

**PRIVATE INFORMATION EFFECTS ON THE LABOUR WEDGE CYCLICAL
BEHAVIOR**

A Thesis
Presented to
The Academic Faculty

By

María Paula Tulcán V.

In Partial Fulfillment
of the Requirements for the
Master Degree in
Economics

Universidad del Rosario

May 2019

**PRIVATE INFORMATION EFFECTS ON THE LABOUR WEDGE CYCLICAL
BEHAVIOR**

Supervised by:

Dr. Juan J. Ospina- Tejeiro
Jefe Asesor
Sección Sector Público
Banco de la República

*"My bounty is as boundless as the sea,
My love as deep; the more I give to thee,
The more I have, for both are infinite."*

William Shakespeare, Romeo and Juliet

*Whit all my love to: God, Holly Mary, María, Nelson, Juan, Andrés and Joao
who have always supported and inspired me with their unconditional love.*

TABLE OF CONTENTS

List of Tables	3
List of Figures	4
Chapter 1: Introduction	1
Chapter 2: Technical Approach: The model	4
2.1 Households	4
2.1.1 Utility Maximization	4
2.1.2 Aggregation	5
2.2 Firms	6
2.2.1 First best contract	7
2.2.2 Second best contract	8
Chapter 3: The Labor Wedge	13
Chapter 4: Simulation	16
4.1 Calibration	16
4.2 Methodology	17
4.3 Results	20
4.4 Robustness Analysis	23

Chapter 5: Conclusion	28
Appendix A: Logarithmic preferences	31
Appendix B: Proof of Proposition 1	33
References	35

LIST OF TABLES

4.1	Calibration	17
4.2	Effects of calibration in correlation coefficient (ρ)	24

LIST OF FIGURES

3.1	Labor wedge cyclical behavior in recession periods (taken from Shimer 2009)	15
4.1	Model with Productivity Shocks	20
4.2	Model with Demand Shocks	21
4.3	General Model (50-50 Variance in Output)	22
4.4	Evolution of correlation (ρ) with calibration	25
4.5	Model with positively correlated shocks	26
4.6	Model with negatively correlated shocks	26
A.1	Model with logarithmic preferences	32

ABSTRACT

Explaining the origin and behavior of business cycles has been the focus of a vast array of research. A series of studies have shown that the labor wedge exhibits a countercyclical behavior, which plays a key role in the magnitude and duration of the cycles. Therefore, it is crucial to understand the reasons behind the labor wedge countercyclicity. We propose asymmetric information in the form of adverse selection as a possible explanation for this phenomenon. To determine the effects of asymmetric information on the labor market, we construct a Dynamic Stochastic General Equilibrium (DSGE) model in which we introduce adverse selection through heterogeneity of households.

Our findings suggest that when information costs are not so volatile (this needs elaboration), adverse selection leads to a negative correlation between output and the labor wedge, implying a countercyclical behavior of the latter. We conclude that private information can be considered a driving force behind the dynamics of the labor wedge along the business cycle, and encourage future research to thoroughly explore it.

Keywords: Labor Wedge, Adverse Selection, DSGE

JEL classification codes: E24, E32, D82, J22

CHAPTER 1

INTRODUCTION

The explanation of the origin, the strength and the duration of business cycles is a well-established area of research. A factor that contributes to understand the previous characteristics of the cycles is the behavior of the labor market. In general, this behavior could be explained by the interaction of three variables: the marginal rate of substitution between consumption and leisure, the marginal productivity of labor and the labor wedge. Whereas the first two have been thoroughly explored, the reasons behind the existence and behavior of the wedge are not yet clear.

Shimer [2009](#) provides strong evidence suggesting the existence of a long run labor wedge, and that this wedge is negatively correlated to the output cycle. Additionally, he argues that the countercyclical labor wedge has an impact on the cycle itself. In other words, different wedges lead to different responses of economies to the same shock, thus altering the behavior of the business cycles.

Typical explanations of this correlation are based on the existence of two forms of rigidities in the labor market. The first ones are nominal rigidities. Economists usually argue that all prices are sticky (including nominal wages) and that this stickiness does not need to be the same among them, hence real wages may vary because of this fact. The second ones are real rigidities. Among them, the existence of taxes was initially named¹ as the cause of the wedge. Nonetheless, several studies, including Shimer [2009](#) and McGrattan and Prescott [2009](#), have shown that even if this explanation holds in some countries taxes by themselves can't explain the whole wedge in all countries. Thereby, there must be additional forces driving the behavior of the labor wedge.

Some of the alternative explanations that have been studied are misspecification of

¹McGrattan and Prescott [2009](#)

household's preferences, time varying preference parameters, heterogeneity in agents and the relaxing in the assumption of a competitive labor market. As far as the latter is concerned, research has been mainly focused in search and matching models based on Pissarides 1985 and Mortensen and Pissarides 1994. These models include the additional decision on whether the individual should work or not.

In this paper we explore an alternative explanation for the countercyclical behavior of the labor wedge at business cycles frequencies. We believe that the behavior of the labor wedge can be potentially explained by the existence of asymmetric information in the form of adverse selection in the firm's decision, and we propose an intuitive reason for why it could be the case.

Specifically, we begin from the basic RBC (Real Business Cycle) model and introduce two different types of households (workers) that differ in their labor disutility and can keep this information private. Firms then try to maximize profits facing a different information set. In particular, they do not know each household type but the distribution of the population.

When facing this information constraint, firms decide to incur an additional information cost (a change in labor demand that affects the general equilibrium allocation) to obtain perfect information. This decision is based on their profit maximization strategy as any different decision leads to lower or even negative profits.

We show that the information cost that leads to the existence of a labor wedge is not very volatile, hence implying a countercyclical behavior of the wedge. Intuitively, in a recession firms can not offer sufficiently low wages because the information cost becomes more important in their wage decision. Thus, wages become less efficient and the labor wedge increases. In a symmetric fashion, when the economy is in the high part of the output cycle the information cost becomes less relevant in the wage decision and the wages become more efficient, thus the labor wedge decreases. Hence, when information costs remain relatively constant the adverse selection problem leads to a countercyclical labor

wedge.

The importance and effectiveness of this channel will depend on two facts: the number of shocks that affect the economy and their relative variance. We show that when there is only one source of uncertainty the correlation between the labor wedge and the output is very high. However, when introducing multiple shocks at the same time variance plays a crucial role. Depending on the variance of shocks it can be the case that the volatility of the series is explained by each shock in a different percentage; this is, series can have a different variance decomposition as it will depend on the model structure and the calibration. Different variance decompositions lead to different responses to each shock affecting the correlation between output and the labor wedge series.

The rest of the paper consists of: chapter 2, which describes the theoretical model; chapter 3, which provides an explanation and description of the facts that determine the labor wedge behavior; chapter 4, which shows simulations of the model in order to illustrate previous descriptions, and chapter 5 that concludes and explores some ideas for future research.

CHAPTER 2
TECHNICAL APPROACH: THE MODEL

2.1 Households

2.1.1 Utility Maximization

We assume that there are two different types of households that differ in their labor disutility. There is a proportion Γ of them who are type one and $(1 - \Gamma)$ that are type two. The representative household of each type seeks to maximize its instant utility given by:

$$u_t = \ln \left(c_t^j - \chi^j \frac{(h_t^j)^{1+\eta}}{1+\eta} \right) \quad (2.1)$$

where h_t is the total amount of hours spent working, c_t is the average per capita consumption bundle for each member of the household, η is the inverse of the Frisch elasticity and $j \in \{1, 2\}$ represents the household type where $\chi^2 = 2\chi^1$.

Each household earns a real wage after taxes per worked hour, $(1 - \tau^w) w_t^j$ (where τ^w is the effective tax rate over labor income) and receives real profits, ξ_t , from firms. Then, the budget constraint for each type of household is:

$$c_t^j = (1 - \tau^w) w_t^j h_t^j + \xi_t \quad \text{for } j = 1, 2 \quad (2.2)$$

This is also known as households being hand-to-mouth.

The first order conditions for both households are:

$$\begin{aligned} [c_t^j]: \quad \lambda_t^j &= \frac{1}{c_t^j - \chi^j \frac{(h_t^j)^{1+\eta}}{1+\eta}} \\ [h_t^j]: \quad (1 - \tau^w) w_t^j &= \chi^j (h_t^j)^\eta \end{aligned}$$

Taxes are used to finance government spending (g_t) which is exogenous and will not have any effect on production. Government spending follows a log-AR(1) process of the form:

$$\ln(g_t) = \rho_g \ln(g_{t-1}) + (1 - \rho_g) \ln(\bar{g}) + \varepsilon_t^g$$

where \bar{g} is the long run mean, $\rho_g \in [0, 1)$ and $\varepsilon_t^g \stackrel{iid}{\sim} \mathcal{N}(0, \sigma^g)$.

We decided to introduce distorting taxation due to the absence of smoothing mechanisms that will account for movements in the GDP when facing this type of shocks. In other words, under our setup if taxes are not distorting then we have perfect crowding out leading to an unchanged GDP.

2.1.2 Aggregation

We allow for imperfect substitution among labor types², hence our definition of aggregate labor is:

$$h_t = (h_t^1)^\alpha (h_t^2)^{(1-\alpha)}$$

As there is a proportion Γ of households of type one, all other aggregated real variables are linear combinations of households specific variables, then:

$$c_t = \Gamma c_t^1 + (1 - \Gamma) c_t^2$$

$$w_t = \Gamma w_t^1 + (1 - \Gamma) w_t^2$$

²The reasons to have this imperfect substitution are described in the explanation of the production function.

2.2 Firms

We assume profit-maximizing firms. Profits are given by:

$$\xi_t = y_t - \Gamma w_t^1 h_t^1 - (1 - \Gamma) w_t^2 h_t^2 \quad (2.3)$$

where,

$$y_t = z_t (h_t^1)^\alpha (h_t^2)^{(1-\alpha)} \quad (2.4)$$

is the production function and z_t is a transitory productivity shock that follows a log-AR(1) process of the form:

$$\ln(z_t) = \rho_z \ln(z_{t-1}) + (1 - \rho_z) \ln(\bar{z}) + \varepsilon_t^z \quad (2.5)$$

As in the case of the government spending shocks, we have that \bar{z} is the long run mean, $\rho_z \in [0, 1)$ and $\varepsilon_t^z \stackrel{iid}{\sim} \mathcal{N}(0, \sigma^z)$.

The functional form of the production function captures two empirical relations among different workers in enterprises. First, it captures differences in productivity that may lead to task specification and second, as suggested by Grossman 2004, different people learn from each other and that learning might increase their productivity.

Additionally, firms face an adverse selection problem given by their need of hiring labor from both types of households and their inability to see each household type (determined by its specific labor dis-utility), then, we define first and second best contracts in order to determine the changes in the economy introduced by the hidden information.

Notice here the importance of both heterogeneity and private information. The existence of private information implies that the marginal productivity of labor (MPL) is not equal to the wage. This difference means that the labor market is not competitive and, hence, it is crucial for the existence of a labor wedge. As remarked by Shimer 2009 the

labor market being not competitive is one of the possible reasons of the existence of the labor wedge. However, in order to have adverse selection we need to introduce heterogeneity in the households. The reason is that in the absence of heterogeneity private information doesn't imply information asymmetry, as all workers will be identical. This equilibrium is the second best equilibrium.

Heterogeneity by itself (under our modeling) doesn't generate a labor wedge. The reason is that the optimal decision of firms will be to adjust their demand by household type and the equilibrium will have two wages that will be optimal (equal to the correspondent MPL). This is in fact the first best equilibrium.

2.2.1 First best contract

In the first best contract, firms can see each household type, then, they face an unconstrained maximization of ξ_t by replacing y_t . First order conditions are:

$$\begin{aligned} [h_t^1]: \quad \Gamma w_t^1 &= \alpha \frac{y_t}{h_t^1} \\ [h_t^2]: \quad (1 - \Gamma) w_t^2 &= (1 - \alpha) \frac{y_t}{h_t^2} \end{aligned}$$

As usual, the firm equalizes each household wage to its correspondent MPL. Notice that if $\alpha = \Gamma$ we create an environment in which the difference between households wages and hours worked depends only in their labor disutility.

In this environment the contract offered to household type one will be one in which they work more hours leading to a fewer wage and the opposite will be true for household type two, hence type one households will have incentives to hide its type (and pretend to be type two) if that information becomes private leading to negative profits of firms.

It's important to understand the difference between a partial equilibrium contract and a general equilibrium one. In partial equilibrium the typical interpretation is that firms offer a wage and households decide the amount of time they are willing to work at that wage. In general equilibrium however, with price-taking firms, the best way to understand a contract

is by thinking in demand curves. When firms can identify each household type they create a different demand for each type of labor leading to two different general equilibrium outputs for wages and hours worked. Both the quantity and the wage are the result of general equilibrium interaction between supply and demand, not an imposition of any of the agents. The resulting contract is then the wage-hours couple that each household takes.

Clearly, if the firms don't solve the private information problem they can only provide one demand curve (which is going to be a flat wage) and the difference will be in terms of hours offered at that wage.

An important remark is that calibration of the model must be very careful as some choices of parameters α and Γ may lead to situations in which type one households do not want to keep their information private and/or type two households decide to hide their type.³

2.2.2 Second best contract

When firms can not see households' type they face an issue as type one households would find optimal to pretend to be type two as they will get a higher utility. Then, firms must introduce both incentive and participation constraints into their maximization problem in order to offer enough incentives to households to accept their specific contract and also reveal their specific type, in general firms solve:

$$\max_{\{h_t^1, h_t^2\}} \xi_t = z_t (h_t^1)^\alpha (h_t^2)^{(1-\alpha)} - \Gamma w_t^1 h_t^1 - (1 - \Gamma) w_t^2 h_t^2$$

subject to

³Through the rest of the paper we describe environments as the one of $\alpha = \Gamma$ but we also provide values for this parameters the may lead to changes in this setup.

$$\begin{aligned}
\ln \left(c_t^1 - \chi^1 \frac{(h_t^1)^{(1+\eta)}}{1+\eta} \right) &\geq \bar{u}^1 \\
\ln \left(c_t^2 - \chi^2 \frac{(h_t^2)^{(1+\eta)}}{1+\eta} \right) &\geq \bar{u}^2 \\
\ln \left(c_t^1 - \chi^1 \frac{(h_t^1)^{(1+\eta)}}{1+\eta} \right) &\geq \ln \left(c_t^2 - \chi^1 \frac{(h_t^2)^{(1+\eta)}}{1+\eta} \right) \\
\ln \left(c_t^2 - \chi^2 \frac{(h_t^2)^{(1+\eta)}}{1+\eta} \right) &\geq \ln \left(c_t^1 - \chi^2 \frac{(h_t^1)^{(1+\eta)}}{1+\eta} \right)
\end{aligned}$$

and to the budget constraints of both households.

Notice that, even with hidden information, firms profits are the same because the probability of being a type one household has to be equal to the proportion of this type of households in the economy.

Now we determine which of these four constraints should be binding. Lets consider first the incentive constraints. As described above, only type one households have incentives to keep their information private so we keep their incentive constraint (and we make an appropriate chose of parameters α and Γ).

Regarding participation constraints it is usually the case that one of them is binding as firms should assure that both households decide to take their contracts. However, that case is based on the assumption of the existence of some reservation utility, in our setup Inada conditions and the absence of other sources of income imply that any household will decide to take any contract offered by the firm as it will represent the possibility of getting some positive consumption. Thus, neither of the participation constraints is binding.

Firm's problem is then reduced to:

$$\max_{\{h_t^1, h_t^2\}} \xi_t = z_t (h_t^1)^\alpha (h_t^2)^{(1-\alpha)} - \Gamma w_t^1 h_t^1 - (1 - \Gamma) w_t^2 h_t^2 \quad (2.6)$$

subject to

$$\ln \left(c_t^1 - \chi^1 \frac{(h_t^1)^{(1+\eta)}}{1+\eta} \right) = \ln \left(c_t^2 - \chi^1 \frac{(h_t^2)^{(1+\eta)}}{1+\eta} \right) \quad (2.7)$$

and to the budget constraints of both households.

First order conditions are:

$$\begin{aligned} [h_t^1] : \alpha \frac{y_t}{h_t^1} - \Gamma w_t^1 + \varphi_t \frac{(1 - \tau^w) w_t^1 - \chi^1 (h_t^1)^\eta}{c_t^1 - \chi^1 \frac{(h_t^1)^{(1+\eta)}}{1+\eta}} &= 0 \\ [h_t^2] : (1 - \alpha) \frac{y_t}{h_t^2} - (1 - \Gamma) w_t^2 - \varphi_t \frac{(1 - \tau^w) w_t^2 - \chi^1 (h_t^2)^\eta}{c_t^2 - \chi^1 \frac{(h_t^2)^{(1+\eta)}}{1+\eta}} &= 0 \end{aligned}$$

The assumption of hand-to-mouth households is critical in this approach to keep things simple and tractable. The reason is that current consumption will depend only on the current budget constraint. The introduction of any backward looking asset (debt, capital, among others) implies that we have to take into account both the lifetime budget constraint and the lifetime expected utility, not just the current ones, leading to an intertemporal problem both for firms and households.

Notice that for both households labor supply combined with the first order condition of its consumption implies that the additional term in type 1 labor demand is equal to zero, to see this remember that:

$$(1 - \tau^w) w_t^i = \chi^i (h_t^i)^\eta$$

with this in mind and using the the budget constraint of household type 2 we can rewrite first order conditions as:

$$\begin{aligned} [h_t^1] : \Gamma w_t^1 &= \alpha \frac{y_t}{h_t^1} \\ [h_t^2] : (1 - \Gamma) w_t^2 &= (1 - \alpha) \frac{y_t}{h_t^2} - \varphi_t \frac{(h_t^2)^\eta (\chi^2 - \chi^1)}{(h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) + \xi_t} \end{aligned} \quad (2.8)$$

As expected, there is no distortion in the contract offered to type one households, however the additional term in type 2 labor demand warranty that their new contract is incentive compatible.

An important question remains regarding if the firm has incentives to solve the information asymmetry. Clearly, firms will solve this problem if they can make more profits from this decision. Thus, a comparison between profits among both expected scenarios is sufficient as a proof of the firms incentives to solve the problem. Propositions 1 lead to a formal description of profits when firms do not solve the adverse selection problem.

Proposition 1. *Under asymmetric information in the form of adverse selection, if firms do not solve this problem they perceive negative profits.*

Proof. See Appendix B.

However, if the firm does solve the adverse selection problem then the expected and realized profits will be identical. We can then apply the solution proposed as a second best. In particular, from the first order conditions of the firm, we have:

$$\begin{aligned} w_t^1 h_t^1 &= \frac{\alpha}{\Gamma} y_t \\ w_t^2 h_t^2 &= \frac{(1-\alpha)}{(1-\Gamma)} y_t - \frac{\varphi_t}{(1-\Gamma)} \frac{(h_t^2)^{(1+\eta)} (\chi^2 - \chi^1)}{(h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) + \xi_t} \end{aligned}$$

Hence the realized profits of the firm are:

$$\begin{aligned} \xi_t &= z_t (h_t^1)^\alpha (h_t^2)^{(1-\alpha)} - \Gamma w_t h_t^1 - (1-\Gamma) w_t h_t^2 \\ &= y_t - \alpha y_t - (1-\alpha) y_t + \varphi_t \frac{(h_t^2)^{(1+\eta)} (\chi^2 - \chi^1)}{(h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) + \xi_t} \\ &= \varphi_t \frac{(h_t^2)^{(1+\eta)} (\chi^2 - \chi^1)}{(h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) + \xi_t} \end{aligned}$$

The last equality implies that ξ_t has two roots given by the following equation:

$$0 = (\xi_t)^2 + (h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) \xi_t - \varphi_t \frac{(h_t^2)^{(1+\eta)} (\chi^2 - \chi^1)}{1+\eta}$$

As the independent term is negative the roots must have different signs, which means that a positive root exists. Also by taking into account the optimal decision of firms we can discard the negative root, then $\xi_t > 0$ when the firms solve the asymmetric information problem.

Clearly, as firms want to maximize their profits they have incentives to solve the information asymmetry leading to an equilibrium with positive profits. This equilibrium however, is not optimal. There is a loss of welfare driven by the difference between marginal productivity and wage. This allocation however is more beneficial to households than the one in which the information asymmetry is not solve. The reason is that under the last equilibrium firms cease to produce and consumption is zero, leading to an extremely negative utility and welfare.

CHAPTER 3

THE LABOR WEDGE

Before any analysis can take place, we must provide the labor wedge definition implied by the model. Notice here that as we are working with two different households, the aggregate labor wedge will depend on changes in each household particular labor wedge. We need to include both households in the definition because of the substitution effect that might arise when the economy face a shock.

Following Shimer 2009, we will consider the labor wedge as the ratio between the aggregated marginal product of households and the aggregated marginal rate of substitution between their consumption and labor. That is:

$$w_t^{MPL} (1 - \tau) = \overline{w_t^{MRS}}$$

where τ represents the labor wedge.

In our model the $w_t^{MRS} = w_t$ is defined by :

$$w_t = \Gamma w_t^1 + (1 - \Gamma) w_t^2 = \alpha \frac{y_t}{h_t^1} + (1 - \alpha) \frac{y_t}{h_t^2} - \varphi_t \frac{(h_t^2)^\eta (\chi^2 - \chi^1)}{(h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) + \xi_t}$$

Whereas w_t^{MPL} is:

$$w_t^{MPL} = \Gamma w_t^{1,MPL} + (1 - \Gamma) w_t^{2,MPL} = \alpha \frac{y_t}{h_t^1} + (1 - \alpha) \frac{y_t}{h_t^2}$$

Hence, by definition of labor wedge we have:

$$\tau = \varphi_t \left(\frac{(h_t^2)^\eta (\chi^2 - \chi^1)}{(h_t^2)^{(1+\eta)} \left(\chi^2 - \frac{\chi^1}{1+\eta} \right) + \xi_t} \right) \left(\alpha \frac{y_t}{h_t^1} + (1 - \alpha) \frac{y_t}{h_t^2} \right)^{-1}$$

We first focus on the importance of calibration. As previously discussed, calibration

is crucial in the model. In this case notice that we have to pick α in order to obtain a reasonable long run value for τ (we will use parameters χ^j to calibrate the steady state of hours worked). Specifically, we follow the calibration procedure suggested by Shimer 2009 by picking this parameter in a way that implies a long run value of $\tau = 0.4$. However, we also have to be careful to satisfy the incentive conditions explained in the firm's problem, that is, we need to create an environment in which type 1 households have incentives to keep its information private.

Once the calibration is completed we focus on the determinants of the labor wedge. Initially we would like to highlight the importance of the existence of a steady state, or in other words a long run value for the wedge. One of the early critiques of RBC models was the absence of a labor wedge, in order to solve this issue, economists introduced taxes (consumption taxes, labor income taxes, capital rent taxes, among many others) in their models as a real rigidity. Nonetheless, even if they were a good approach these taxes by their own couldn't explain the size of the wedge between the MRS and the MPL, giving space to some additional explanations. Our approach provides a reasonable argument that may cover a portion of this gap, giving some new light in this field.

Now, notice that we also have space for movements of the wedge around the cycle. These movements are critical to explain the behavior of the wedge. Economists (McGrattan and Prescott 2009, Uhlig 2003, Shimer 2009, among others) have shown that there exists a negative correlation between output and the labor wedge; in other words labor wedge is countercyclical. Specifically, Shimer 2009 makes a comparison between GDP and his calculated labor wedge for the U.S. economy, which is illustrated in figure 3.1:

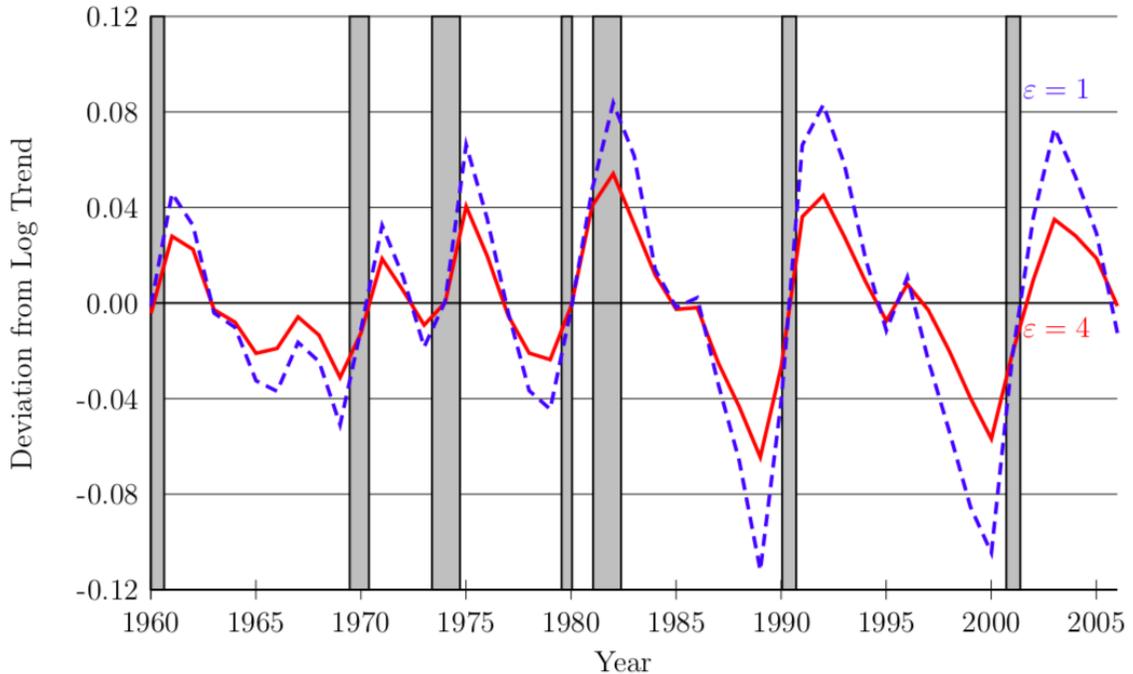


Figure 3.1: Labor wedge cyclical behavior in recession periods (taken from Shimer 2009)

Here both the red line and the blue dotted line represent calculations made for the labor wedge and the gray bars highlight recession periods according to the NBER. The importance of this figure falls in the movement of the wedge during the recessions. Notice that in recession times (when GDP is low) the implicit labor wedge is high and vice versa. These movements can be partially explained by changes in taxes. Nonetheless, taxes by themselves cannot account for such wide variations, hence the need to provide additional explanations for this observation.

Again, as in the long-run case, our approach can be a source of answers. Explicitly, our labor wedge depends indirectly on the aggregate shocks faced by the economy. This dependence leads to cyclical movements of the wedge that might correspond to those prevailing in reality. As our expression depends on a huge combination of variables it is possible to obtain a negative relation between τ and output, hence a countercyclical labor wedge, as a result of the calibration and general equilibrium effects in the model.

CHAPTER 4

SIMULATION

4.1 Calibration

Our model has nine parameters that must be calibrated. Among them, only the persistence parameters (ρ_g and ρ_z) do not affect the steady state of the economy but solely its dynamics. To calibrate them we follow a conservative approach and set them equal to 0.5. This value is standard in the literature as a prior for these type of parameters. Also from the literature, we pick the value of the inverse Frisch Elasticity (η). This value usually lies between one and four with a typical value of two which we follow in our calibration.

The steady state values for the shocks (\bar{g} and \bar{z}) follow two different approaches. The last one is picked such as GDP (y_t) is equal to one in steady state. Notice that setting the steady-state value equal to one is arbitrary and does not have an impact on. Selecting other value (hence a different \bar{z}) will lead to the same results. Given that GDP is equal to one, \bar{g} also represents the ratio between government spending and GDP, which we calibrate to 10%.

To determine the value of χ^1 we use a similar approach to the one of the GDP. We calibrate aggregate labor (h_t) in 0.3 and pick χ^1 accordingly. The value of 0.3 is based on the empirical fact that people use approximately one third of their time working. Once we have χ^1 and following our heterogeneity definition we define χ^2 as $2\chi^1$.

As previously explained, we calibrate α such that the labor wedge (τ) is equal to 0.4. This value follows Shimer [2009](#) calibration which took a deep look into US data to get it.

Finally, regarding the distribution of labor parameter (Γ) we do not have any information, but a restriction. As previously discussed we need to provide a value for Γ that warranties that type 1 households have incentives to keep their information private. As

there is no other source of information, we calibrate Γ using the following procedure: We pick a value for Γ , and then solve for the endogenous values of all other parameters. Once we get these values, we solve the first best problem and check for the existence of incentives in type 1 households. If these incentives exist we keep the value of Γ and treat it as a feasible calibration value. As this procedure leads to an interval for Γ instead of a single value, we define $\Gamma = 0.5$ as our benchmark case but provide results for additional values in the interval in an effort to bring robustness to our results.

Table 4.2 summarizes the previous description:

Parameter	Value	Source
ρ_g	0.5	Literature
ρ_z	0.5	Literature
η	2	Literature
\bar{g}	0.1	Government Spendings / GDP
\bar{z}	Endogenous	to get $y_t=1$
χ^1	Endogenous	to get $h_t=0.3$
χ^2	$2\chi^1$	
α	Endogenous	to get $\tau=0.4$
Γ	0.5	Robustness Analysis

Table 4.1: Calibration

4.2 Methodology

Given our definition of labor wedge and the theoretical model we have described, we can move to the simulation analysis. We initially describe the simulation characteristics and then we move on to explanation of the results.

We designed three simulation environments. In the first one we only allow for produc-

tivity shocks. In the second one we only allow for demand (government spending) shocks. In the third one we create an environment in which both shocks are present and each of them explain a 50% of output variance.

Observe, that the first two are extreme cases of the third in which all variance of output is explained only by one shock. We use these two environments to analyse the effect of the shock's variance on the results.

We want to construct series of output and labor wedge that can take place in the three previously described environments. In order to do so, we simulate for each case two hundred periods (quarters) and we get rid of the fifty percent of them in order to control for potential initial-condition effects, leaving series of one hundred periods. Once we have the simulated series we make a graphical comparison among them, allowing us to identify cyclical behaviors of both output and labor wedge, as well as to analyse the relation between them in order to determine if there exists correlation (following Shimer 2009 we present graphic evidence of the series being countercyclical. We do not focus solely on recession periods but present strong arguments that verify a countercyclical behavior of the labor wedge). We additionally calculate the correlation coefficient as a measure of the relation between the two series. In this first part of the results we only focus on the benchmark calibration in each case, as we want to point out the importance of the shocks taking place in the economy.

It's important to remark that our approach only accounts for changes in the cycle given a steady state. Even if we can have a long run value for the labor wedge this value doesn't change in any exercise, hence any difference between the simulated series and their steady state is considered as a cyclical component of the series and not as a variation in the series trend.

Modeling changes in trends through the use of a DSGE is uncommon and it usually requires abstraction from microfoundation. We decided to focus our attention only on cyclical changes, as we believe that the introduction of private information effects in the

labor market deserves to be analyzed separately. Nevertheless, we consider the inclusion of changes in trends as a natural extension to our work and encourage researchers to develop models that can account for them.

In order to complement our results and bring robustness to our exercise (as discussed in the calibration section) we repeat the simulations for the general case (third environment) under different calibrations (lead by changes in the parameter Γ). As we want to emphasize in the changes in results due to calibration we abstract from the graphical analysis. Instead, we report tables with the corresponding correlation coefficient between the cyclical component of output and the labor wedge series under some calibration set ups. We additionally analyze the evolution of the correlation coefficient through a graph in order to determine if there exists a relations between the labor distribution parameter (Γ) and the cyclical behavior of the labor wedge.

4.3 Results

We begin by analyzing the results of the model when we only allow for productivity shocks.

Figure 4.1 describes the behavior of the simulated output and labor wedge series:

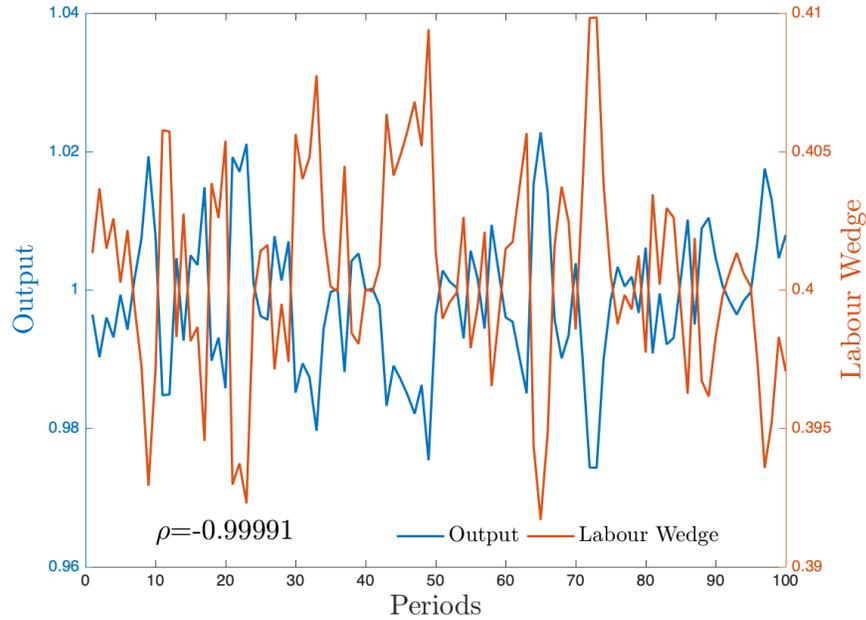


Figure 4.1: Model with Productivity Shocks

Observe that the negative correlation among them is almost perfect. This relation is a result of the negative effect of output in the labor wedge combined the existence of only one shock and the loglinearization of the model.

The last effect accounts for the fact that all relations among variables are linear once loglinearization has taken place. As the labor wedge mainly depends on outcome (negatively) this strong correlation is not entirely surprising. However, this result is also due to the absence of other sources of variance in the model. As variables only change with productivity shocks a strong correlation had to arise.

The reason behind the negative correlation is that a shock decreasing output leads to a decrease in wages by firms to reduce costs. However, under the second best equilibrium

(or the adverse selection environment) the firms face a not very volatile information cost. This cost is important when wages are low but loses importance if wages are high. Under this scenario, if the firms reduce the wages too much (not satisfying the information cost), type 1 households may decide not to reveal their information and pretend to be type 2. This information cost implies that wages do not decrease as much as the optimal ones leading to an increase in the labor wedge (in absolute terms or distance terms). Thus, the labor wedge exhibits a countercyclical behavior.

To confirm our intuition we introduce the results of the model when only demand (government spending) shocks have positive variance. Figure 4.2 describes the behavior of output and labor wedge:

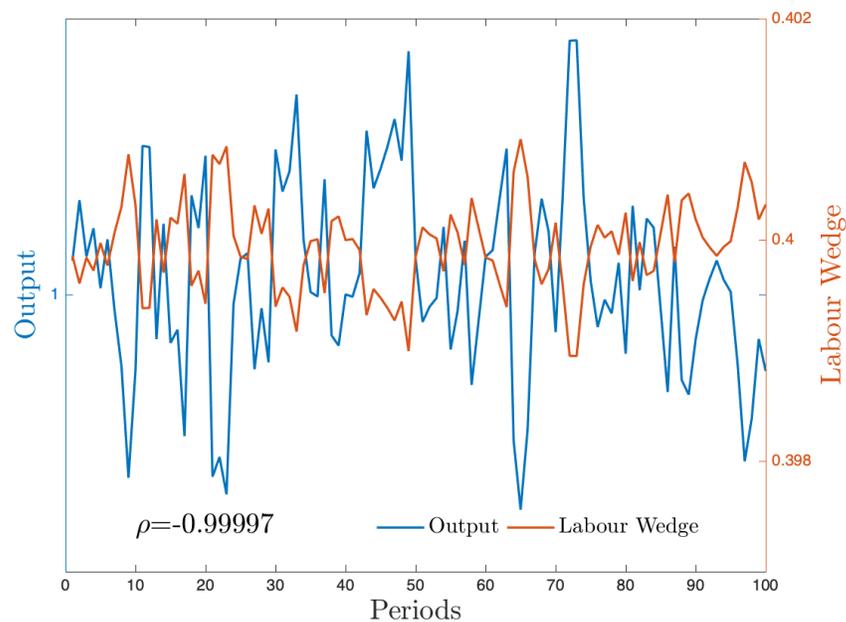


Figure 4.2: Model with Demand Shocks

Notice that we get very similar results. Almost perfect correlation arises when there is only one source of uncertainty as the variance of both series depends solely in the existing shock.

We then introduce our general environment. As explained, we calibrate shock variances such that both shocks account for approximately 50% of GDP variance. However, the effect on the labor wedge is much different. Under this calibration productivity shocks explain around 95% of labor wedge variance, whereas demand shocks account only for approximately the resultant 5%. Although this difference is due to the structure of the model, we do find that it's similar under different preference definitions and shock origins.⁴ In particular we tested for KPR preferences and preference shocks (shocks to consumption in the utility function) as demand shocks. In both cases, when output variance is divided in equal parts among shocks, the productivity shocks sharply dominate the variance of the labor wedge. We then conclude that this behavior is due a strong dependence of labor wedge in the production side of the economy. As in previous cases, Figure 4.3 shows the relation between output and labor wedge under the general model:

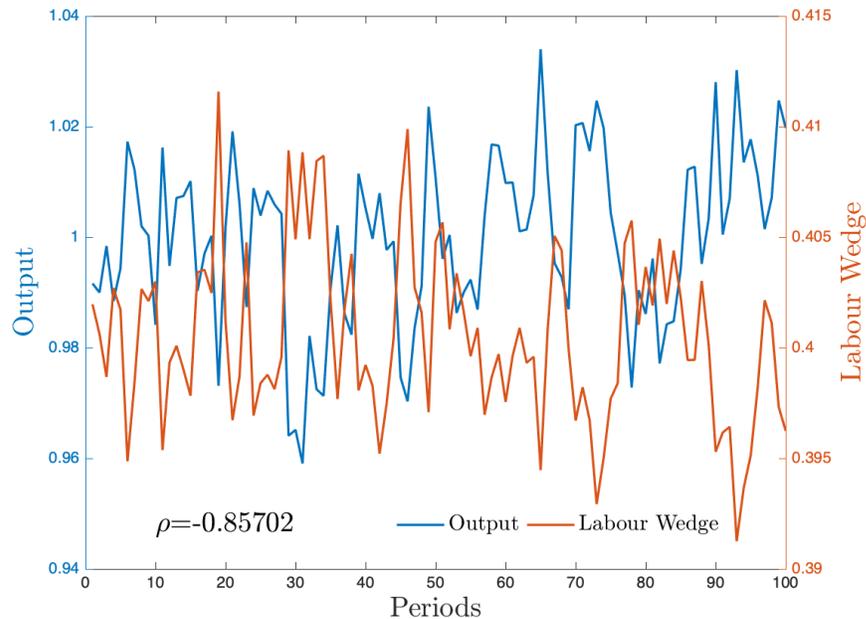


Figure 4.3: General Model (50-50 Variance in Output)

First we remark that there is still a strong negative correlation between both variables.

⁴We provide results for the assumption of logarithmic preferences in Appendix A.

This result is explained by the same reasons of the previous two cases, namely, the strong negative dependence of labor wedge in outcome and the linearity of this dependence.

Nevertheless, the correlation is far from being perfect. This is a result of variance. When facing productivity shocks both variables move in opposite directions in relatively high amounts. However, when facing demand shocks output moves strongly once again but the labor wedge remains practically unchanged, leading to a difference in both series responses against the shocks in the economy and hence avoiding perfect correlation

In general all three experiments have one common denominator. They all account for an endogenous negative correlation between labor wedge and outcome. We have then provided an environment in which the empirical fact of a countercyclical labor wedge (explained by Shimer 2009) can take place through the introduction of private information and the consequent adverse selection problem.

We believe that the strong correlation we found is due to the simplicity of the model we used and should be taken carefully. In reality there are many additional variables that might play a role in this correlation. Examples are capital, debt, monetary and fiscal policy, open good markets, among many others. However, we also believe that adverse selection problems account for a portion of the empirically unexplained movements in labor wedge and should be explored in depth.

Adverse selection is definitely not the only possible explanation to a countercyclical labor wedge, but we have shown that it might play an important role in the behavior of the labor market.

4.4 Robustness Analysis

One of the issues we faced when calibrating the model was to pick a value for the labor distribution parameter (Γ). As explained in the calibration section we decided to pick an uninformative one (0.5) as the benchmark. In this section we relax that assumption and demonstrate that our results do not highly depend on the value of Γ , which allowed us to

follow the calibration procedure described.

Initially we determined the lowest possible value of Γ that will be consequent with a long run value of 0.4 for the labor wedge and a positive value for α . This lower bound is 0.1. Below 0.1 it is not possible to fulfill both requirements. As Γ lies in the (0,1) interval we find the lower bound reasonable enough. (in fact, if we relax our assumption of $\tau = 0.4$ an increase to 0.5 we find values for α in the whole domain of Γ).

Once we pick a value for Γ we confirm that under our combination of parameters the first best approach of firms provides incentives to type one households to hide their real type and pretend to be type 2. In other words, we verify that adverse selection problems do exist. We also confirm that under our calibration of variances each shock explains approximately 50% of output variance.

Finally, once these two conditions are verified we repeat our simulations under each calibration (each possible value of Γ). Both table 4.2 and figure 4.4 summarize our findings. Additionally, table two also reports the corresponding value of ρ in some of the calibrations:

Value of Γ	Value of α	Value of ρ
0.11	0.0972	-0.9066
0.2	0.1713	-0.8956
0.4	0.3212	-0.8702
0.6	0.4540	-0.8437
0.8	0.5728	-0.8164
0.99	0.6750	-0.7902

Table 4.2: Effects of calibration in correlation coefficient (ρ)

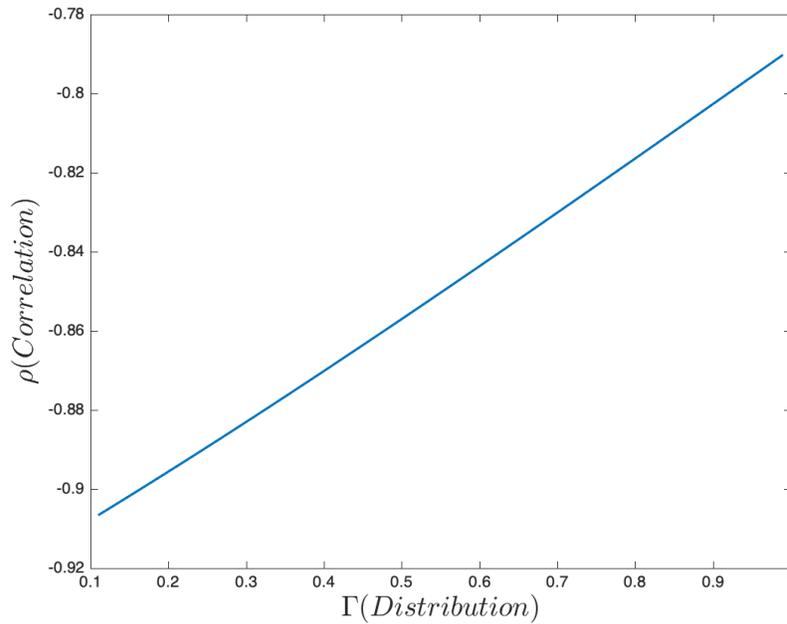


Figure 4.4: Evolution of correlation (ρ) with calibration

Notice that in any possible calibration, we are still able to provide a negative correlation (ρ) between output and labor wedge. Even though the correlation decreases (in absolute value) when Γ increases it never goes below -0.8 (approximately). We believe that the relation between Γ and ρ is due to the increase in the importance of type 1 household labor in the production function (α). If α is high, then when facing a productivity shock the economy will increase type 1 households labor more than the one of type 2 households, leading to fewer increases in the labor wedge and hence to a smaller correlation.

In any case, our results are robust to the only parameter that was free in our calibration. We can be reassured that the negative correlation we found is a result of the existence of adverse selection in the model and not one of the parameters we picked.

Additionally we consider two special cases of correlation between shocks: perfect positive correlation and perfect negative correlation. The results under these assumptions are summarized in figures 4.5 and 4.6:

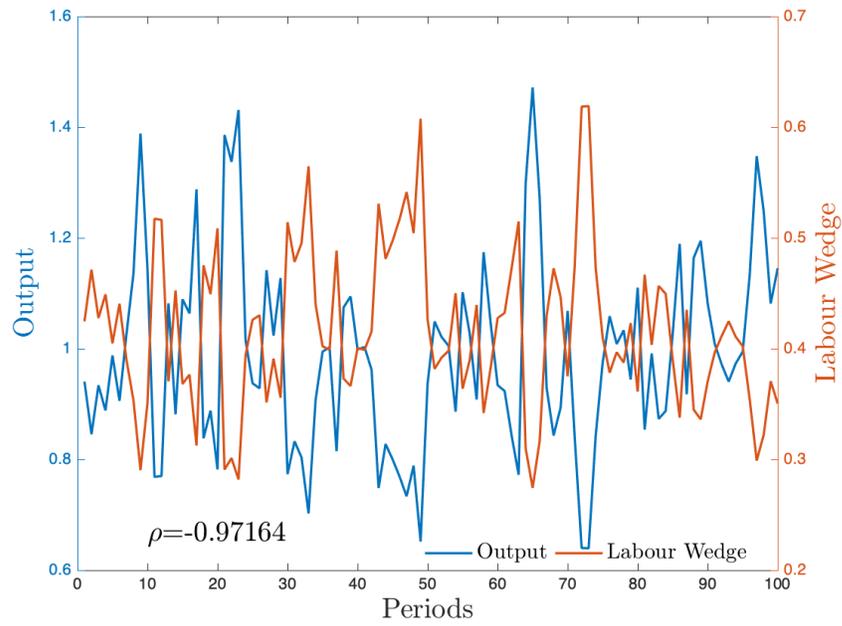


Figure 4.5: Model with positively correlated shocks

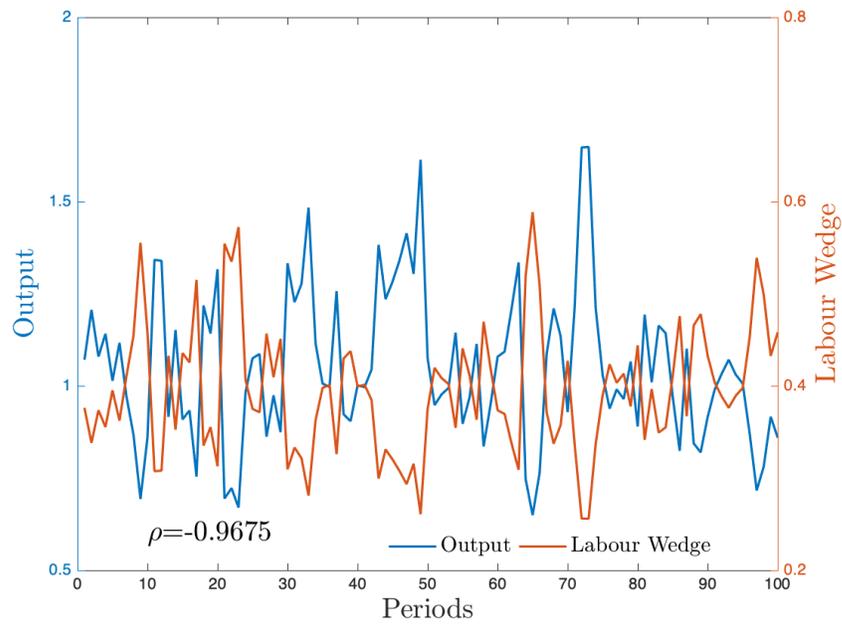


Figure 4.6: Model with negatively correlated shocks

Both figures reinforce the previous results of a countercyclical behavior of the labor wedge. Nonetheless, when shocks are correlated the variance decomposition effects disappear and the results are driven by the policy functions. As there is an endogenous negative relation between labor wedge and GDP (driven by the information cost) the result is a negative correlation of the series.

CHAPTER 5

CONCLUSION

The goal of this paper was to determine whether the empirical fact of a countercyclical labor wedge could be explained to some degree by the existence of an adverse selection environment in the labor market.

To achieve this goal we started from a basic RBC model and introduced heterogeneity of households, providing them with some private information in terms of their labor disutility. We then demonstrated that firms could increase their profits by solving the appropriate second best maximization problem, providing incentives to make all information public.

Under this environment we conducted a series of experiments that showed the existence of a negative correlation between labor wedge and output, and that this correlation might be strong. We then conclude that the existence of private information can explain not only a long run value for the labor wedge, but also its empirical countercyclical behavior.

As an additional result, we showed that the correlation between labor wedge and output depends heavily on the relative variance of shocks. This dependence is a result of the use of a DSGE model. Once we calibrated the relative variance decomposition of output we let the model determine the one of the labor wedge. As this relation depends on the structure of the model there was no reason to believe that it would be the same. In fact, the variance decompositions were very different leading to differences in the degree of response to shocks and hence changes in the correlation among the series.

Finally, through the use of robustness analysis we demonstrated that the negative correlation we found is not a coincidence of calibration but a general equilibrium effect of our simulated economy. This result reinforces the importance of adverse selection as a determinant of the labor wedge behavior.

We believe that the size of the negative correlation we found should be taken carefully.

Our model is simple and lacks of some transmission mechanisms and key variables that could diminish this relation. Some examples include consumption smoothing mechanisms, fiscal and monetary policies and access to foreign markets among others. We are unable to know a priori how the correlation will react when facing these additional mechanisms, hence the caution.

Nevertheless, we also believe that adverse selection plays a crucial role in the labor market behavior and that our results highlight an important research agenda in this area. We encourage future economists to allow for our specific transmission mechanism when explaining the cyclical behavior of the labor wedge.

Appendices

APPENDIX A
LOGARITHMIC PREFERENCES

In this section we present the results of the model when we use the following utility function for households:

$$u_t = \ln(c_t^j) + \chi^j \ln(1 - h_t^j)$$

The change of the utility function have the following implications:

- The household first order conditions are:

$$\begin{aligned} [c_t^j]: \quad \lambda_t^j &= \frac{1}{c_t^j} \\ [h_t^j]: \quad (1 - \tau^w) w_t^j \lambda_t^j &= \frac{\chi^j}{(1 - h_t^j)} \end{aligned}$$

- The firms first order conditions are:

$$\begin{aligned} [h_t^1]: \quad \Gamma w_t^1 &= \alpha \frac{y_t}{h_t^1} \\ [h_t^2]: \quad (1 - \Gamma) w_t^2 &= (1 - \alpha) \frac{y_t}{h_t^2} - \varphi_t \frac{(\chi^2 - \chi^1)}{(1 - h_t^2)} \end{aligned} \tag{A.1}$$

- The labor wedge is:

$$\tau = \varphi_t \frac{(\chi^2 - \chi^1)}{(1 - h_t^2)} \left(\alpha \frac{y_t}{h_t^1} + (1 - \alpha) \frac{y_t}{h_t^2} \right)^{-1}$$

Under this setup and using the same methodology for the simulations we get the following results:

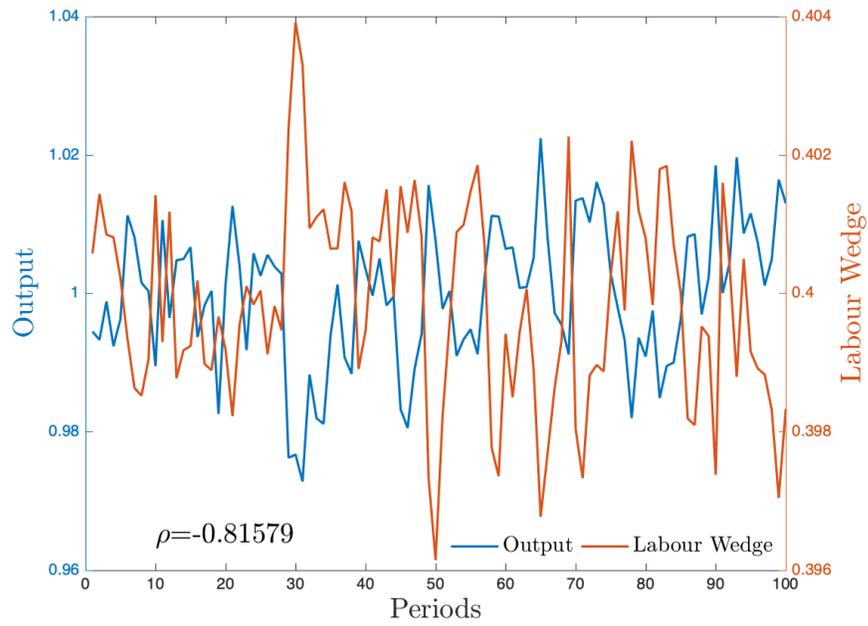


Figure A.1: Model with logarithmic preferences

From figure A.1 we can conclude that the relation between the labor wedge and the GDP is robust to this type of preferences.

APPENDIX B
PROOF OF PROPOSITION 1

First, notice that under asymmetric information the firm can only offer one contract to both households based on its prior beliefs of the distribution of the types.

Thus, the firm offers a contract based on the expected aggregate labor and the corresponding optimal wage. Under this contract, given the definition of aggregate labor and the fact that a the production function is linear on it we have the following optimal wage:

$$w_t = z_t$$

As the wage offered is unique, each household adjusts its labor supply to satisfy their specific marginal rate of substitution between consumption and labor. For a unique wage we have that household type one picks labor according to:

$$(1 - \tau^w) w_t = \chi^1 (h_t^1)^\eta$$

Hence, the labor supply of household one is:

$$h_t^1 = \left(\frac{(1 - \tau^w) w_t}{\chi^1} \right)^{\frac{1}{\eta}}$$

Conversely, household type two labor supply is:

$$h_t^2 = \left(\frac{(1 - \tau^w) w_t}{\chi^2} \right)^{\frac{1}{\eta}} = \left(\frac{(1 - \tau^w) w_t}{2\chi^1} \right)^{\frac{1}{\eta}} = \left(\frac{1}{2} \right)^{\frac{1}{\eta}} h_t^1$$

Hence the realized profits of the firm are:

$$\begin{aligned}
\xi_t &= z_t (h_t^1)^\alpha (h_t^2)^{(1-\alpha)} - \Gamma w_t h_t^1 - (1 - \Gamma) w_t h_t^2 \\
&= \left(\frac{1}{2}\right)^{\frac{(1-\alpha)}{\eta}} z_t h_t^1 - \Gamma z_t h_t^1 - (1 - \Gamma) \left(\frac{1}{2}\right)^{\frac{1}{\eta}} z_t h_t^1 \\
&= \left(\left(\frac{1}{2}\right)^{\frac{(1-\alpha)}{\eta}} - \Gamma - (1 - \Gamma) \left(\frac{1}{2}\right)^{\frac{1}{\eta}} \right) z_t h_t^1 \\
&= \left(\left(\frac{1}{2}\right)^{\frac{1}{\eta}} \left(\left(\frac{1}{2}\right)^{(1-\alpha)} - 1 \right) + \Gamma \left(\left(\frac{1}{2}\right)^{\frac{1}{\eta}} - 1 \right) \right) z_t h_t^1
\end{aligned}$$

Clearly as $\alpha \in [0, 1]$ and $\eta > 0$ both expressions in parenthesis are negative which implies that if the firm does not solve the information asymmetry problem the optimal decision is to leave the market and make zero profits. ■

REFERENCES

- Bolton, Patrick and Mathias Dewatripont. *Contract Theory*. Vol. 1. MIT Press Books. The MIT Press, 2005.
- Grossman, Gene M. “The Distribution of Talent and the Pattern and Consequences of International Trade”. In: *Journal of Political Economy* 112.1 (2004), 209–239.
- Guerrieri, Veronica and Robert Shimer. “Dynamic Adverse Selection: A Theory of Illiquidity, Fire Sales, and Flight to Quality”. In: *American Economic Review* 104.7 (2014), 1875–1908.
- McGrattan, Ellen R and Edward C Prescott. *Technical appendix: Unmeasured investment and the puzzling US boom in the 1990s*. Vol. 395. Federal Reserve Bank of Minneapolis, 2009.
- Mortensen, Dale T. and Christopher A. Pissarides. “Job Creation and Job Destruction in the Theory of Unemployment”. In: *The Review of Economic Studies* 61.3 (1994), 397–415.
- Pissarides, Christopher A. “Short-Run Equilibrium Dynamics of Unemployment, Vacancies, and Real Wages”. In: *The American Economic Review* 75.4 (1985), 676–690.
- Schmitt-Grohe, Stephanie and Martin Uribe. “Closing small open economy models”. In: *Journal of International Economics* 61.1 (2003), 163–185.
- Sergi, Francesco. “The DSGE models and the Lucas Critique. A Historical Appraisal”. In: *Colloque International de l’Association Charles Gide Strasbourg* (2016).
- Shimer, Robert. “Convergence in Macroeconomics: The Labor Wedge”. In: *American Economic Journal: Macroeconomics* 1.1 (2009), 280–297.
- Uhlig, Harald. “How well do we understand business cycles and growth? Examining the data with a real business cycle model”. In: *Manuscript, January* (2003).