE ACCOUNTING PERSPECTIVE FOR SWEDEN

3.1   Introduction

In the first part of this paper we apply the Business Cycle Accounting (BCA) methodology, pioneered in Chari Kehoe and McGrattan (2007a), to the boom-bust business cycle episode that Sweden experienced between the end of the 80s and the beginning of the 90s.

BCA augments a standard one-sector growth model with stochastic variables that enter the model's equilibrium as *reduced form* distortions, altering the outcome of agents' optimal decisions. The variables included in the benchmark procedure, named *wedges* because of their distorting role, are the *efficiency wedge*, the *labor wedge*, the *investment wedge* and *government spending wedge.*

Using quarterly OECD data on Swedish macroeconomic aggregates, covering years 1970-2007, we first estimate the stochastic process governing the behavior of the wedges and then measure the actual behavior of the distortions that those wedges are meant to capture. We focus on two crucial episodes of the Swedish business cycle: i) the *credit boom* period of years 1986-1990, that followed the implementation of financial liberalization measures of 1983-85; ii) the economic *recession* of the early 90s.

Our findings on the dynamics of the efficiency wedge and the investment wedge in years 1986-1990 can shed light, at the macro level, on the effects of the measures of financial liberalization on the financial constraints of Swedish households and firms. With their *equivalence results* Chari et al. (2007a) show how models in which firms have liquidity constraints in input financing can be mapped into a benchmark BCA model augmented with an efficiency wedge, while models of financial frictions à la Bernanke-Gertler-Gilchrist (1998) (hereafter BGG) and Carlstrom-Fuerst (1997) map into BCA economies augmented with an investment wedge.

We find that distortions to efficiency of production stay basically unchanged in Sweden during the credit boom of years 1986-1990. The investment wedge, combining by construction both households and firms liquidity constraints, stays roughly unchanged in years 1986-1987

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while it displays a pattern of improvement in the subsequent three years. The underlying tax on investment goods reaches in 1990:Q1 a value which is by 10% smaller than its value in 1987:Q2. The timing of the investment wedge's improvement coincides to the delayed expansion in corporate lending, as opposed to lending to households, as documented by the figures reported in Englund (1999). This seems to suggest that, if any, financial deregulation had a small easing effect on firms' liquidity constraints. Previous work on financial constraints in Sweden during those years concludes for the absence of household's liquidity constraints and for a positive though quantitatively small role of firms' financing constraints. The literature supports the choice of focusing the analysis on the side of firms although, unlike in this paper, no evidence is found of a beneficial effect of the implemented measures of financial deregulation.

The economic recession of the early 90s is the most severe episode of the Swedish business cycle since the depression of the 30s, both in terms of GDP decline and skyrocketing unemployment.

Our findings on the pattern of *realized wedges* for those years seem to suggest two facts: i) the efficiency wedge is the only reduced form distortion that displays a sensible improvement during the long lasting recovery phase beginning in 1994; ii) the investment wedge does not play in the Swedish recession a counterfactual role, i.e. it does not improve during the years of output decline, as instead is found to be the case in the US Great Depression episode and the UK recession of the 80s, analyzed respectively in Chari et al. (2007a) and Kersting (2008).

In order to get a deeper insight on the driving forces of the Swedish recession we also perform what Chari et al. (2007a) name *output decomposition* exercises. The benchmark BCA equilibrium can be solved so as to let only one wedge, or a chosen combination of wedges, vary over time while the remaining ones are fixed at constant values and therefore stay inactive in the economy. Imposing on the active wedge its realized behavior we can simulate a one-wedge driven economy and see what would have been the pattern of percapita output had only that specific distortion been at work during the Swedish recession. The findings about the decomposition of percapita output during the recession years suggest two facts: i) distortions to efficiency of production play a crucial role in shaping the recession/recovery pattern and turn out to be essential for the recovery phase; ii) distortions represented by the investment wedge made the recession only slightly deeper although it sensibly contributed to increase its persistence.

We then exploit the quantitative results of the BCA application on the effects of the Swedish financial liberalization policy package to run an additional 'counterfactual' experi-

ment concerning the Swedish recession. We simulate for Sweden a closed economy version of the BGG financial accelerator whose micro-foundations allow for the possibility of calibrating a financial contract between lender and borrower in both *pre-liberalization* and *post-liberalization* economic environments. We characterize the economy's steady-state prior to the financial deregulation measures as one in which the amount of resources that banks have to devote to monitoring borrowers, and consequently the premium for lending that they charge borrowers, is larger. By feeding in the same BCA estimated Total Factor Productivity series (Solow residual) of the recession in both calibrations/financial environments, one is able to explore the extent to which the financial liberalization policy impacted on the vulnerability of the Swedish economy faced with the recessionary shock that triggered right after the boom period.

The choice of modeling the easing of the firms' financial constraint as a 10% decrease in the share of resources devoted to monitoring activities, within a BGG framework, results in no sensible differences in the way the Swedish economy responds to the recessionary productivity shock. Exploiting the insights of the Business Cycle exercise seems to suggest that the structural changes brought about by the financial deregulation reform did not worsen the vulnerability of the economy.

3.2 The Swedish boom-bust

Jonung et al. (2006) compare the Swedish (and Finnish) boom-bust episode of years 1984-1995 (see Figure 3.1) to the average boom-bust episode calculated on an international sample of developed economies covering years 1970-2002[1]. The conclusion they reach is twofold: i) the Swedish-Finnish episode is more volatile than the average boom-bust; ii) differences are mostly due to a deeper recession phase and a faster recovery phase in the Swedish-Finnish case. The authors define the Swedish (and Finnish) boom-bust episode a textbook example boom-bust and relate most of its features to the design of two types of economic policy in those countries, namely the fixed exchange rate policy and the policy reform of financial deregulation.

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[1]They adopt the Jaeger and Schuknecht (2004) technique to disentangle boom-bust episodes from standard business cycle events within large sets of countries.

3.2.1 Financial deregulation and credit boom

The agenda of financial deregulation was implemented in Sweden, in the middle of the 80s, in an economic context of high inflation, high inflation expectations, high public deficit[2] and deteriorating competitiveness on the global markets, as documented in detail in Backstrom (1997) and Ergungor (2007).

Englund (1990) and Englund (1999) investigate the financial deregulation process in Sweden and its role in the banking crisis that developed in the 1990s. The Swedish financial market of the early 80s is described as one of the most heavily regulated ones, as banks insurance companies and other financial institutions were subjected to *quantity regulations*, *price regulations* and *border restrictions*. Within the first category the placement requirements (liquidity ratios), obliging banks and insurance companies to hold large shares of long-term bonds issued either by the Government or by mortgage institutions, were abolished in 1983 and 1986 for banks and insurance companies respectively. Ceilings on loans, falling in the same regulatory category, were also abolished in 1985[3]. Price restrictions such interest rate ceilings on loans were abolished in 1985. Additional measures were aimed at increasing the openness of the Swedish financial system: although restrictions to the international movements of capital had been partially removed already at the beginning of the 1970s, only in 1986 the first subsidiaries of foreign banks were allowed to operate in the Swedish territory[4].

The deregulation measures unambiguously achieved the double aim of stimulating bank lending and promoting competition within the market for credit. The latter had justified the Riksbank's support towards it. Englund (1999) describes years 1986-1990 as a period of *credit boom*, in which bank lending increased by 136% and banks and mortgage institutions expanded their business by 174% and 167% respectively, somehow compelling finance and insurance companies to develop alternative and sometimes riskier types of activities.

The author considers lending to households, on one hand, and lending to firms on the other. Corporate lending showed the largest increase over the credit boom, expanding by 129%, against the 86% expansion of households' lending. The timing of the response to the deregulation reform is, though, different across categories of borrowers. Credit to households expanded right after the measures were implemented while corporate lending had a delayed reaction, sluggishly increasing in 1986 and 1987 and jumping quite dramatically in years

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[2]Inflation reached its 14% peak in 1980, when public deficit was 10% of GDP.

[3]The implementation of this measure is sometimes defined, in the literature, as the "November Revolution" of the Riksbank.

[4]To this last respect, however, one has to consider that regulations on domestic investment in foreign securities and on foreign investment in domestic securities were abolished only in 1989.

1988-1990.

It is not clear whether or not the financial deregulation agenda of the first half of the 80s played a crucial role in determining the price bubble: Englund (1999) claims that both the increase of borrowing opportunities and the easing of the lenders' risk evaluation practices helped amplifying and deepening the impact of the bubble's burst.

Table 1 - Key facts of the Swedish financial deregulation agenda

Policy Measure	Year
Abolishment of requirement that Banks hold bonds	1983
Deregulation of Banks' lending rates	1985
Loan ceilings on Banks and Finance Companies lifted	1985

Table 2 - Changes in households and corporate lending

Borrower	Δ	Timing
Lending to corporations	+ 86%	mostly 1985-88
Lending to households	+ 129%	mostly 1988-90

3.2.2 The bust

The Crisis came as the resultant of multiple events. According to the literature each of the following factors played a role:

- The 1977 currency peg to the German Mark forced Sweden to "import" higher German interest rates due to the weakening of the D-Mark against the US Dollar that accompanied the German reunification process (1990).

- The Central Bank implemented a restrictive monetary policy in order to peg the Krona to the Ecu.

- The export sector was particularly hit by the collapse of trade relations between Finland and the Soviet Union.

- The tax reform implemented in Sweden in 1990-91 increased the after tax cost of borrowing, making debt less attractive.

In 1990 finance companies highly involved in the real estate finance business began declaring to be unable to roll over loans; soon after the crisis spread to other sectors of the money

market and, in 1991, reached two of the six largest Swedish banks[5], bringing them below the minimum prudential capitalization requirements. Commercial and residential prices dropped by 42% and 25% respectively between 1990 and 1995, accounting for approximately half of the losses banks recorded in that period.

Between 1990 and 1993, as reported in Backstrom (1997), GDP fell by 6%, unemployment jumped from 3% to 12% of the labor force and public deficit reached 12% of GDP.

3.3 The BCA benchmark model

The prototype model used by Chari et al. (2007a) to perform Business Cycle Accounting exercises is a standard neoclassical dynamic growth model augmented with four stochastic variables: *efficiency wedge, labor wedge, investment wedge* and *government wedge.*

Household's problem

The representative household maximizes expected utility over per capita consumption (c_t) and labor (l_t):

$$\max_{c_t, l_t, x_t} \sum_{t=0}^{\infty} \sum_{s_t} \beta^t \pi_t(s^t) U(c_t(s^t), l_t(s^t)) N_t \tag{3.1}$$

subject to the budget constraint:

$$c_t + [1 + \tau_{xt}(s^t)] x_t(s^t) = [1 - \tau_{lt}(s^t)] w_t(s^t) l_t(s^t) + r_t(s^t) k_t(s^{t-1}) + T_t(s^t) \tag{3.2}$$

and the law of motion of capital:

$$(1 + g_n) k_{t+1} = (1 - \delta) k_t + x_t. \tag{3.3}$$

Here $s^t = (s_0, ..., s_t)$ denotes the history of events up to and including period t , occurring

with probability $\pi_t(s^t)$. β is the discount factor, N_t is the population, x_t and k_t are per capita investment and per capita capital stock, δ is the constant depreciation rate of capital, r_t and w_t are the rental rate of capital and the real wage , T_t are lump-sum transfers to the household, and g_n is the constant growth rate of population. $(1 + \boldsymbol{\tau}_{xt})$ and $(1 - \boldsymbol{\tau}_{lt})$,in turn the *investment wedge* and the *labor wedge*, act in the model as time-varying taxes on investment purchases and on labor income.

Firm's problem

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[5]I am referring to Forsta Sparbanken and Nordbanken.

The representative firm optimally chooses labor (l_t) and capital (k_t) so as to maximize:

$$\max_{k_t, l_t} A_t(s^t) F(k_t(s^{t-1}), (1 + g_z)^t l_t(s^t)) - w_t(s^t) l_t(s^t) - r_t(s^t) k_t(s^{t-1}) \tag{3.4}$$

where $(1 + g_z)$ is the constant growth rate of labor-augmenting technological progress. Note that the *efficiency wedge, A_t,* takes the form of a time-varying Total Factor Productivity term.

Equilibrium

Once the aggregate budget constraint is taken into account, one can easily solve the agents' optimization problems and characterize the model's equilibrium as follows (where for simplicity the history notation s_t is dropped):

$$c_t + x_t + g_t = y_t \tag{3.5}$$

$$y_t = A_t F(k_t, (1 + g_z)^t l_t) \tag{3.6}$$

$$-\frac{U_{lt}}{U_{ct}} = (1 - \tau_{lt}) A_t (1 + g_z)^t F_{lt} \tag{3.7}$$

$$U_{ct}(1 + \tau_{xt}) = \beta E_t U_{ct+1}[A_{t+1} F_{kt+1} + (1 - \delta)(1 + \tau_{xt+1})] \tag{3.8}$$

where the *government wedge g_t* is a simple time varying government consumption term "distorting" the aggregate budget constraint.

Interpretation of the wedges

By distorting the optimality conditions of the prototype model the wedges provide a measure of different broad categories of frictions at work in the economy. The labor wedge, for instance, invalidates the intratemporal equivalence between the household's labor-leisure marginal rate of substitution, on one hand , and the marginal product of labor on the other. As clarified in Chari et al. (2007b) the stochastic wedges are not meant to capture the effects of "primitive shocks" on macroeconomic aggregates, such as for example monetary shocks, shocks to preferences and financial market shocks. The wedge of the BCA methodology simply measures the extent to which a whole range of unidentified primitive shocks manifest in the distortion of the optimality condition it is associated to. The specificity of each of

the wedges, in other words, is the channel through which many sources of shock hit the macroeconomic aggregates rather than the specific source of shock.

The *investment wedge*, that we discuss more deeply in this paper, captures all shocks and distortions that affect the optimality of the inter-temporal condition (3.8). The latter is the outcome of the inter-temporal choices of both households and firms and, as such, can be distorted by economic frictions such as, for instance, liquidity constraints on households and investment financing frictions on firms.

The multiplicity of explanations to which each of the wedges is open to determines the richness of the BCA methodology. In Chari et al. (2007a), as well as in previous work, the authors provide proof of important *equivalence results*: broad classes of detailed quantitative models of the business cycle, containing fairly complex friction mechanisms and primitive shocks, are shown to result in equilibrium allocations equivalent to the ones reached by a prototype growth model appropriately modified with one or more wedges. As far as financial frictions are concerned Chari et al. (2007a) show how models that incorporate financial frictions à la BGG (1998) are equivalent to a prototype economy modified with an investment wedge and how models of input-financing frictions can result in equilibrium allocations equivalent to the ones of a prototype economy appropriately augmented with an efficiency wedge. In previous work they also prove an equivalence result between the financial frictions model of Carlstrom and Fuerst (1997) and a prototype economy modified with an investment wedge.[6]

The possibility of identifying one or more broad classes of business cycle models, behind each of the wedges, makes the benchmark growth model a laboratory economy to be used for two kinds of exercise:

- measuring the *actual realization* of the wedges during relevant business cycle episodes of an economic system, like boom-bust periods or periods of economic reform.

- run *counterfactual simulations* of wedges-augmented model economies where a single wedge (a combination of wedges) is allowed to vary across time according to its actual (historical) realization, while the remaining wedges are shut down to constant values. The *decomposition* exercises illustrate what would have been the behavior of the macroeconomic aggregates during a given episode if only one type of distortions (those specific distortions) had been at work in the economy. A comparison with historical realizations of macroeco-

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[6]The equivalence results are not limited to detailed business cycle models including financial frictions. In Chari et al. (2007a) one can find two additional equivalence results: a detailed model economy with international borrowing and lending is reproduced by a prototype model augmented with a government consumption wedge, while a detailed economy with sticky wages and monetary shocks is shown to be equivalent to a prototype economy modified with a labor wedge. In the same work several other equivalence results are cited.

nomic aggregates sheds light on which distortions crucially drove the business cycle episode, or at least played a dominant role in shaping it.

3.4 The accounting procedure for Sweden

The benchmark BCA model economy is first to be used for the measurement of the wedges' historical dynamics. Notice that, by construction, measuring the *government wedge,* (g_t), the *efficiency wedge,* (A_t), and the *labor wedge,* $(1 - \tau_{lt})$, simply implies combining the appropriate macroeconomic time series according to the static optimality conditions of the benchmark growth model, once functional forms and parameter values have been chosen.

The measurement of the investment wedge $(\frac{1}{1+\tau_{xt}})$, though, is not equally straightforward. The investment wedge enters the dynamic first-order condition (8) and, as a consequence, depends on the policy functions of the benchmark model equilibrium. The computation of the latter, in turn, requires the specification of a stochastic process for the wedges upon which households form their expectations when taking their decisions.

The following sections describe the model's solution approach, the estimation technique for the stochastic process governing the wedges, and then present the results of the accounting procedure.

3.4.1 Calibration

Following Chari et al. (2007a) we choose a Cobb-Douglas production function, $F(k_t, l_t) = k_t^{\theta} l_t^{1-\theta}$ and a separable log-utility function of the type $U(c_t, l_t) = \log c_t + \psi \log(1 - l_t)$. The capital share is set to $\theta = 0.25$, as in an open economy model calibrated to Sweden in Adolfson et al. (**?**), while the time allocation parameter is set so as to obtain a steady-state share of time allocated to working activities equal to 30%. We choose a capital depreciation rate δ and a discount factor β such that, on an annualized basis, depreciation is 4.64% and the rate of time preference is 3%. Annual growth rate of population is set to $g_n = 0.0115$ to match the average 1.15% population growth in Sweden in period 1970-2005, as computed from OECD Stats annual data. The labor-augmenting technological progress parameter is set to $g_z = 0.014$ to match an annual growth of per capita GDP of 1.4%.

Table 2: Annualized Parameter Values - Benchmark Economy

Parameter	Value
θ	0.35
δ	0.0464
β	0.9722
g_n	0.0115
g_z	0.014

3.4.2 Model Solution and Estimation

We follow Chari et al. (2007a) and use two fundamental assumptions concerning the stochastic structure of the model:

1. A realization of the four wedges uniquely uncover event $s_t = (\log A_t, \tau_{lt}, \tau_{xt}, \log g_t)$, i.e. there is a one-to-one mapping between the wedges and the stochastic event.

2. The four wedges follow a VAR(1) process defined by: $s_{t+1} = P_0 + P s_t + Q \varepsilon_{t+1}$

The disturbances ε_t are i.i.d. and follow a Normal distribution with zero mean and variance-covariance matrix V.[7] The parameters that enter matrices $P0, P$ and Q are estimated using a Maximum Likelihood procedure. Once the model's equilibrium is log-linearized around its steady-state, an expression for k_{t+1} can be found in terms of the five states of the benchmark economy (k_t and the four wedges) using the method of undetermined coefficients: the latter expression and the VAR(1) assumed for the wedges allow rewriting the model in State-Space form and applying the Kalman Filter for the construction of the likelihood function.

3.4.3 Accounting and decomposition results

3.4.3.1 Financial deregulation and liquidity constraints

Figure 3.2 plots the behavior of the investment wedge and the efficiency wedge during the *credit boom* period.

The investment wedge displays the largest volatility, over the years of credit expansion, if compared to the series of actual output and to that of the efficiency wedge. It stays roughly

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[7]In order to ensure semiposidefiniteness of the latter we estimate the lower triangular matrix Q which is such that $V = QQ'$.

at the same level until the second half of 1987 and subsequently takes on a decreasing trajectory (i.e. $\frac{1}{1+\tau_{xt}}$ increases and the distortion weakens) until the end of the first quarter of 1990 is reached. The improvement of the investment wedge over the period 1987:Q2-1990:Q1 is approximately of 10%. Although in principle the methodology applied does not allow disentangling the separate roles of households and firms within the combined financial distortion, the timing of the investment wedge's response to the measures of financial deregulation could help identifying those roles. Despite the prompt reaction of households lending described in Ergungor (1999) our measure of investment wedge does not move materially in years 1986-1987 while it starts improving simultaneously to the spike in corporate lending reported for years 1988-1990.The easing of aggregate distortions to investment that the BCA methodology finds in the Swedish economy in during the late 80s, could therefore represent a small although steady trend of improvement in firms' investment financing constraints during the corporate lending boom that followed the deregulation measures.

The efficiency wedge is also to be considered an indicator of the degree of financial imperfection, within a Business Accounting Framework, because of Chari et al. (2007a)'s *equivalence result* that maps model economies with input financing frictions into an efficiency-wedge-agumented BCA economy.

The roughly constant behavior of the efficiency wedge seems to exclude that firms' constraints in input financing, if ever a concern in the Swedish economy, were materially affected by the financial reforms.

Previous studies on households and firms' liquidity constraints in Sweden support the choice of focusing the analysis on the firm side although they don't seem to find any evidence of an easing of those constraints after the financial deregulation measures implemented in 1983-85.

Ekman (1997) estimates the consumption equation, as a function of permanent income and non-human wealth, on a repeated cross-section of Swedish households for the period 1981-1993, crucially including the years of the deregulation agenda. No jumps in the propensity to consume can be identified in the second half of the 80s, essentially suggesting no impact of the financial reforms on consumption behavior.

Agell and Berg (1996) estimate an Euler Equation augmented with a current income term, meant to capture the tightness of the Swedish households' liquidity constraints, and conclude for a small quantitative role of the liquidity constraint though invariant across the 1985-90 period.

Hansen and Lindberg (1997) investigate the role of financial deregulation on firms' investment decisions by estimating the Euler Equation on an unbalanced panel of Swedish

manufacturers for the period 1979-1994. The financial constraint, which is captured by the assumption that the cost of capital is increasing in the level of the firm's indebtedness, is found to be significant although invariant over the deregulation years. Somewhat more relevant is the worsening of the financial constraint measured, in Hansen and Lindberg (1997), during the first years of the 90s recession.

Jappelli and Pagano (1989) suggest that Swedish households, on aggregate, were among the least credit-constrained within the OECD group of countries.

3.4.3.2 The driving forces of the recession

Figure 3.3 shows the behavior of detrended per capita macroeconomic series - output, investment, hours worked and public spending - during the Swedish recession of the 1990s. Gustafsson and Palmer (2002) identify the recession in years 1991-1995 and the beginning of the recovery in 1996. The OECD Outlook data series, that we use in this analysis, show a peak decline in per capita GDP in 1993 of about 10% of its 1990 value. Weak signs of recovery are there already from 1994 even though only at the end of 1996 the economy starts following the recovery path that will bring per capita GDP back to its pre-crisis value at the beginning of years 2000s. Per capita hours worked mimic more closely the pattern of output during the recession years than during the recovery path, while investment's 40% dramatic fall in years 1990-1994 is followed by a quite volatile trajectory of (only partial) recovery.

Figure 3.4 compares the behavior of government wedge (g_t), investment wedge ($\frac{1}{1+\tau_{xt}}$) , labor wedge ($1 - \tau_l$) and efficiency wedge (A_t) to actual Swedish output for the period 1990-2000.

Efficiency labor and investment distortions all display a cyclical behavior during the recession years, i.e. they worsen as long as per capita output drops. The efficiency wedge is the only distortion that improves during the output recovery started in 1996. Even though disentangling the specific role of each of the wedges requires decomposition simulations, already at this stage one can argue that the counterfactual behavior of distortions to investment, notably found for the Great Depression in the US in Chari et al. (2007a) and for the UK depression of the 1980s in Kersting (2008), does not apply to the Swedish recession of the early 1990s . The dynamics of the investment wedge are such that one cannot exclude the

possibility that liquidity constraints in investment financing played a relevant role during the Swedish recession.

Figure 3.5 reports the results of a decomposition exercise showing what would have been the pattern of per capita output, in years 1990-2000, if only one specific wedge had been operating in the economy. As shown in the upper panel the efficiency-generated output mimics very closely the behavior of output during the steep decline of 1990-93, indicating the efficiency wedge as the main driving force behind the Swedish recession. Distortions in the labor market would have driven output in an equally severe recession although characterized by a less steep decline and no recovery phase.

Figure 3.6 reports the comparison between Swedish per capita output in the data and the output that would have been generated by a model economy where all the wedges but the efficiency one are allowed to vary across time. The efficiency wedge is the only essential distortion to be considered in order for the simulated output series to keep displaying patterns of recession and recovery in years 1990-2000[8]: as can be seen in the figure the wedge is strikingly relevant if one wants to account for the recovery phase beginning in 1996.

Figure 3.7 plots simulations aimed at further exploring the role of distortions to investment in the recession years 1990-94. The drop in per capita output is almost fully explained by a model economy where the efficiency wedge is the only distortion allowed to operate. Simulating a model economy where investment distortions operate *on top of* the distortions in production efficiency shows that the investment wedge only slightly contributes to the depth of the output decline while it definitely plays a role in increasing the persistence of the recession. The recession pattern gets prolonged by approximately one year (from 1993 to 1994). Aggregate distortions represented by the investment wedge, among which the combined liquidity constraint of households and firms, therefore amplified the impact of worsened efficiency of production in Sweden during the first half of the 1990s.

The present application of BCA methodology to Swedish business cycle adds to several other country examples. Chari et al. (2007a) apply the method to the US, Kersting (2008) to the UK, Simonovska and Soderling (2008) to Chile, Cavalcanti (2007) to Portugal, both Chakraborty (2004) and Kobayashi and Inaba (2005) to Japan, Xu (2007) to the Chinese

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[8]Further non-reported simulations of model economies where only 1 wedge a the time is kept inactive show that whenever either the investment wedge, the labor wedge or the government wedge are shut down in the economy the output series still follow a recession-recovery pattern.

economy, Lama (2005) investigated the fluctuations of Argentina, Brazil and Mexico, and Otsu (2007) the business cycle of the Asian Crisis.

3.5 A counterfactual exercise about the Swedish recession

In this section we further investigate the linkages between investment financing frictions and the Swedish recession by combining the BGG micro-foundation of the investment wedge with two main quantitative results of the BCA application. We take the estimated Solow Residual for the recession years, i.e. the productivity wedge computed in the BCA application, to be the main driving force of the Swedish business cycle. We then feed in the estimated shock into two different model economies of the financial accelerator economy, which differ among them for the calibration of the steady-state financial contract between banks and entrepreneurs. In particular,the model economy whose banks' monitoring costs are calibrated to a larger (smaller) value mimics the tightness of firms' credit constraints in Sweden before (after) the implementation of financial deregulation measures. The responses of the macro aggregates to the estimated productivity shock in an environment of large monitoring costs (i.e. tight credit constraints) provide a quantitative assessment of what would have been the productivity-driven Swedish recession had the effects of financial liberalization not been there.

3.5.1 A model economy with financial accelerator frictions

The detailed economy is a closed-economy model featuring nominal rigidities, investment adjustment costs, and a financial accelerator mechanism like the one described in Bernanke Gertler and Gilchrist (1998). The modeling follows Dib and Christensen (2008) and entails five categories of agents: households, capital producers, entrepreneurs, retailers and a monetary policy authority.

This model differs from Dib and Christensen (2008) in two main respects: i) entrepreneurs inelastically provide all of their labor force (normalized to equal unity) to their production technology and, consequently add to their net worth the value of their labor earnings, as originally assumed in BGG (1998) and Gertler Gilchrist and Natalucci (2003); ii) The micro-foundation of the financial contract between lender and borrower are explicitly modelled, as in BGG (1998), Gertler Gilchrist and Natalucci (2003) and Meier Muller (2005).

3.5.1.1 Entrepreneurial activity and external finance

Entrepreneurial activity is the channel through which financial markets and their frictions enter the model, as first introduced in Bernanke et al. (1998). Entrepreneurs are risk neutral agents whose expected life horizon is finite, i.e. their business will survive until next period only with probability υ. The latter assumption ensures that entrepreneurs' own wealth,

which accumulates through past earnings and capital gains, will never be enough to fully finance the purchase of capital goods. At the end of each period t, when purchasing capital k_{t+1} to be used next period at current price q_t, the entrepreneur has to borrow funds from a financial intermediary (bank) for the amount b_t, which isby how much capital purchases, $q_t k_{t+1}$, exceed entrepreneurial net worth n_{t+1}.

In order to introduce in the model a micro-founded friction in the financial market we follow BGG and assume that entrepreneurial activity is exposed to an idiosyncratic shock, ω_t, whose realization is known ex-post to the entrepreneur but cannot be costlessly observed by the financial intermediary. BGG show how, in such a setting, the optimal one-period contract between borrower and lender establishes that for realizations of the shock above a given threshold $\bar{\omega}_t$ the borrower pays the lender a fixed amount, while for realizations below the threshold the borrower defaults on her debt and the lender seizes all remaining assets net of the costs of *monitoring*. These costs amount to a fraction μ of the entrepreneur's total payoff. They also show that in the presence of aggregate risk and a risk neutral intermediary, the financial contract is such that the entrepreneur bears all of the aggregate risk.

Costly monitoring and default introduce a gross premium, $S(.)$, between the expected marginal cost of external financing, $E_t(R_{t+1}^K)$, and the opportunity costs of funds borne by the intermediary in the absence of frictions in the financial market, i.e. the expected gross real riskless rate $E_t(R_t/\pi_{t+1})$. As BGG show the risk premium is an increasing function of the borrower's leverage ratio:

$$S(.) = S(\frac{q_t k_t}{n_{t+1}}) \qquad with S'(.) > 0 and S(1) = 1 \tag{3.9}$$

Intuitively, an entrepreneurial higher leverage ratio makes misreporting by the entrepreneur more likely, it increases the riskiness of the loan and its expected monitoring costs, and therefore makes the lender ask for a higher premium over the opportunity cost of funds. The log-linear version of the risk premium definition is given by:

$$\hat{R}_{t+1}^K - \hat{R}_t + \hat{\pi}_{t+1} = \psi(\hat{q}_t + \hat{k}_t - \hat{n}_{t+1}) \tag{3.10}$$

and includes the financial parameter ψ, representing the elasticity of the risk premium to changes in the leverage condition of the entrepreneur.

The optimal demand for funds for capital purchasing has to fulfill the following condition:

$$E_t \left[S(\frac{q_t k_t}{n_{t+1}})(R_t/\pi_{t+1}) \right] = E_t \left[\frac{r_{t+1}^k + (1-\delta)q_{t+1}}{q_t} \right] \tag{3.11}$$

where the right-hand-side term is the expected gross return on capital, composed of the marginal productivity of capital and the capital gains.

The wealth of entrepreneurs is composed of the firm equity,V_t, for the fraction v of entrepreneurs remaining in business and of the real managerial earnings w_t^e that entrepreneurs obtain by inelastically supplying all of their time to the firm. Therefore entrepreneurial wealth evolves according to[9]:

$$N_{t+1} = vV_t + w_t^e \qquad (3.12)$$

Firm equity is given by:

$$V_t = R_t^K Q_{t-1} K_t - R_t(Q_{t-1}K_t - N_t) - \mu \int_0^{\bar{\omega}} \omega R_t^K Q_{t-1} K_t f(\omega) d\omega \qquad (3.13)$$

where the first term of the left-hand-side represents realized returns on capital, the second term subtracts the loan repayments and the third term represents the loss that the entrepreneur in default has to bear due to the costly monitoring assumption.

Combining the previous two expressions, and log-linearizing around the non-stochastic steady-state we obtain the following law of motion of entrepreneurial net worth:

$$\frac{\hat{N}_{t+1}}{vR^K} = \frac{k}{n}\hat{R}_t^K - (\frac{k}{n}-1)\hat{R}_{t-1} + (\frac{k}{n}-1)\hat{\pi}_t - \Psi(\frac{k}{n}-1)\hat{K}_t - \Psi(\frac{k}{n}-1)\hat{Q}_{t-1} - [\Psi(\frac{k}{n}-1)+1]\hat{N}_t \quad (3.14)$$

$$+ \frac{1}{\mu vR^K}\alpha\frac{Y}{K}\hat{w}_t^e - \Theta$$

$$\text{where } \Theta = v\left(\mu\int_0^{\bar{\omega}}\omega R^K f(\omega)d\omega\right)\log\left(\frac{\mu\int_0^{\bar{\omega}}\omega R_t^K Q_{t-1}K_t f(\omega)d\omega}{\mu\int_0^{\bar{\omega}}\omega R^K K f(\omega)d\omega}\right)$$

Entrepreneurs produce wholesale goods according to the following technology:

$$y_t = k_t^\alpha (A_t h_t^{1-\Omega} h_t^{e\Omega})^{1-\alpha} \qquad (3.15)$$

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[9]This condition of evolution of entrepreneurial net-worth is slightly different from the one adopted in the previous two chapters of the thesis. The original BGG formulation of the problem, followed in this chapter, assumes that entrepreneurs inelastically provide labor force to the production process. Aggregate networth is therefore determined by the equity of surviving entrepreneurs and the real wage earned through entrepreneurial labour services.

where h_t^e is managerial labor service, $\alpha \in (0,1)$ and $\Omega \in (0,1)$. Optimal demand of household's and managerial labor satisfy respectively the following conditions:

$$w_t = (1 - \alpha)(1 - \Omega)\frac{y_t}{h_t}mc_t \tag{3.16}$$

$$w_t^e = (1 - \alpha)\Omega\frac{y_t}{h_t^e}mc_t \tag{3.17}$$

where mc_t represents the real marginal cost. For simplicity, as in Gertler Gilchrist and Natalucci (2003), we assume hereafter that h_t^e can be normalized to unity. Optimal demand of capital satisfies in turn:

$$r_t^k = \alpha\frac{y_t}{k_t}mc_t \tag{3.18}$$

3.5.1.2 Capital Producers

Capital producers purchase final goods from retailers and combine them with undepreciated (old) capital, to produce new capital goods that add to the capital stock. Producing and selling an amount $Q_t I_t$ of capital goods implies bearing the cost of I_t units of goods augmented with a quadratic capital adjustment cost. Their profit maximization problem looks as follows:

$$\max_{I_t} E_t \left[Q_t I_t - I_t - \frac{\varphi}{2}(\frac{I_t}{K_t} - \delta)^2 K_t \right] \tag{3.19}$$

The optimal choice of investment, which defines a standard Tobin's Q relation, is:

$$E_t \left[Q_t - 1 - \varphi(\frac{I_t}{K_t} - \delta) \right] = 0 \tag{3.20}$$

Aggregate capital evolves according to a standard law of motion:

$$K_{t+1} = I_t + (1 - \delta)K_t \tag{3.21}$$

3.5.1.3 Retailers

Retailers purchase wholesale goods from entrepreneurs, at their marginal costs, differentiate them, and sell them on a monopolistically competitive market.

The price stickiness assumed here is of the Calvo (1983) type: with probability θ_p the firm does not receive the signal allowing her to optimally reset the price.[10] When she gets the chance to reoptimize prices the firm chooses the optimal price $p_t^*(h)$ by solving the following profit maximization problem:

$$\max_{p_t^*(h)} E_t \left[\sum_{k=0}^{\infty} (\beta\phi_p)^{t+k} \lambda_{t+k} \Phi_{t+k}(h) \right] \tag{3.22}$$

where the nominal profit function is:

$$\Phi_t(h) = [p_t^*(h) - MC_t(h)] Y_t(h) \tag{3.23}$$

and the demand function is :

$$Y_t(h) = \int \left(\frac{p_t^*(h)}{P_t} \right)^{-\theta_p} Y_t = \int \left(\frac{p_t^*(h)}{P_t} \right)^{-\theta_p} (C_t + I_t) \tag{3.24}$$

The first order condition of this problem is:

$$P_t^*(f) = \frac{\theta_p}{\theta_p - 1} \frac{E_t \sum_{k=0}^{\infty} (\beta\phi_p)^k \lambda_{t+k} MC_{t+k}(h) D_{t+k}(h)}{E_t \sum_{k=0}^{\infty} (\beta\phi_p)^{t+k} \lambda_{t+k} D_{t+k}(h)} \tag{3.25}$$

The price stickiness of the Calvo type is such that the final product price evolves according to:

$$P_t^{1-\theta_p} = \phi_p(\pi P_{t-1})^{1-\theta_p} + (1 - \phi_p) P_t^{*1-\theta_p}. \tag{3.26}$$

Combining the log-linear expressions for the optimal price and the evolution of aggregate prices yields the well known New-Keynesian Phillips curve, expressing present inflation as a function of current real marginal cost and expected inflation:

$$\pi_t = \beta\pi_{t+1} + \frac{(1 - \beta\theta_p)(1 - \theta_p)}{\theta_p} mc_t. \tag{3.27}$$

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[10] The resulting price duration is given by: $\dfrac{1}{1 - \theta_p}$

3.5.1.4 Households

The representative household chooses sequences for consumption, hours worked, and bank deposits $\{C_t, H_t, D_t\}_{t=0}^{\infty}$ in order to maximize her expected life-time utility:

$$U_0 = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(C_t, H_t) \right\} \tag{3.28}$$

subject to the sequence of budget constraints (in real consumables terms):

$$C_t + \frac{D_t}{P_t} \leq \frac{W_t}{P_t} H_t + \frac{R_{t-1}}{\pi_t} D_{t-1} + \frac{T_t}{P_t} + \frac{\Omega_t}{P_t} \tag{3.29}$$

where C_t is consumption of final good, D_t is nominal deposit bearing gross nominal riskless interest rate R_t, T_t are nominal lump sum transfers/taxes from the Government and Ω_t are nominal monopolistic profits due to the ownership of intermediate goods producing firms.

The first order conditions of the problem look as follows:

$$(C_t): \qquad U_{C,t} = \lambda_t \tag{3.30}$$

$$(H_t): \qquad U_{H,t} = \lambda_t w_t \tag{3.31}$$

$$(D_t): \qquad \frac{\lambda_t}{R_t} = \beta E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}} \right) \tag{3.32}$$

where λ_t is the Lagrange multiplier associated with the budget constraint, $w_t = \frac{W_t}{p_t}$ denotes real wage and $\pi_{t+1} = \frac{p_{t+1}}{p_t}$ denotes the gross inflation rate.

Households have monopolistic power in the labor market and therefore set their own wages. A continuum of different labor types indexed by $j \in [0,1]$ is assumed to exist; labor employed by firm i is assumed to be an index given by:

$$H_t(i) \equiv \left[\int_0^1 H_t(i,j)^{\frac{\theta_w - 1}{\theta_w}} \right]^{\frac{\theta_w}{\theta_w - 1}}$$

where θ_w is a parameter denoting the substitution elasticity among labor varieties.

Let $W_t(j)$ denote the nominal wage set by households for $j - type$ of labor, for all $j \in [0, 1]$. Optimal demand for $j - type$ of labor, aggregating the cost minimization result of each and every firm i, is given by:

$$H_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\theta_w} H_t \qquad (3.33)$$

for all $j \in [0, 1]$.

$H_t = \int_0^1 H_t(i)$ represents total hours worked, across firms, in the economy, while W_t is an aggregate nominal wage index given by:

$$W_t \equiv \left[\int_0^1 W_t(j)^{1-\theta_w}\right]^{\frac{1}{1-\theta_w}} \qquad (3.34)$$

Nominal wages are sticky a-la Calvo (1983), in that a fraction ϕ_w of households is not allowed to optimally reset her own wage in each period t. The resulting average duration of wage contracts, in such a framework, is notably given by $1/(1 - \phi_w)$.

When setting her own optimal wage W_t^* household j maximizes (3.28) subject to both the budget constraint (3.29) and the optimal demand (3.33) for her own variety of labor services. The FOC are given by:

$$\sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ H_{t+k}(j) \left[\frac{W_t^*}{P_{t+k}} MU_{C,t+k} + \mu_w MU_{H,t+k}(j) \right] \right\} = 0 \qquad (3.35)$$

where MU_C and MU_H are the marginal utility of consumption and hours respectively and where $\mu_w = \frac{\theta_w}{\theta_w - 1}$ is the desired (steady-state) markup of the real wage. (3.35) can be rewritten as:

$$\sum_{k=0}^{\infty} (\beta\phi_w)^k E_t \left\{ H_{t+k}(j) MU_{C,t+k} \left(\frac{W_t^*}{P_{t+k}} - \mu_w MRS_{t+k} \right) \right\} = 0 \qquad (3.36)$$

where $MRS_{t+k} \equiv -\frac{MU_{H,t+k}}{MU_{C,t+k}}$ is the marginal rate of substitution between hours worked and consumption. As can be inferred by looking at 3.36, when households are fully free to optimally reset their wages in each period t, i.e. when $\phi_w = 0$, they do so by setting:

$$\frac{W_t^*}{P_t} = \frac{W_t}{P_t} = \mu_w MRS_t \qquad (3.37)$$

For this reason the constant wage markup μ_w is usually defined a "desired" wage markup in the economy. By combining a log-linear version of 3.36 with an expression for the Calvo-type evolution of wages[11] one obtains the commonly used log-liner New Keynesian Phillips curve for wage inflation:

$$\pi_t^w = \beta \pi_{t+1}^w - \kappa_w \mu_w \tag{3.38}$$

where $\kappa_w \equiv \frac{(1-\phi_w)(1-\beta\phi_w)}{\phi_w(1+\theta_w\sigma_L)}$.

3.5.1.5   Equilibrium

The economy's resource constraint is:

$$Y_t = C_t + I_t \tag{3.39}$$

Notice that, as in most of the BGG-related literature, the (wasted) resources devoted to the payment of monitoring costs are disregarded in the above constraint because of their negligible amount.

3.5.1.6   Monetary policy

The benchmark Taylor Rule is a feedback rule responding to deviations of the gross nominal inflation rate and of output from their corresponding steady-state values, and allowing for some degree of inertia:

$$\frac{R_t}{R} = \left(\frac{\pi_t}{\pi}\right)^{\rho_\pi(1-\rho_R)} \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \tag{3.40}$$

3.5.2   Calibration: pre and post financial deregulation economy

The discount factor β is set equal to 0.992, to imply an annual steady-state real interest rate of about 3.3% which approaches the historical average of the years which are being considered. As stated in Englund (1999) Sweden experienced sharply increasing interest rates at the beginning of the bust: real after-tax interest rate jumped from 1% in 1989 to 5% in 1991 and remained at high levels in subsequent years due to several factors. The German unification process led to an increase in international interest rates on one hand. Riksbank's

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[11] Given the probabilistic structure of the Calvo wage rigidity mechanism aggregate wage indeax in the economy, in each period t, evolves according to: $W_t = \left[\phi_w W_{t-1}^{(1-\theta_w)} + (1-\phi_w) W_t^{*(1-\theta_w)}\right]^{\frac{1}{1-\theta_w}}$

monetary policy became more restrictive after 1990 and both capital income tax and interest rate deductions were lowered by the tax reform becoming effective at the beginning of 1991.

The parameter χ, denoting the weight households assign to leisure in the utility function is calibrated so as to imply, as it is standard, a 1/3 share of households' time spent on market activities. The inverse elasticity of labor supply σ_L is set to 1, implying a benchmark elasticity of labor supply equal to unity. The parameters θ_p, denoting the degree of retailers' monopoly power, is set to 6 in order to obtain a steady-state markup equal to 20% , which is a value commonly used in the New-Keynesian literature. Price stickiness is modelled by setting $\phi_p = 0.75$, ensuring an average duration of price contracts of approximately 4 quarters. ϕ_w is set to 0 so as to assume flexible wages. The Central Bank inflation target π is set to 1 for simplicity. The share of entrepreneurial labor service,Ω, is set to 0.01 so as to ensure that entrepreneurial labor service accounts for 1% of the total wage bill, as explained in BGG. The quarterly capital depreciation rate δ is set equal to 0.015 to ensure that the quarterly steady-state capital-output ratio approaches the Swedish average ratio over the period. The capital share in the production of wholesale goods, α, is set to 0.25 as in Adolfson et al. (?). For the calibration of the monetary policy rule we choose $\rho_\pi = 1.4$ and no response of interest rates to deviations of output from steady-state ($\rho_y = 0$). The degree of inertia is chosen to be at $\rho_R = 0.4$.

As far as the financial contract is concerned, we illustrate in Appendix 7 as the steady-state of the key financial variables strictly depends on the value assigned to σ_ω, the standard deviation of the idiosyncratic shock to entrepreneurial activity, v, the survival rate of the entrepreneur and μ_b, the share of resources devoted to monitoring costs, once structural parameters α, β, δ and Ω have been calibrated as reported above.

We choose the share of resources devoted to direct and indirect costs of monitoring, μ_b, as the crucial parameter of the calibration exercise. Our BCA application finds that financial liberalization measures implemented in Sweden in the first half of the 1980s only marginally contributed to relax the investment financing constraints of firms. We choose to consider two detailed model economies that only differ with respect to the share of resources devoted to monitoring costs and, consequently, with respect to the steady-state level of those variables of the financial contract that are a function of monitoring costs. In particular, the BGG model economy with higher (lower) monitoring costs, μ_{bH} (μ_{bL}), is characterized by higher (lower) elasticity of the risk premium to the leverage position of the firm, higher (lower) steady-state risk premium and lower leverage ratio. Keeping the survival probability of firms to the upper bound proposed by Meier and Muller (2005), $v = 0.988$, and setting $\mu_{bL} = 0.236$[12] allows

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[12]Well within the estimated interval for the monitoring costs parameter estimated in Calstrom-Fuerst

matching the *leverage ratio* of firms in year 1990,documented in Englund (1999) to be at 68.2%. The model economy featuring higher monitoring costs (μ_{bH}) represents Sweden prior to the unfolding of credit boom phase, when the constraint-easing effects of the financial liberalization measures are not yet in place. Exploiting the BCA result on the dynamics of the investment wedge (see Figure 3.2 above), we set $\mu_{bH} = 0.26$ and therefore choose to model the easing of the investment financing frictions in Sweden as a 10% decrease in the share of economic resources devoted to monitoring costs. The calibration choice is such that the high monitoring costs economy is characterized by a firms' leverage ratio only 1 percentage point lower than the value matched for 1990. It is interesting to note that in order to match firms' leverage ratio dynamics documented in Englund (1999) for the period 1986-1990 the modeling approach adopted here would require a change in the monitoring costs share μ_b of approximately 30 percentage points.

Table 3: Quarterly Parameter Values - Detailed Economy

Parameter	Value	Parameter	Value
β	0.9722	α	0.25
η	1.4819	σ_ω	0.27
θ_p	6	v	0.988
θ_w	6	μ_{bL}	0.236
δ	0.015	μ_{bH}	0.26
ϕ_p	0.75	ρ_π, ρ_y	1.4 , 0
ϕ_w	0	ρ_R	0.4
Ω	0.01	σ_L	1

3.5.3 Results

When an adverse technology shock hits the economy described in the previous sections, two opposite effects are at work. Due to the jump of both nominal interest rates and inflation, the real cost of debt decreases causing an increase in entrepreneurial net worth. A fall in entrepreneurial net worth is instead the direct effect of falling returns on capital following an adverse aggregate shock. The second effect dominates, as already documented in Dib and Christensen (2008), when the monetary policy Taylor-rule is calibrated with sufficiently low responses to output deviations from steady-state. The rise in aggregate hours, independent

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(1997).

from the policy rule, appears to be a standard feature of New-Keynesian impulse responses to adverse aggregate productivity shocks, as is documented in Gali (1999): fallen productivity requires firms to produce the same amount of output with larger amounts of labor input.

To generate the impulse responses graphed in Figure 3.8 we use ρ_y to 0. The latter shows the behavior of output investment and consumption during the years 1990-1994 of the productivity-driven recession in Sweden. Each plot reports the behavior of the corresponding macroeconomic aggregate in both calibrations of *high* (μ_{bH}) and *low* (μ_{bL}) financial constraint. The exact overlapping of the series shows that, within a BGG economy, the firms' financial constraint improvement estimated through the BCA method is not able to generate noticeable differences in the way the economy responds to negative productivity shocks.

3.6 Concluding remarks

In the first part of this paper we apply the Business Cycle Accounting (BCA) methodology, pioneered in Chari Kehoe and McGrattan (2007a), to two episodes of the Swedish business cycle: the *credit boom* period of years 1986-1990, that followed the implementation of financial liberalization measures, and the economic *recession* of the early 1990s. We find a pattern of improvement of the investment wedge between the second half of 1987 and the beginning of 1990, contemporaneous to the main expansion of corporate lending figures reported in the literature. This result seems to suggest that, if any, financial deregulation had a small positive impact on firms' investment financing constraints. Our findings on the pattern of *realized wedges* and on *output decomposition* for the recession years suggest that: i) distortions to efficiency of production play a crucial role in shaping the recession pattern and turn out to be the only driving force of the recovery phase; ii) distortions captured by the investment wedge made the recession only slightly deeper but sensibly contributed to increase its persistence. We use the results of the BCA application on the easing of the financial constraint in order to calibrate to Sweden a Bernanke et al. (1998) economy in both the environments of pre and post financial liberalization and then feed in into the model the BCA-measured TFP series of the Swedish recession. Modeling the easing of the financial constraint as a 10% fall in the share of resources devoted to monitoring costs turns out to generate no material difference in the way Swedish macro variables respond to the recessionary productivity shock, suggesting that the measures of financial liberalization did not affect the vulnerability of the Swedish economy.
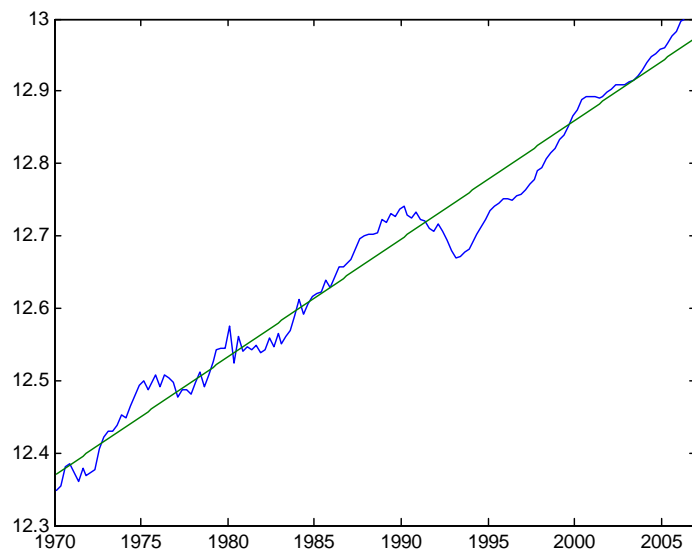
3.7 Figures

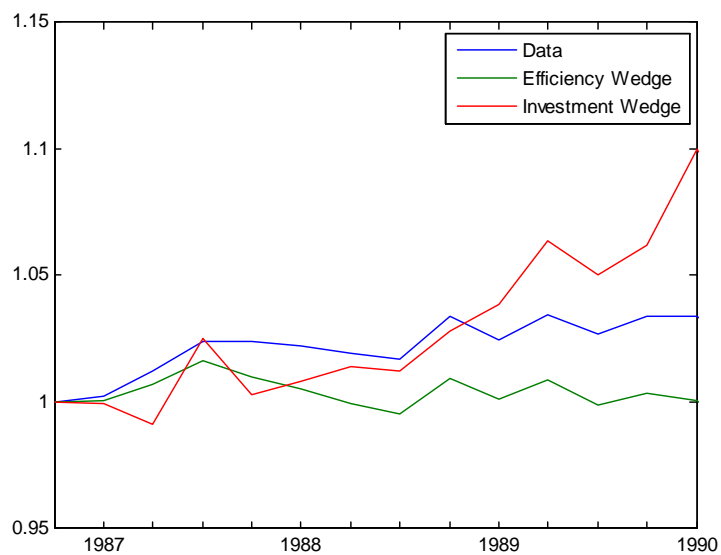Figure 3.1: Percapita GDP with linear trend 1970-2007 (log of 2000 chained SEK

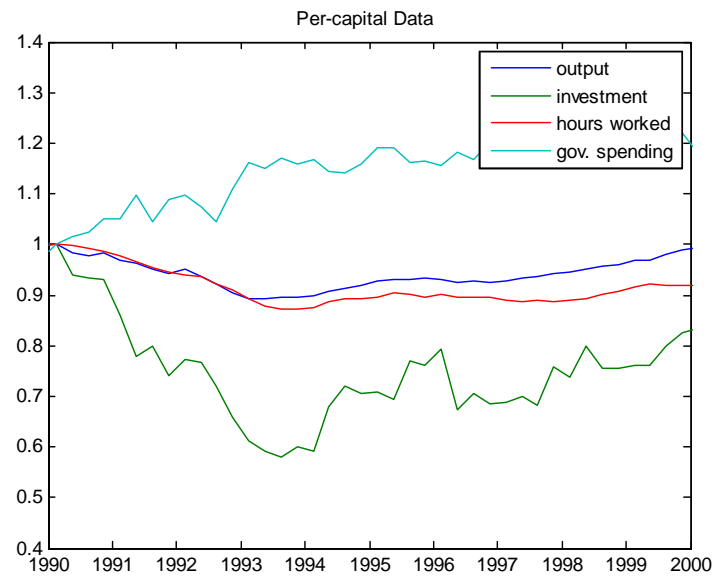Figure 3.2: Output and measured wedges: 1986-1990

Figure 3.3: Output, Investment, Hours, Public spending (percapita - detrended, 1990:Q1=1)
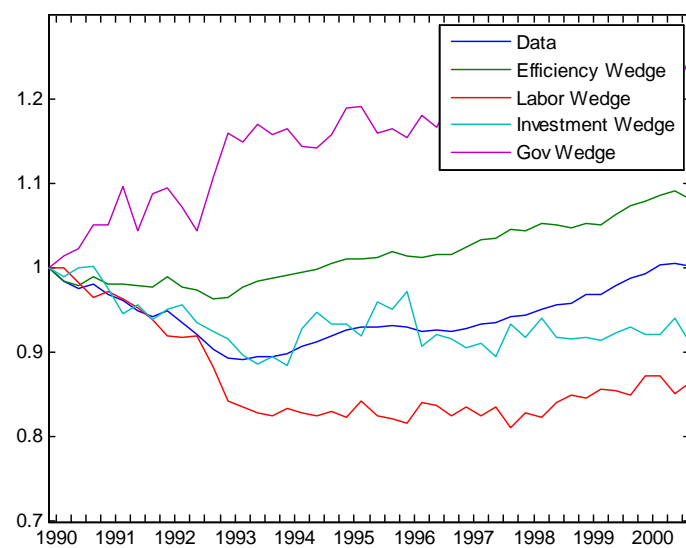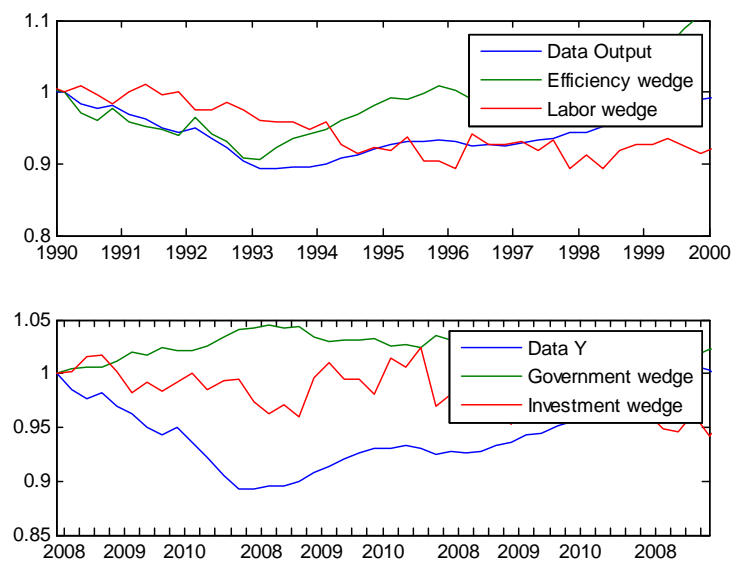

Figure 3.4: Output and measured wedges: 1990-2000.

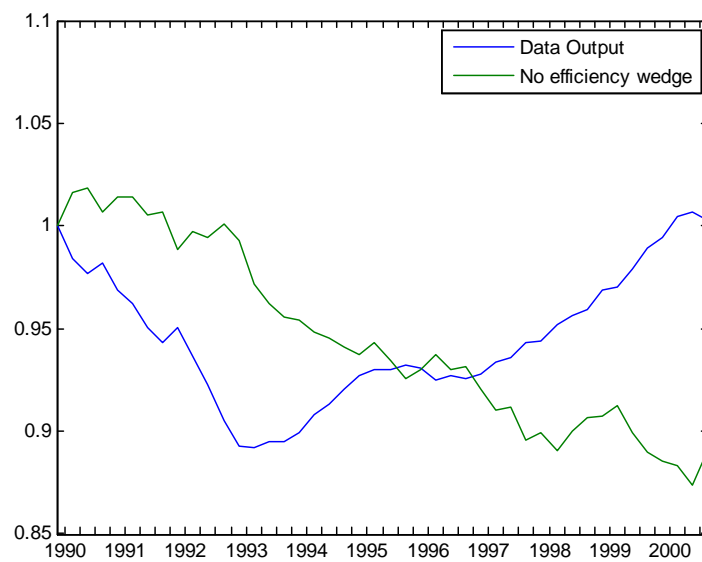Figure 3.5: Data variables and 1-wedge-economy variables

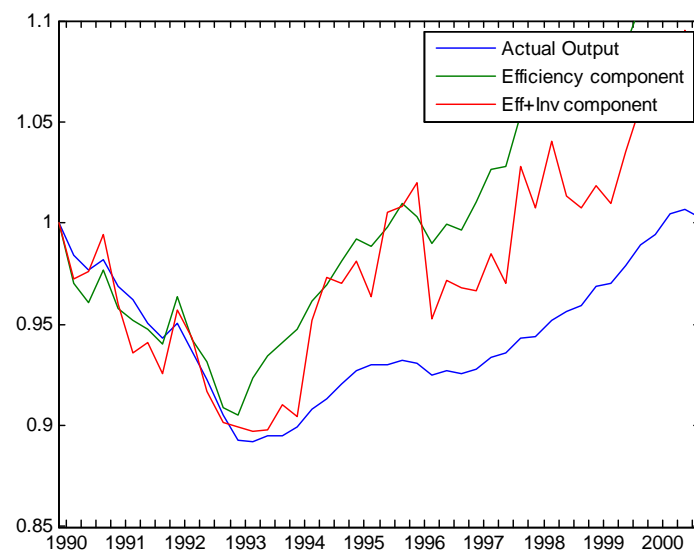Figure 3.6: Data variables and multiwedge-economy variables

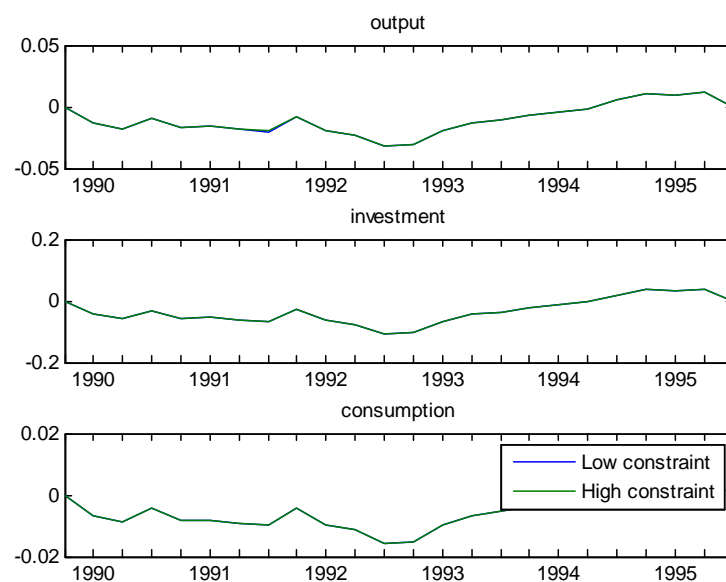Figure 3.7: Actual Output and 2-wedges model output

Figure 3.8: Estimated shock: responses are % deviations from steady-state. Different severity of financial constraint

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3.8 Appendices

3.8.1 Appendix 6: construction of variables for the BCA application

All of the time series data used in this paper, concerning Sweden in years 1970-2007, has been taken from OECD Economic Outlook 2008.[13] Most of the variables therein are *volume variables* reported in millions of 2000 SEK.

The percapita output series (y) has been obtained from Real GDP, subtracting deflated indirect taxes and then dividing by non-institutional population (population in the age 16-64). Percapita investment series (x) has been obtained summing Real Gross Private Investment (fixed plus inventories) to Government Gross Investment and then dividing by non-institutional population. Percapita public spending (g) results from the sum of Government Consumption and Net exports of goods and services, all divided by non-institutional population. The variable hours per worker (l) has been obtained using the quarterly figure of the Annual Average Hours Worked in the economy. The latter has been multiplied by the quarterly figure of Total Employment and then divided by non-institutional population.

The time series for the economy Capital Stock has been constructed making use of the perpetual inventory method.

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[13]Available online for subscribers at www.sourceoecd.org.

3.8.2 Appendix 7: the financial accelerator at steady-state

In this appendix we illustrate the characterization of the financial contract between the entrepreneur and the bank at the non-stochastic steady-state.

Let N denote the steady-state level of entrepreneurial wealth, K the steady-state level of the capital stock and Q the steady-state price of capital (equal to unity because of the absence of capital adjustment costs at steady-state). The entrepreneur borrows at steady-state the amount $QK - N$ to purchase K units of capital. The total payoff provided by the project of the individual entrepreneur, for a given realization of idiosyncratic risk, is given by ωR^K when aggregate risk is not in the model, and by $u\omega R^K$ when one allows for the possibility of aggregate shock u to occur.

After the realization of the idiosyncratic shock, the borrower can costlessly observe it while the lender has to pay a monitoring cost $\mu_b \omega R^K$ which

is proportional to the realized payoff. As already mentioned, the optimal contract in this framework establishes a threshold value $\bar{\omega}$ such that: i) for $\omega \geq \bar{\omega}$ the borrower pays the lender the fixed amount $\bar{\omega} u R^K QK$ and keeps the remaining resources $(\omega - \bar{\omega})u R^K QK$; ii) for $\omega < \bar{\omega}$ the borrower defaults and the lender is allowed to seize all remaining resources net of monitoring costs, i.e. $(1 - \mu_b)\omega u R^K QK$.

Given that the lender operates by assumption in a competitive market it has to earn zero profits and therefore faces an opportunity cost which is given by the simple real interest rate of the economy, R/π. Therefore the optimal contact has to maximize the entrepreneur's share of resources subject to the following zero-profits condition for the competitive bank:

$$\left((1-\mu)\int_0^{\bar{\omega}} \omega f(\omega)d\omega + \bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega)d\omega\right) u R^K QK = (R/\pi)(QK - N) \quad (3.41)$$

Defining the following variables:

$$\Gamma(\bar{\omega}) = \int_0^{\bar{\omega}} \omega f(\omega)d\omega + \bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega)d\omega \qquad \text{lender's gross share,}$$

$$\mu G(\bar{\omega}) = \mu\int_0^{\bar{\omega}} \omega f(\omega)d\omega \qquad \text{share of resources devoted to monitoring costs,}$$

$k = QK/N$ \quad capital to net worth ratio,

$s = R^K/R \cdot \pi$ \quad gross risk premium,

the payoff of the entrepreneur can be rewritten as $1 - \Gamma(\bar{\omega})$ and therefore the optimal contract is defined by the threshold $\bar{\omega}$ that solves the following Lagrangian problem:

$$L = E\left\{[1 - \Gamma(\bar{\omega})]\,usk + \lambda\left[\Gamma(\bar{\omega}) - \mu G(\bar{\omega})\right]usk - (k-1)\right\}, \quad (3.42)$$

where $E\{\}$ is the expectation taken over the distribution of the aggregate shock u. The problem is characterized by the following First Order Conditions:

$$\bar{\omega}: \qquad \Gamma(\bar{\omega}) - \lambda\left[\Gamma'(\bar{\omega}) - \mu_b G'(\bar{\omega})\right] = 0 \qquad (3.43)$$

$$k: \qquad E\left\{\left[(1 - \Gamma(\bar{\omega})) + \lambda(\bar{\omega})(\Gamma(\bar{\omega}) - \mu_b G(\bar{\omega}))\right]us - \lambda(\bar{\omega})\right\} = 0 \qquad (3.44)$$

$$\lambda: \qquad \left[\Gamma(\bar{\omega}) - \mu_b G(\bar{\omega})\right]sk - (k-1) = 0 \qquad (3.45)$$

Since we are interested here in the steady-state calibration of the financial contract, when the multiplicative aggregate shock is equal to 1, we solve the FOC following Gilchrist and Natalucci (2003).

Using the FOC with respect to the threshold $\bar{\omega}$ one can obtain:

$$\lambda(\bar{\omega}) = \frac{\Gamma'(\bar{\omega})}{\Gamma'(\bar{\omega}) - \mu_b G'(\bar{\omega})} \qquad (3.46)$$

using the FOC with respect to k :

$$s = \frac{\lambda(\bar{\omega})}{(1 - \Gamma(\bar{\omega})) + \lambda(\bar{\omega})\left[\Gamma(\bar{\omega}) - \mu_b G(\bar{\omega})\right]} \qquad (3.47)$$

using the FOC with respect to λ :

$$k(\bar{\omega}) = \frac{1 - \Gamma(\bar{\omega}) + \lambda(\bar{\omega})[\Gamma(\bar{\omega}) - \mu_b G(\bar{\omega})]}{1 - \Gamma(\bar{\omega})} \qquad (3.48)$$

BGG show that both with and without aggregate shocks in the model, one has that $s'(\bar{\omega}) > 0$ and $k'(\bar{\omega}) > 0$. As a consequence there exists a relationship of the type $k = F(s)$ with $F'(s) > 0$, i.e. the capital to net worth ratio of the entrepreneur is crucially linked to the level of the external finance premium.

We follow BGG and assume that $\ln(\omega)\tilde{\,}N(-(1/2)\sigma_\omega^2, \sigma_\omega^2)$ and that $E(\omega) = 1$. This implies that:

$$\Gamma(\bar{\omega}) = \Phi(z - \sigma) + \bar{\omega}[1 - \Phi(z)] \qquad (3.49)$$

and

$$\Gamma(\bar{\omega}) - \mu_b G(\bar{\omega}) = (1 - \mu_b)\Phi(z - \sigma) + \bar{\omega}[1 - \Phi(z)] \tag{3.50}$$

To find out the steady-state $\bar{\omega}$ one has to recall the steady-state expression of entrepreneurial net worth:

$$N = vV + \frac{1}{\mu}\Omega Y \tag{3.51}$$

where:

$V = (1 - \Gamma(\bar{\omega})) R^K Q K$ and $R^K = \alpha \cdot \frac{1}{\mu} \cdot \frac{Y}{K} + (1 - \delta)$.

Combining the previous two:

$$\frac{N}{K} - (1 - \Gamma(\bar{\omega})) R^K - \frac{1}{\mu}\Omega\frac{Y}{K} = \frac{N}{K} - (1 - \Gamma(\bar{\omega})) R^K - [R^K - (1 - \delta)]\frac{\Omega}{\alpha} \tag{3.52}$$

$$= \frac{N}{K(R/\pi)} - (1 - \Gamma(\bar{\omega})) \frac{R^K}{R/\pi} - [\frac{R^K}{R/\pi} - \frac{(1-\delta)}{R/\pi}]\frac{\Omega}{\alpha}$$

$$= \beta k^{-1} - (1 - \Gamma(\bar{\omega})) s - [s - (1 - \delta)\beta]\frac{\Omega}{\alpha} = 0$$

After choosing appropriate values for $\Omega, \alpha, \beta, \delta, \mu_b, v, \sigma_\omega^2$ one can numerically compute the threshold $\bar{\omega}$ that minimizes the right-hand-side of the expression above.

3.8.3 Appendix 8: The system at steady-state

Steady-state gross inflation rate is set to $\pi = 1$.
From condition3.32 one has:

$$R = \pi/\beta = 1/\beta = RR \tag{3.53}$$

Capital evolution law 3.21 is such that at steady-state:

$$I = \delta K \tag{3.54}$$

Replacing the former in the Tobin's Q equation 3.20 provides the price of capital at steady-state:

$$Q = 1 \tag{3.55}$$

From condition **??** one has:

$$R^K = RR \cdot rp \tag{3.56}$$

From definition **??** one has that steady-state marginal product of capital is:

$$z = R^K - 1 + \delta \tag{3.57}$$

Pricing 3.25 at steady-state is such that real marginal cost is pinned down as follows:

$$mc = \frac{1}{\mu_p} = \frac{\theta_p - 1}{\theta_p} \tag{3.58}$$

Wage setting at steady-state is such that:

$$\frac{w}{MRS} = \mu_w = \frac{\theta_w}{\theta_w - 1} \tag{3.59}$$

Steady-state **??** determines:

$$\frac{K}{Y} = \frac{\alpha}{z} \cdot mc \tag{3.60}$$

From 3.39:

$$\frac{C}{Y} = 1 - \delta\frac{K}{Y} \tag{3.61}$$

Real wage **??** is :

$$w = mc(1 - \Omega)(1 - \alpha)\frac{Y}{H} \tag{3.62}$$

$$w^e = mc\Omega(1 - \alpha)\frac{Y}{H} \tag{3.63}$$

Imposing $H = 1/3$ at steady-state one can obtain the resulting weigh of hours worked in the utility function:

$$\chi = \frac{w}{\mu_w H^{(\sigma_L)}C} \tag{3.64}$$

3.8.4 Appendix 9: The log-linear system

$$\lambda_t = -c_t \tag{3.65}$$

$$w_t - (\sigma_L h_t + c_t) = wmp_t \tag{3.66}$$

$$rr_t = r_t - E_t \pi_{t+1} \tag{3.67}$$

$$0 = \lambda_{t+1} - \lambda_t + rr_t \tag{3.68}$$

$$w_t = y_t + mc_t - h_t \tag{3.69}$$

$$\hat{w}_t^e - \hat{y}_t - \hat{m}c_t = 0; \tag{3.70}$$

$$z_t = y_t + mc_t - k_{t-1} \tag{3.71}$$

$$L_t = (1 - \Omega)h_t \tag{3.72}$$

$$y_t = (1 - \alpha)L_t + \alpha k_{t-1} \tag{3.73}$$

$$y_t = \frac{c}{y}c_t + \frac{i}{y}i_t + \Gamma_t \tag{3.74}$$

$$k_t = (1 - \delta)k_{t-1} + \delta i_t \tag{3.75}$$

$$q_t = \varphi(i_t - k_{t-1}) \tag{3.76}$$

$$d_t = \frac{k}{d}(q_t + k_t) - \frac{n}{d}n_t \tag{3.77}$$

$$rp_t = \Phi(q_t + k_t - n_t) \tag{3.78}$$

$$r_t^K = \frac{z}{R^K} \cdot z_t + \frac{(1-\delta)}{R^K} q_t - q_{t-1} \tag{3.79}$$

$$r_{t+1}^K = rp_t + rr_t \tag{3.80}$$

$$\pi_t = \beta \pi_{t+1} + \kappa mc_t \tag{3.81}$$

$$\frac{n_t}{vR^K} = \frac{k}{n} r_t^K - (\frac{k}{n} - 1)(rp_{t-1} + rr_{t-1}) + n_{t-1} + (1-\alpha)\Omega \frac{y}{n} \frac{1}{\mu v R^K} \hat{w}_t^e \tag{3.82}$$

$$r_t = (1 - \rho_R)\rho_\pi \pi_t + \rho_R r_{t-1} \tag{3.83}$$

where the term:

$\Gamma_t = R^K(1-v)\{\Psi(\frac{n}{Y} - \frac{k}{Y})q_{t-1} + \Psi(\frac{n}{Y} - \frac{k}{Y})k_t + [\Psi(\frac{k}{Y} - \frac{n}{Y}) + \frac{n}{Y}]n_t + (\frac{n}{Y} - \frac{k}{Y})R_{t-1} + (\frac{k}{Y} - \frac{n}{Y})\pi_t\}$
is usually considered negligible due to $v \simeq 1$.