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Wages, Risk Sharing and Economic Fluctuations.

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Abstract

This paper documents a stylized fact on the aggregate wage structure of firms and proposes an explanation for this stylized fact based on the existence of capital market imperfections. We first provide empirical evidence that, every thing else equal, workers real compensation is more sensitive to economic fluctuations in economies where the variance of fluctuations is larger. Secondly we show that this can be accounted for in a framework where firms are confronted to imperfect capital markets. In this case, the wage insurance provided to workers can have a negative effect on the borrowing capacity of firms. Then with risk averse workers, a trade-off appears for firms between the cost of labor and the intensity of borrowing constraints. Finally in a macroeconomic model where the risk sharing agreement between firms and workers directly impacts the macroeconomic behavior of the economy, this model yields the observed positive correlation between real wages procyclicality and the volatility of economic fluctuations.

Keywords: Wages, Insurance, Capital Market Imperfections, Volatility.

JEL Codes: D21, E24, E25.

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1. Introduction.

"Observed real wages are not constant over the cycle but neither do they exhibit consistent pro- or counter-cyclical tendencies. This suggests that any attempt to assign systematic real wage movements a central role in an explanation of business cycle is doomed to failure." Robert Lucas (1977, p. 226)

It is a stylized fact of the labor market that aggregate real wages do not vary with the cycle¹. In this paper we try to show that empirically and theoretically, there are good reasons for why aggregate real wages may be much more procyclical than is usually considered. More specifically we aim at showing that economies where output growth volatility is large are also economies where aggregate real wages are largely procyclical. As a first piece of evidence denying the conventional wisdom about real wage a-cyclicity, the cross-country correlation between workers real compensation growth volatility and real output growth volatility happens to be positive and significant. Economies with the largest real compensation growth volatility are also, every thing else equal, economies with the largest real GDP growth volatility².

Insert figure 1 here

Second, measuring real compensation sensitivity to output fluctuations as the correlation coefficient between real compensation growth and output growth, we find that it is, every thing else equal, positively related to GDP growth volatility.

Insert figure 2 here

Empirical evidence³ therefore shows that, every thing else equal, real wages growth is more procyclical in economies where output growth variance is larger. From this empirical result we raise two questions. First if firms are risk neutral and workers risk averse, firms should provide a larger insurance to workers when the environment is more volatile and hence more risky. We therefore need to ask how possible it is to reconcile

¹However it also well-know that this observation has been put into question, especially because of composition effects in aggregate indicators of real wages (cf. Solon, Barsky and Parker [1994]).

²As Easterly, Islam and Stiglitz [2001] put it *"Models based on price and wage rigidities become unpersuasive if countries have both more flexible wages and prices and still exhibit high volatility in growth output. We need to ask: whether this high level of volatility can be explained simply by the fact that the countries are exposed to more shocks (or have a less diversified economy), or are there other aspects of their structure or policy regimes which explain this volatility or relative stability?"*

³For more details about the empirical analysis, c.f. appendix 7.1 data & plots.

the empirical evidence with this theoretical framework. Second since GDP growth volatility decreases with capital accumulation and diversification. (Gavin and Hausman [1996] and Acemoglu and Zilibotti [1997]), the empirical evidence raised implies that workers are undergoing a larger share of macroeconomic shocks in developing compared to developed countries. Moreover these shocks have a larger volatility in developing compared to developed countries. We therefore ask the question of why and how capital accumulation and diversification differences explain both differences in the volatility of economic fluctuations and labor market structures and whether there are any interactions between these two last elements.

1.1. Mechanism of the model.

Let us consider a risk neutral firm which can hire workers and borrow capital from financial markets and whose technology is subject to random shocks. Workers being risk averse while firms are risk neutral, Pareto optimality implies that firms insure workers against fluctuations in labor productivity (Azariadis [1978] and Azariadis and Stiglitz [1983]). However this conclusion is modified when imperfect capital markets are introduced. To illustrate this, let us consider that the gross risk free interest rate on loans is lower than the firm marginal productivity of capital on average but larger than the firm marginal productivity of capital when the firm receives a bad shock⁴. Moreover let us assume the core assumption that there are costs for lenders to recover their loans in case the firm is not able to repay for its debts. Then, on the one hand the first best capital stock is such that the marginal productivity of capital is equal to the gross risk free interest rate on loans. On the other hand this implies that there are situations in which firms are not able to pay for all their debts. Therefore lenders refuse to lend this "first-best" quantity of capital. To increase their borrowing capacity, firms have to increase their profits before debt repayments. One way to achieve that goal for firms consists in reducing their wage bill when bad shocks happen⁵. The wage bill being lower, the firm repayment capacity is larger. It can borrow a larger amount of capital. However reducing the wage bill in the case of bad shocks is costly because some variability is introduced in the compensation of risk averse workers.

⁴The shocks we consider affect the TFP of firms technology. We therefore exclude any other type of shock such as demand shocks. However since the paper is about labor market long term evolutions, it is reasonable to focus on technological shocks.

⁵This argument is based on the assumption that wages are senior to debt holder claims. If this priority structure were endogenous, that would come out to be the same since this structure is only relevant in as much as default is possible. In this model firms never default.

Therefore when firms increase the ex ante variability of wages, they trade-off an increase in their borrowing capacity against an increase in the average cost of labor⁶. Assuming decreasing marginal returns to capital, firms incentives to propose contingent wage contract to workers are therefore large when the level of firms own capital is low. Similarly when the risk free interest rate on loans is low, firms demand for capital is large so that firms have large incentives to propose contingent debt contracts⁷. Finally with a dynamic structure in which the wage bill distributed to workers constitutes firms own capital at the next period and assuming that capital and labor are complements in firms technology we can replicate the stylized fact raised: If the variability of shocks is low (resp. large), firms have a large (rep. low) borrowing capacity, wages are large (resp. low) and firms own capital at the next period is also large (resp. low). This implies that firms have incentives to propose uncontracted (resp. contingent) contracts because the marginal productivity of capital is low (resp. high). Therefore, if differences in growth volatility mainly come from differences in the underlying shocks the economy faces, then the model can account for the positive correlation between real wage procyclicality and output volatility. Finally the model can give some insight as to the relation between the average growth rate of the economy and the volatility of shocks. Unsurprisingly, the relation is negative because more volatile shocks reduce firms borrowing capacity and thereby capital accumulation⁸.

1.2. Related literature.

In a very stylized framework, we try to give some insights as to which type of agent participating to production (workers, entrepreneurs and/or external financiers) is undergoing output risk? Gomme and Greenwood [1995] study a similar question in order to assess how the cyclical allocation of risk between workers and entrepreneurs can help to understand cyclical variations of wages and the labor share in output. Danthine and Donaldson [1992] show that taking into account risk sharing considerations can help explain the wage-employment variability puzzle. Ichino [1994] also studies a similar question and asserts that when firms

⁶A possible illustration of the conclusions of the paper can lie in the differences in the compensation structure between large and small firms. The cost of capital is much lower for the former while insurance through labor contracts is much larger. Sometimes, large non financial corporations even have their own financial intermediary.

⁷The model therefore gives an explanation to the stylized fact put forth by Rodrik [1998]: a decrease in the cost of capital increase, every thing else equal, the volatility of workers compensation.

⁸The model therefore gives an explanation to this stylized fact put forth by Ramey and Ramey [1995] and Imbs [2003].

increase the risks beard by workers, this can help them to reduce the cost of external capital⁹. Chevalier and Scharfstein [1996] is relatively close to this type of problems since it shows that the existence of credit market imperfections can help to explain the cyclical behavior of mark-ups. More generally, there is a growing literature (Bronars and Deere [1991], Wasmer and Weil [2000]) which studies the possible interactions between the labor and the capital markets. Contingent wages have also been studied as a mechanism to solve for moral hazard problems. When it is difficult (costly) for a firm to monitor the effort delivered by workers, a labor contract with a contingent wage rate can give workers the incentives to deliver the optimal effort. Contingent wage contracts are therefore generally considered as an incentive device when there is asymmetric information (c.f. Gibbons [1998] for a survey). This paper is close. However contingent labor contracts here arise as the result of capital market imperfections while the labor market is perfectly competitive.

1.3. Road map of the paper.

The paper is organized as follows. The following section lays down the model and its main assumptions. Section 3 describes the different strategies firms can adopt as regards the labor and capital demands. In section 4, we first examine individual and social optimality for the different strategies considered in the previous section. We also build the dynamics of the economy. The main results of the model can then be found in section 5 and section 6. Conclusion is eventually found in section 7.

2. The microeconomic framework.

2.1. Agents and markets.

We consider a single good economy which lasts one period with three types of agents, entrepreneurs, workers and international investors. There is a continuum of unit mass of workers and a continuum of unit mass

⁹Ichino [1994] is based on a similar idea to this paper: that risk sharing agreements between an entrepreneur, its workers and its financiers can modify the value of the firm. However this paper completes this idea in four different ways. First we derive firms optimal compensation and financial policies. Second we build the dynamics of the economy where firms own capital level determines the type of labor contract agreed upon and where the type of labor contract determines firms own capital level at the next period. This allows us to generate some interesting dynamics in the development process for some economies. Thirdly a comparative statics exercise on the main exogenous parameters is carried out. Finally we show that with this comparative statics exercise that the mechanism of the model can explain the empirical correlations raised in the introduction.

of entrepreneurs. Workers are risk averse, have a labor supply equal to one but do not have any capital. Their preference writes as $U_w = \log(c_w)$ where c_w is a worker's end-of-life consumption. Entrepreneurs are risk neutral have no labor endowment and have a capital endowment k . Their preference writes $U_e = c_e$ where c_e is an entrepreneur's end-of-life consumption. They have access to a constant returns to scale technology which uses capital and labor. Entrepreneurs technology writes as $y_{s,i} = A_s k_i^\alpha l_i^{1-\alpha}$. It is subject to a macroeconomic shock s , the capital stock invested by entrepreneur i is k_i and l_i is the number of workers he hires. There are two states of nature, a good $s = h$ and a bad one $s = l$ with $A_h > A_l$. Both states of nature are equiprobable. We note EA the mean of A_s . We adopt the following notations: $EA - A_l = A_h - EA = \delta EA$.

At the beginning of each period, there are two different markets which open one after the other. The first market on which transactions take place is the capital market. On this market, risk neutral entrepreneurs sign one period contracts with risk neutral international investors and we assume ex post costly state verification¹⁰. International investors have to undergo some cost to recover claims on defaulting firms. Assuming that these costs are sufficiently large, there are no contingent debt contracts because the interest rate charged on such contracts would be too large. We therefore focus on risk free debt contracts¹¹. The risk free gross interest rate is exogenous¹² noted \bar{r} and financial capital supply is infinitely elastic. The amount of capital lent to firm i is d_i . Once firms have signed contracts with financial investors, the labor market opens. The labor market is competitive. At the end of the period, firms pay wages to workers and debt contracts to financial investors.

¹⁰In the case of ex post costly state verification, lenders need a mechanism to force borrowers to reveal their true repayment capacity. This can be achieved with a penalty system where borrower pay for an extra fee in case of untruthful report. If the borrower declares that he is able to pay for the face value of the contract, then he does so. If he declares to be unable to do so, then the lender pays for the ex post verification costs. Then if the borrower's declaration was truthful, the lender gets the residual value of the firm while if the borrower's declaration was untruthful, then the lender gets the total cash flow of the firm. Likewise, borrowers always make truthful reports.

¹¹See appendix 7.4 for more details. The core assumption of the model is that default is costly. How costly it is does modify the results only quantitatively. Moreover this assumption helps to overcome the relative seniority issue of workers w.r.t. financiers' claims. Since firms are always able to pay for all their liabilities, seniority analysis is irrelevant.

¹²This is a small open economy. This hypothesis is not crucial to the results of the model, it simply simplifies the resolution of the model and the exposition of its results.

2.2. Workers insurance and firms borrowing capacity: a micro model.

Firms decisions about capital and labor are sequential. The program of a representative firm can be solved with backward induction. First we determine the strategy of the representative firm as regards the labor market and then we turn to the capital demand of the representative firm. Let us consider a firm i which chooses a given compensation scheme $\{w_l, w_h\}$ when other firms choose to propose a wage rate \bar{w} . The program of firm i first consists in choosing the number of worker l_i such that it solves

$$\begin{aligned} \max_{l_i} E\Pi(l_i) &= EA(k_i + d_i)^\alpha l_i^{1-\alpha} - Ew_s l_i - \bar{r}d_i \\ \text{s.t. } E \log(w_s) &\geq \log(\bar{w}) \end{aligned}$$

The constraint firm i faces is a standard participation constraint: workers do not accept to work for firm i if the compensation scheme yields a lower level of welfare than the level provided by their outside option. The solution to this problem (firm i optimal demand for labor) then writes as

$$(1 - \alpha) EA(k_i + d_i)^\alpha l_i^{-\alpha} = Ew_s \quad (2.1)$$

Now one can solve the problem consisting for firm i in determining its optimal amount of debt finance d_i .

This amounts to solve the following problem

$$\begin{aligned} \max_{d_i} E\Pi(d_i) &= EA(k_i + d_i)^\alpha l_i^{1-\alpha} - Ew_s l_i - \bar{r}d_i \\ \text{s.t. } \left\{ \begin{array}{l} (1 - \alpha) EA(k_i + d_i)^\alpha l_i^{-\alpha} = Ew_s \\ \forall s, A_s(k_i + d_i)^\alpha l_i^{1-\alpha} \geq w_s l_i + \bar{r}d_i \end{array} \right. \end{aligned}$$

Introducing firm i optimal labor demand (2.1) in both the objective function $E\Pi(d_i)$ and the borrowing constraints $A_s(k_i + d_i)^\alpha l_i^{1-\alpha} \geq w_s l_i + \bar{r}d_i$ we get to the following problem

$$\begin{aligned} \max_{d_i} E\Pi(d_i) &= \left[\frac{(1-\alpha)EA}{Ew_s} \right]^{\frac{1-\alpha}{\alpha}} [EA - (1-\alpha)EA](k_i + d_i) - \bar{r}d_i \\ \text{s.t. } \forall j, \left[\frac{(1-\alpha)EA}{Ew_s} \right]^{\frac{1-\alpha}{\alpha}} \left[A_j - (1-\alpha)EA \frac{w_j}{Ew_s} \right] (k_i + d_i) &\geq \bar{r}d_i \end{aligned}$$

Then there are then two different cases: if $\left[\frac{(1-\alpha)EA}{Ew_s}\right]^{\frac{1-\alpha}{\alpha}} \alpha EA \leq \bar{r}$, then firms expected profits write as $E\Pi^* = \bar{r}k$. As is clear the expected profits of firm i do not depend upon on the type of the labor contract. On the contrary when $\left[\frac{(1-\alpha)EA}{Ew_s}\right]^{\frac{1-\alpha}{\alpha}} \alpha EA > \bar{r}$ then firm i optimal expected profits write as

$$E\Pi\left(\frac{w_k}{Ew_s}, Ew_s\right) = \frac{\alpha EA - \left[A_k - (1-\alpha)EA\frac{w_k}{Ew_s}\right]}{\left[\frac{Ew_s}{(1-\alpha)EA}\right]^{\frac{1-\alpha}{\alpha}} \bar{r} - \left[A_k - (1-\alpha)EA\frac{w_k}{Ew_s}\right]} \bar{r}k_i$$

where k is the state of nature for which the borrowing constraint is binding.

$$k = \arg \min_j \left[d_j \left| \left[\frac{(1-\alpha)EA}{Ew_s}\right]^{\frac{1-\alpha}{\alpha}} \left[A_j - (1-\alpha)EA\frac{w_j}{Ew_s}\right] (k_i + d_j) \geq \bar{r}d_j \right. \right]$$

The expected profits of firm i now do depend upon the type of the labor contract firm i chooses to propose. We can then derive the following proposition.

Proposition 1. *The optimal wage contract $\{w_l^*, w_h^*\}$ is such that $w_l^* < \bar{w} < w_h^*$ if and only if firms cannot issue contingent debt and are credit constrained. Then the difference $w_h^* - w_l^*$ decreases with the risk free gross interest rate \bar{r} and with the volatility of macroeconomic shocks A_s .*

Proof. c.f. appendix. ■

In this proposition, we have three different properties. The first one states that when firms are not able to equal the expected marginal productivity of capital with the gross risk free interest rate then this constitutes a necessary and sufficient condition for firms to pay contingent wages to workers. Secondly the proposition states that a large interest rate reduces firms incentives to serve contingent wages. This is so because a large interest rate reduces firms demand for capital and therefore reduces the need to pay contingent wages. Finally when macroeconomic shocks are more volatile then firms also have less incentives to serve contingent wages.

3. The macroeconomic model.

We embed the microeconomic framework we considered in the previous section into a dynamic macroeconomic model where workers give birth to entrepreneurs and vice-versa. At each point in time there is a continuum of workers and a continuum of entrepreneurs. Workers' preferences write as $u_w = \log(b)$ where b is a worker's end-of-life bequest and entrepreneurs' preferences write as $u_e = c$ where c is an entrepreneur's end-of-life consumption. Every thing else is identical to the microeconomic framework. The main element of the macroeconomic model is therefore that workers compensation at the end of period t constitutes the level of firms own capital at the beginning of period $t + 1$.

To derive the results one can infer from the mechanism we shed light on, in the previous paragraph, we limit the macroeconomic analysis to two types of compensation policies. A fixed compensation strategy $\{\bar{w}\}$, firms then provide risk free wages and a contingent compensation strategy $\{w_l, w_h\}$, firms then provide wages with a given indexation $w_s = \eta_s \bar{w}$ where $\eta_h = \eta_l^{-1}$. We can then derive the following proposition.

Proposition 1. *If η_l is such that $\eta_l^2 \leq \frac{1-\alpha-\delta}{1-\alpha+\delta}$ then firms choose to provide workers with contingent compensation schemes if and only if their level of own capital k is lower than k_c with*

$$k_c = \gamma(\eta_l) \frac{EA - A_l}{\bar{r}} \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1-\alpha}}$$

where $\gamma(\eta_l) < 1$. Firms reach their first best capital labor ratio if and only if their level of own capital k is equal or larger than k_f with

$$k_f = \frac{EA - A_l}{\bar{r}} \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1-\alpha}}$$

Proof. c.f. Appendix. ■

The economy and its dynamics can then be described as follows. Let us note k_t the capital stock of firms at date t . If $k_t < k_c$ then firms choose the contingent compensation strategy, firms expected profits and the capital stock of firms at the next period (which corresponds to the macroeconomic wage bill) respectively

write as

$$\begin{aligned} E\Pi_c &= \left[\left(\alpha + (1 - \alpha) \frac{2\eta_l^2}{1 + \eta_l^2} \right) EA - A_l \right] (k_t + d_2)^\alpha && \text{if } k_t < k_c \\ k_{t+1}^s &= \eta_s \frac{2\eta_l}{1 + \eta_l^2} (1 - \alpha) EA (k_t + d_2)^\alpha \end{aligned} \quad (3.1)$$

where $\eta_h = \eta_l^{-1}$. Firms then ask for the maximal amount of capital which is compatible with the no default constraint. This volume of debt d_2 verifies the equation $\bar{r}d_2 = \left[A_l - (1 - \alpha) EA \frac{2\eta_l^2}{1 + \eta_l^2} \right] (k_t + d_2)^\alpha$. If $k_c \leq k_t < k_f$, then firms choose the fixed wage strategy. Their expected profits and the capital stock of firms at the next period respectively write as

$$\begin{aligned} E\Pi_f &= [EA - A_l] (k_t + d_1)^\alpha && \text{if } k_c \leq k_t < k_f \\ k_{t+1} &= (1 - \alpha) EA (k_t + d_1)^\alpha \end{aligned} \quad (3.2)$$

Once again, firms ask for the maximal amount of capital which is compatible with the no default constraint. This volume of debt d_1 verifies $\bar{r}d_1 = [A_l - (1 - \alpha) EA] (k_t + d_1)^\alpha$. In these two cases, firms are able to pay for all the claims workers and debt holders have on their cash flows in any state of the world A_s . However when firms get the shock A_l then they generate zero profits, the wage bill and debt repayments are equal to the realized cash flow. Finally if $k_t \geq k_f$ then firms choose the fixed wage strategy. Their expected profits and firms own capital stock at the next period respectively write as

$$\begin{aligned} E\Pi_f &= \bar{r}k_t && \text{if } k_t \geq k_f \\ k_{t+1} &= (1 - \alpha) EA \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1 - \alpha}} \end{aligned} \quad (3.3)$$

Two remarks are possible. First d_2 is larger than d_1 . The contingent compensation strategy allows firms to borrow more capital than the fixed compensation strategy. However since firms rely more on outside capital in the contingent compensation scheme, the average profitability per unit of output is lower than in the fixed compensation scheme. Secondly the fixed compensation strategy is possible if and only if firms are always able to pay for the fixed wage rate. This needs the condition $(1 - \alpha) EA \leq A_l$ which simplifies as $\delta \leq \alpha$. If this inequality is correct, then the fixed compensation strategy is possible¹³ and the contingent

¹³If we had $(1 - \alpha) EA > A_l$ then firms in case the bad shock A_l happens, would not be able to pay for their wage bills. Then

compensation strategy allows firms to borrow more capital from financiers.

4. Dynamics of the economy.

For the rest of the paper we assume that $\eta_l^2 \leq \frac{1-\alpha-\delta}{1-\alpha+\delta}$.

The dynamics of the macroeconomic model is the following: firms with a given level of own capital choose the strategy which maximizes their individual profits. Firms individual choices then translate after the realization of a state of nature into an aggregate flow of profits for firms which is consumed and an aggregate wage bill which workers bequeath the next generation of entrepreneurs. The dynamics of the capital stock in the economy is then determined by equations (3.3)-(3.1).

4.1. The unique regime case.

The economy experiences a unique regime if and only if

$$(1 - \alpha) \frac{1 - \eta_l^2}{1 + \eta_l^2} \leq (\alpha - \delta) \left[\left(\frac{1 + \eta_l^2}{2\eta_l} \right)^{\frac{1-\alpha}{\alpha}} - 1 \right] \quad (4.1)$$

As is clear this inequality is true if and only δ is sufficiently small, i.e. if A_l is sufficiently close to EA . As is clear this inequality is true if and only A_l is sufficiently close to EA . We can therefore deduct that the economy never experiences the contingent compensation strategy when the variance of technological shocks A_s is sufficiently small. This is very natural. When the volatility of shocks the economy receives is small, the increase in the borrowing capacity of firms due to the change on the compensation policy is also small. On the other hand, the increase in the cost of labor is independent of the volatility of shocks. Firms trade-off for contingent compensation is then negative and they prefer to propose fixed wages even for very low levels of own capital.

the fixed wage strategy would not be possible. However as clear for reasonable values of parameters, this inequality implies that macroeconomic shocks can as large as 30-35%. This figure seems to be too large to be realistic for a macroeconomic shock.

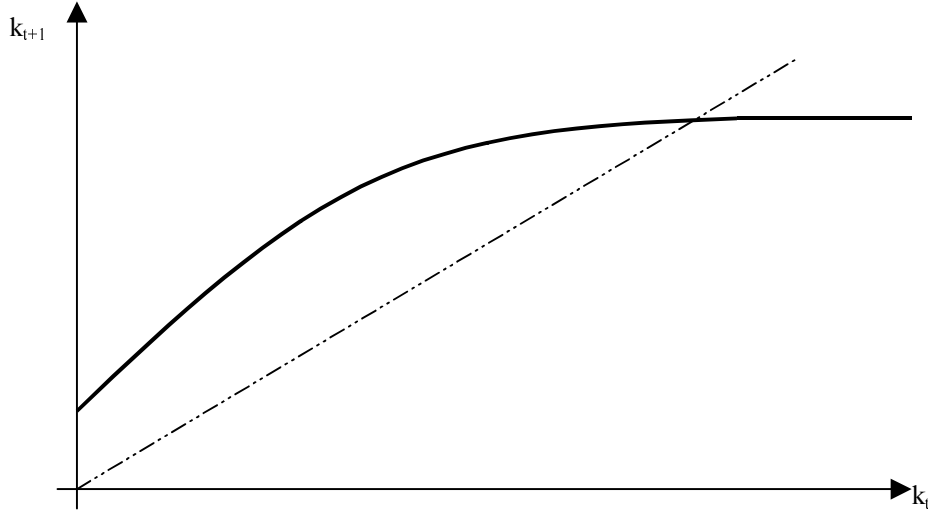


Figure 3 : Dynamics of the economy when the variance of technological shocks is low.

The dynamics of the economy is

$$k_{t+1} = \begin{cases} (1 - \alpha) EA (k_t + d_1)^\alpha & \text{if } k_t < k_f \\ (1 - \alpha) EA \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1-\alpha}} & \text{if } k_t \geq k_f \end{cases}$$

The transitional dynamics of the economy is monotonic, there are no fluctuations, nor permanent nor temporary and the economy reaches in finite time its steady state in the fixed compensation zone. This case is somewhat very close to the situation of developed countries because these economies are largely diversified and as a matter of fact real wage procyclicality is low in these economies. In this case, real wages volatility and real wages procyclicality are both equal to zero.

4.2. The two regimes case.

In the case where both regimes are possible the distribution of macroeconomics shocks verifies

$$\frac{EA - A_l}{EA} \geq \alpha - (1 - \alpha) \frac{1 - \eta_l^2}{1 + \eta_l^2} \left[\left[\frac{1 + \eta_l^2}{2\eta_l} \right]^{\frac{1-\alpha}{\alpha}} - 1 \right]^{-1} \quad (4.2)$$

Condition (4.2) is true if and only if the volatility of shocks A_s is sufficiently large. This case can therefore be identified to that of developing countries which experience shocks with a larger variance than developed economies. The dynamics of the economy is then

$$k_{t+1}^s = \begin{cases} \eta_s \frac{2\eta_l}{1+\eta_l^2} (1-\alpha) EA (k_t + d_2)^\alpha & \text{if } k_t < k_c \\ (1-\alpha) EA (k_t + d_1)^\alpha & \text{if } k_c \leq k_t < k_f \\ (1-\alpha) EA \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1-\alpha}} & \text{if } k_t \geq k_f \end{cases}$$

The two compensation regimes are possible and the transition from the contingent to the fixed one can lead to an increase or a decrease in the wage bill. In the good state of nature, the compensation regime transition necessarily leads to a decrease in the wage bill. In the bad state of nature, the compensation regime transition leads to a decrease in the wage bill when the bad state of nature offsets the positive effect of a larger capital stock. It leads to an increase in the wage bill when the positive effect of a larger capital stock offsets the bad state of nature. Given the dynamics of the capital stock, there are three different cases. In the first case, the steady state belongs to the contingent compensation regime. This is the case if and only if $\eta_h \frac{2\eta_l}{1+\eta_l^2} (1-\alpha) EA (k_c + d_2)^\alpha < k_c$ where d_2 verifies $\left[A_l - (1-\alpha) EA \frac{2\eta_l^2}{1+\eta_l^2} \right] (k_c + d_2)^\alpha = \bar{r} d_2$. This writes as

$$(1-\alpha) \bar{r} \frac{2}{1+\eta_l^2} - (1-\alpha) \frac{2\eta_l^2}{1+\eta_l^2} + 1 - \delta < \alpha \left(\frac{1+\eta_l^2}{2\bar{r}} \frac{\gamma(\eta_l)}{1-\alpha} \delta \right)^{\frac{1-\alpha}{\alpha}}$$

If the gross risk free interest rate \bar{r} is sufficiently low then the steady state is in the contingent compensation regime. This condition is natural: When the gross risk free interest rate is low, firms demand for capital is large. Firms are then keen on choosing the contingent compensation strategy because it helps them increase their borrowing capacity. Moreover since there are decreasing marginal returns on capital, wages reach a steady state in the contingent wage strategy. In this case, the mean growth rate and the variance of the growth rate steadily decrease although fluctuations do not disappear at the steady state.

In the second case the steady state belongs to the fixed compensation strategy. This is the case if and

only if $(1 - \alpha) EA (k_c + d_1)^\alpha > k_c$ where d_1 verifies $[A_l - (1 - \alpha) EA] (k_c + d_1)^\alpha = \bar{r}d_1$. This writes as

$$(1 - \alpha)\bar{r} + \alpha - \delta > \alpha \left(\frac{\gamma(\eta_l)\delta}{(1 - \alpha)\bar{r}} \right)^{\frac{1-\alpha}{\alpha}}$$

Possibility of transitional crises when the bad state of nature happens. Then there exist a value for firms own capital k_1 with $k_1 < k_c$ such that if $k_t < k_1$, then firms choose the contingent wage strategy and the growth rate of the economy is positive whatever the state of the world. This is essentially due to the scarcity of capital and to the existence of decreasing marginal returns to capital. On the contrary, when $k_t > k_c$ then firms choose the fixed wage strategy and the growth rate of the economy is positive for any state of the world because workers are insured against aggregate uncertainty. Finally when $k_1 < k_t < k_c$ then the behavior of the economy directly depends upon the state of the world which happens. On the one hand the economy has accumulated enough capital and aggregate shocks have a larger impact on the growth rate. On the other hand, the economy has not accumulated enough capital to switch from the contingent to the fixed wage strategy. When a good state of nature happens, the economy reaches the fixed wage regime. When a bad state of a nature happens, the economy is brought back in terms of capital accumulation. Moreover the situation where $k_1 < k_t < k_c$ is not a steady state since a sufficiently "lucky" economy will get out of this area. This is a zone of transitory and not permanent instability. The probability of a negative growth rate first increases and then decreases with capital accumulation. Second, real wage procyclicality decreases with capital accumulation. Finally, in intermediate development stages, the behavior of the economy heavily depends upon "luck".

Finally in the last case there are no steady states in the contingent nor in the fixed compensation regimes. This is the case if and only if $(1 - \alpha) EA (k_c + d_1)^\alpha < k_c < \eta_h \frac{2\eta_l}{1+\eta_l^2} (1 - \alpha) EA (k_c + d_2)^\alpha$ where d_1 and d_2 are determined as previously. These two last inequalities write as

$$(1 - \alpha)\bar{r} + \alpha - \delta < \alpha \left(\frac{\gamma(\eta_l)\delta}{(1 - \alpha)\bar{r}} \right)^{\frac{1-\alpha}{\alpha}} < \left[(1 - \alpha)\bar{r} - (1 - \alpha)\eta_l^2 + (1 - \delta) \left(\frac{1 + \eta_l^2}{2} \right) \right] \left(\frac{2}{1 + \eta_l^2} \right)^{\frac{1}{\alpha}}$$

Then the steady state is a cycle. There is no fixed point in any compensation regime and the economy cycles

asymptotically between the two different regimes. On the one hand, the interest rate \bar{r} is sufficiently low so that the steady state does not belong to the fixed compensation. On the other hand, \bar{r} is sufficiently large so that so that the steady state does not belong to the contingent compensation regime. Beginning with a low initial capital stock, the economy steadily increases until it reaches a fixed point (conditional on the bad state of nature) in the contingent compensation regime. Then if the good state happens, the economy grows positively and reaches the fixed compensation regime. Once in this regime, the economy experiences a contraction (the capital stock decreases) because the marginal productivity of capital is too low compared to the gross risk free interest rate \bar{r} . The economy then comes back to the contingent compensation regime in which a good state yields positive growth while a bad state generates negative growth. We can eventually sum up the two regimes possibility with three following different cases

- case 1: If the gross risk free interest rate is low then the economy converges monotonically towards its steady state situated in the contingent compensation strategy.
- case 2: If the gross risk free interest rate is large then the economy converges monotonically towards its steady state situated in the fixed compensation strategy.
- case 3: If the gross risk free interest rate is intermediate, then the economy converges towards a cyclical steady state with permanent fluctuations in the capital stock.

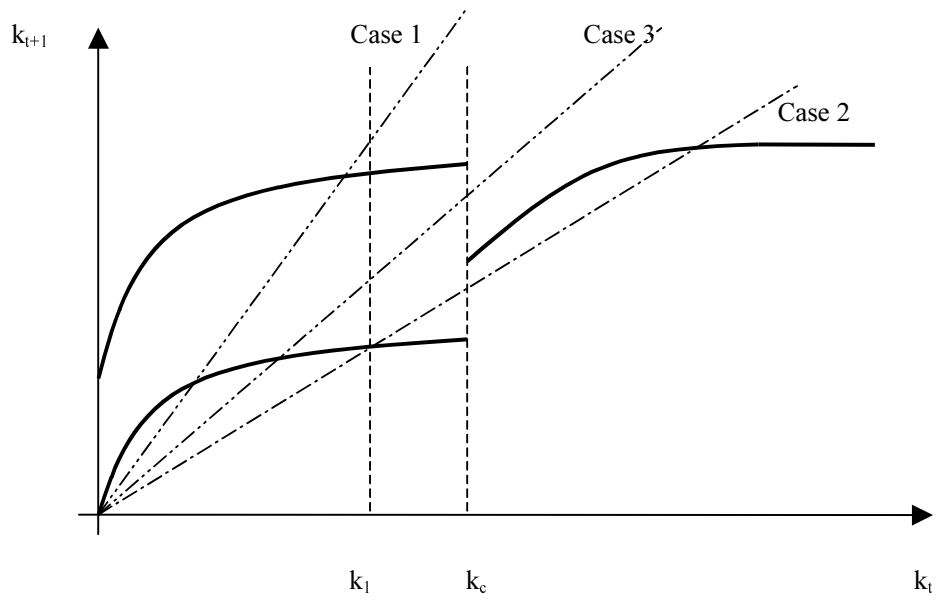


Figure 4.a: Dynamics of the economy when the variance of technological shocks is large.

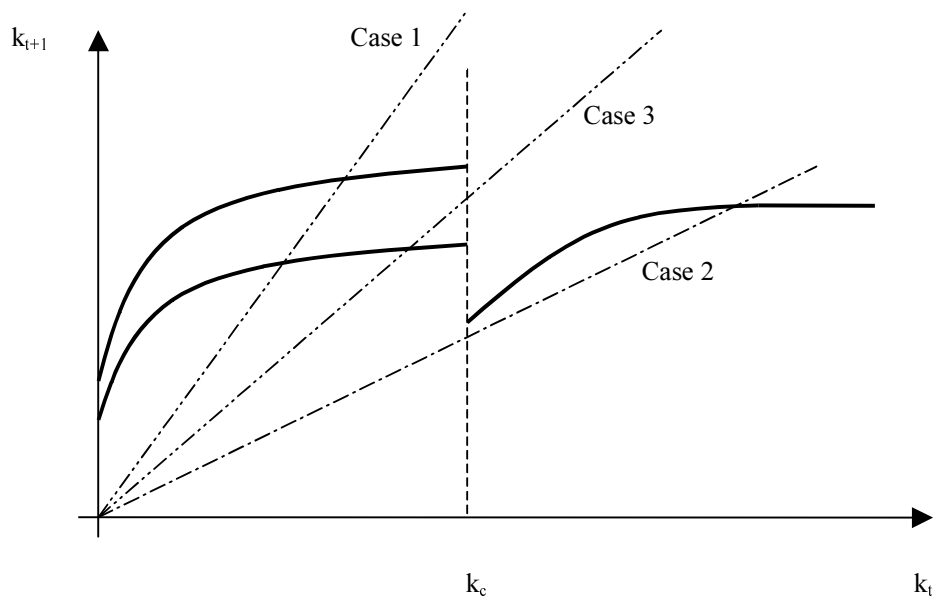


Figure 4.b: Dynamics of the economy when the variance of technological shocks is large.

5. Main Results

In the model we have built, labor contracts are endogenous as far as workers insurance is concerned. We have shown that the variability of workers compensation and economic fluctuations essentially depend upon three elements: the variance of TFP shocks, the cost of external capital for firms, and the level of firms own capital. Based on the previous discussion, we can observe that the variance of workers compensation increases with the variance of TFP shocks. At the steady state, workers compensation is more likely to be contingent when the volatility of technological shocks is large. The volatility of output is then large. On the contrary, compensation is more likely to be fixed, when the volatility of technological shocks is low. In this case, output volatility is low. Therefore the theoretical framework provides an explanation based on the existence of capital market imperfections for the empirical relation we described in the introduction (a positive correlation between the volatility of the economic fluctuations and real wages procyclicality).

Two other remarks are possible. First the cost of external capital has a negative influence on the degree of real wages procyclicality. A decrease in the gross risk free interest rate \bar{r} increases real wage procyclicality. When it is less costly for firms to borrow capital, (when economies become more integrated financially), firms reduce the insurance they provide to workers through their wage contracts because a decrease in the cost of external capital increases firms demand for capital. Since firms are constrained in the amount of capital they can borrow, they more likely choose contingent labor contracts in order to reduce the intensity of the borrowing constraints they face and thereby increase their expected profits. The theoretical framework therefore provides an explanation (based here on the existence of capital market imperfections) for the empirical relation described by Rodrik [1998] according to which the integration degree of economies plays a positive role in the volatility of workers compensation. Secondly this model helps to shed some light on how the volatility of shocks can affect average economic growth. An increase in the volatility of technological shocks always reduces the speed at which the economy accumulates capital. When the volatility of technological shocks is larger, the bad shock A_t is even worse. The borrowing capacity of firms is then reduced and the amount of capital invested is lower. The model therefore predicts a negative relation between the average growth rate of the economy and the volatility of shocks the economy faces.

6. Conclusion.

We have built a model in which the structure of workers compensation is endogenous. This has enabled us to build a theory of growth and macroeconomic fluctuations based on firms choices as to the structure of workers compensation. The main of point of the paper consists in saying that firms trade-off the average cost of labor against the intensity of the borrowing constraints they face. When firms increase the wage insurance they provide to workers this reduces the average cost of labor because workers are risk averse. This has therefore a positive impact on expected profits. However when firms increase the wage insurance they provide to workers, this tightens firms borrowing constraints. This has a negative impact on expected profits because fewer capital is invested. Then we have then shown that this mechanism embedded into a dynamic macroeconomic model can help explain the stylized fact raised in the introduction. Through a comparative statics exercise on the volatility of macroeconomic shocks and the cost of external capital for firms, we have found a possible explanation for the stylized facts about the relation between the structure of workers compensation and the degree of macroeconomic volatility.

Finally, we can make two other remarks. First it would be interesting to study wether introducing other contracts such as equities or short and long term debt would change or modify the results we have obtained. For instance, it is likely that firms which can issue long term debt will also pay more frequently fixed wages. The second remark we can make concerns the supply of capital. In this model we have assumed that capital supply is exogenous. If it was endogenous, i.e. if workers were capital providers for firms, then the compensation structure would influence the amount of capital workers save. In particular, workers whose income is contingent will save more than those whose income is fixed. This could then generate multiple equilibria because the risk transferred to workers impacts positively the demand and the supply for capital. Put differently, a negative relation could emerge between the quantity of capital firms borrow and the cost of external capital for firms.

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7. Appendix.

7.1. Data and plots.

All the data used come from the OECD Economic Outlook database. We consider $w_{i,t}$ the real compensation index per worker in the business sector¹⁴, deflated by consumption or GDP prices in country i at time t and $y_{i,t}$ is the value added in the business sector in country i at date t . There are 22 countries in the sample: Australia, Austria, Belgium, Canada, Denmark, Germany, Finland, France, Greece, Italy, Ireland, Japan, Korea, Mexico, Netherlands, Norway, Portugal, Sweden, Spain, Switzerland, United Kingdom and USA. The time period is 1983-2002. We compute the standard deviation for each country of the growth rate of $w_{i,t}$ and $y_{i,t}$ and put them respectively on the y-axis and on the x-axis (in figure 1, compensation is deflated by GDP prices).

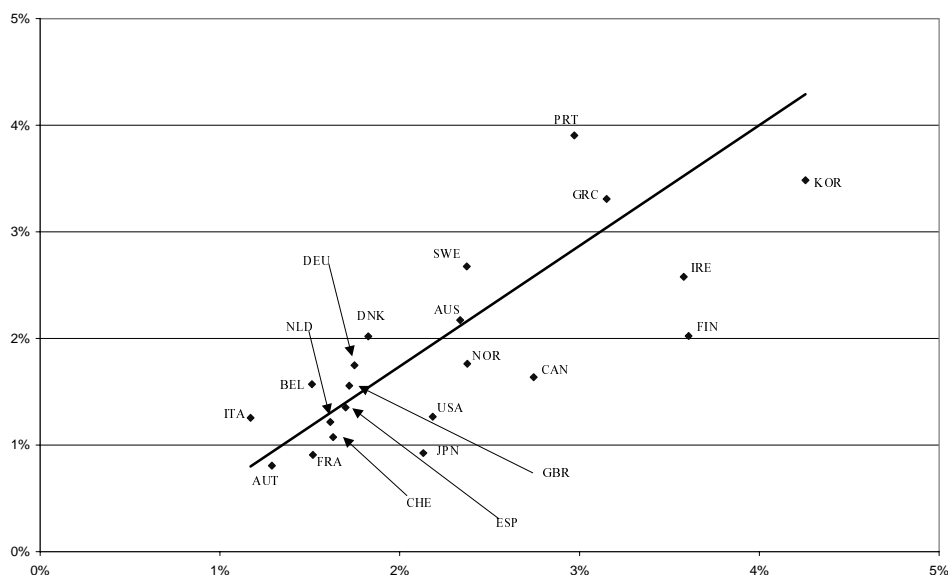


Figure 1 : Standard deviation of GDP growth vs. standard deviation of real wage per worker growth¹⁵.

¹⁴The business sector as it is defined by OECD is the whole economy minus the public sector. c.f. OECD Economic Outlook: Sources and methods, (<http://www.oecd.org/eco/sources-and-methods>).

¹⁵Mexico has been removed from this plot because its real wage growth standard deviation (around 7%) is very large compared to the other countries.

We then run the following regression

$$\ln \frac{w_{i,t}}{w_{i,t-1}} = \alpha_i + \gamma_t + \delta_i \ln \frac{y_{i,t}}{y_{i,t-1}} + \varepsilon_{i,t}$$

The sample is the same as previously, α_i are individual effects and γ_t are time effects. Real wage procyclicality in country i is δ_i . Figure 2 represents a plot where the standard deviation of value added growth is on the x-axis and real wage procyclicality per country δ_i is on the y-axis.

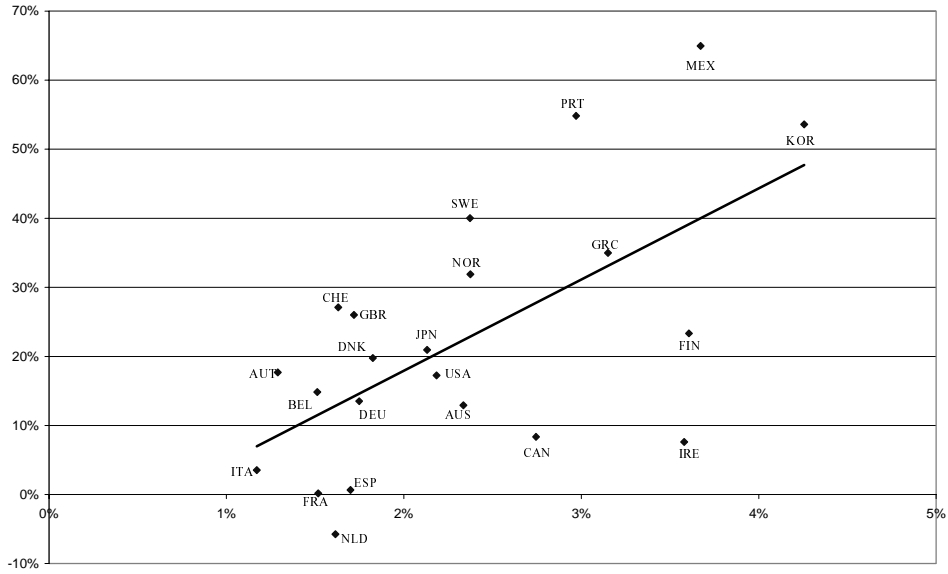


Figure 2 : Standard deviation of GDP growth vs. real wage per worker procyclicality¹⁶.

¹⁶In this diagram, real wage procyclicality has been estimated pulling out of the sample the data for Germany in year 1990 since large changes in output and wages have occurred due to the political unification of the country. Output has risen by almost 15% while real wages have decreased by 10% this year.

Finally, the following equations have been estimated

$$\ln \frac{w_{i,t}}{w_{i,t-1}} = \alpha_i + \gamma_t + \beta x_{i,t} + \delta_0 \ln \frac{y_{i,t}}{y_{i,t-1}} + \delta_1 \sigma_{y_i} \ln \frac{y_{i,t}}{y_{i,t-1}} + \varepsilon_{i,t}$$

$$\ln \frac{w_{i,t}}{w_{i,t-1}} = \alpha_i + \gamma_t + \beta x_{i,t} + \delta_0 \ln \frac{y_{i,t}}{y_{i,t-1}} + \delta_1 \sigma_{e_i} \ln \frac{e_{i,t}}{e_{i,t-1}} + \varepsilon_{i,t}$$

$$\ln \frac{w_{i,t}}{w_{i,t-1}} = \alpha_i + \gamma_t + \beta x_{i,t} + (\delta_0 + \delta_1 \sigma_{y_i}) \ln \frac{y_{i,t}}{y_{i,t-1}} + (\eta_0 + \eta_1 \sigma_{e_i}) \ln \frac{e_{i,t}}{e_{i,t-1}} + \varepsilon_{i,t}$$

Control variables are gathered in vector $x_{i,t}$, σ_{y_i} is the variance for country i of the growth rate of $y_{i,t}$, $e_{i,t}$ is the level of employment in the business sector in country i at date t , σ_{e_i} is the variance for country i of the growth rate of $e_{i,t}$.

Table 1. Dependent variable: Real compensation per worker growth rate in bus. sector deflated by GDP prices.

σ_{y_i} (/100)	-0,15 ^a	-0,07 ^c							
$\ln \frac{y_{i,t}}{y_{i,t-1}}$	-0,09	0,48 ^a	0,49 ^a	0,38 ^a		0,66 ^a	0,63 ^a	0,54 ^a	0,32 ^a
$\sigma_{y_i} \ln \frac{y_{i,t}}{y_{i,t-1}}$ (/100)	4,16 ^a	1,72 ^b	1,59 ^b	1,93 ^b					2,41 ^a
σ_{e_i} (/100)					0,04 ^b	0,01			
$\ln \frac{e_{i,t}}{e_{i,t-1}}$		-0,59 ^a	-0,60 ^a	-0,59 ^a	0,19 ^b	-0,40 ^a	-0,30 ^a	-0,41 ^a	-0,37 ^c
$\sigma_{e_i} \ln \frac{e_{i,t}}{e_{i,t-1}}$ (/100)					-2,31 ^a	-1,23 ^a	-1,45 ^a	-1,02 ^a	-1,21 ^a
R ²	18%	30%	30%	37%	7%	30%	33%	46%	48%
controls	no	yes	yes	yes	no	yes	yes	yes	yes
Fixed effects	no	no	yes	yes	no	no	yes	yes	yes
Heteroscedasticity	no	no	no	yes	no	no	no	yes	yes
N×T	22×20	22×18	22×15	22×15	22×18	22×15	22×15	22×15	22×15

Note: Significance levels 1%, 5% and 10% are indicated respectively with superscript a, b and c. Control variables are the following: ratio of imports in goods and services to total GDP, unemployment rate in total economy, share of business sector employment in total employment, share of business sector added value in total added value. All the samples used are balanced and all estimations include time effects. Estimation periods are the following 1982-2001 with 20 periods, 1984-2001 with 18 periods, 1987-2001 with 15 periods.

All the estimations display the same result: every thing else equal, real wages procyclicality is larger in economies where the volatility of the business cycle is larger.

Table 2. Dependent variable: Real compensation per worker growth rate in bus. sector deflated by cons. prices.

σ_{y_i} (/100)	-0,17 ^a	-0,08 ^b							
$\ln \frac{y_{i,t}}{y_{i,t-1}}$	-0,06	0,33 ^c	0,37 ^a	0,27 ^a		0,52 ^a	0,55 ^a	0,43 ^a	0,18 ^b
$\sigma_{y_i} \ln \frac{y_{i,t}}{y_{i,t-1}}$ (/100)	5,24 ^a	2,09 ^a	1,94 ^a	2,03 ^a					2,87 ^a
σ_{e_i} (/100)					0,04 ^b	0,01			
$\ln \frac{e_{i,t}}{e_{i,t-1}}$		-0,42 ^a	-0,42 ^a	-0,37 ^a	0,25 ^a	-0,17 ^c	-0,12	-0,18 ^b	-0,14 ^c
$\sigma_{e_i} \ln \frac{e_{i,t}}{e_{i,t-1}}$ (/100)					-2,03 ^a	-1,28 ^a	-1,47 ^a	1,17 ^a	-1,43 ^a
R ²	21%	23%	24%	25%	05%	24%	26%	31%	34%
control variables	no	yes	yes	yes	no	yes	yes	yes	yes
Fixed effects	no	no	yes	yes	no	no	yes	yes	yes
Heteroscedasticity	no	no	no	yes	no	no	no	yes	yes
N×T	22×21	22×15	22×15	22×15	22×18	22×15	22×15	22×15	22×15

Note: Significance levels 1%, 5% and 10% are indicated respectively with superscript a, b and c. Control variables are the following: ratio of imports in goods and services to total GDP, unemployment rate in total economy, share of business sector employment in total employment, share of business sector added value in total added value. All the samples used are balanced and all estimations include time effects. Estimation periods are the following 1982-2001 with 20 periods, 1984-2001 with 18 periods, 1987-2001 with 15 periods.

All the estimations display the same result: every thing else equal, real wages procyclicality is larger in economies where the volatility of the business cycle is larger.

7.2. Optimal individual wage contracts.

If firm i decides to propose a contingent compensation scheme $\{w_l, w_h\}$ such that $w_l = \eta_l \bar{w}$, and \bar{w} is the fixed wage proposed by other firms, then workers participation constraint implies that if $w_h = \eta_h \bar{w}$ then

$\eta_h = \eta_l^{-1}$. Moreover the bad state of nature determines firm i borrowing constraint if and only if

$$\eta_l^2 \geq \frac{1 - \alpha - \delta}{1 - \alpha + \delta}$$

Therefore expected profits of firm i $E\Pi$ can be written as

$$E\Pi(\eta_l) = \max[R(\eta_l); 1] \bar{r} k_i$$

where

$$R(\eta_l) = \frac{\alpha EA - \left[A_l - (1 - \alpha) EA \frac{2\eta_l^2}{1 + \eta_l^2} \right]}{\left[\frac{\bar{w}}{(1 - \alpha) EA} \right]^{\frac{1 - \alpha}{\alpha}} \left[\frac{1 + \eta_l^2}{2\eta_l} \right]^{\frac{1 - \alpha}{\alpha}} \bar{r} - \left[A_l - (1 - \alpha) EA \frac{2\eta_l^2}{1 + \eta_l^2} \right]}$$

and the optimal compensation scheme $\{w_l, w_h\}$ is the solution to the program

$$\begin{aligned} & \max_{\eta_l} R(\eta_l) \\ & \text{s.t. } \eta_l^2 \geq \frac{1 - \alpha - \delta}{1 - \alpha + \delta} \end{aligned}$$

Let us note N (resp. D) the numerator (resp. the denominator) of $R(\eta_l)$. We then have

$$\frac{\partial R(\eta_l)}{\partial \eta_l} \equiv \frac{EA}{1 + \eta_l^2} [D(\eta_l) - N(\eta_l)] + \left[\frac{\bar{w}}{(1 - \alpha) EA} \right]^{\frac{1 - \alpha}{\alpha}} \left[\frac{1 + \eta_l^2}{2\eta_l} \right]^{\frac{1 - \alpha}{\alpha}} \frac{\bar{r}}{\alpha} \frac{1 - \eta_l^2}{4\eta_l^2} N(\eta_l)$$

Let us note φ the right hand side variable of the last expression

$$\varphi(\eta_l) = \left[\frac{\bar{w}}{(1 - \alpha) EA} \right]^{\frac{1 - \alpha}{\alpha}} \left[\frac{1 + \eta_l^2}{2\eta_l} \right]^{\frac{1 - \alpha}{\alpha}} \bar{r} \left[\frac{\alpha EA}{1 + \eta_l^2} + \frac{1 - \eta_l^2}{4\eta_l^2} N(\eta_l) \right] - \frac{(\alpha EA)^2}{1 + \eta_l^2}$$

Then φ is a strictly decreasing function of η_l .

$$\frac{\partial \varphi(\eta_l)}{\partial \eta_l} \equiv - (1 - \alpha) \frac{1 - \eta_l^2}{1 + \eta_l^2} EA - 2 \frac{1 - \alpha}{\alpha} \frac{1 - \eta_l^2}{1 + \eta_l^2} \frac{1 - \eta_l^2}{4\eta_l^2} (1 + \eta_l^2) N(\eta_l) - \frac{1 + \eta_l^4}{2\eta_l^2} N(\eta_l)$$

This implies that a necessary and sufficient condition for firms to adopt contingent compensation schemes writes as $\left. \frac{\partial R(\eta_l)}{\partial \eta_l} \right|_{\eta_l=1} < 0$. which simplifies as $\alpha EA > \left[\frac{\bar{w}}{(1-\alpha)EA} \right]^{\frac{1-\alpha}{\alpha}} \bar{r}$. At the equilibrium of the labor market, the wage rate \bar{w} is such that $\bar{w} = (1-\alpha)EA(k+d)^\alpha$. The necessary and sufficient condition therefore writes as

$$\alpha EA (k+d)^{\alpha-1} > \bar{r}$$

This condition simply states that the expected marginal productivity of capital is larger than the gross interest rate. In other words the amount of debt d firms can borrow is not enough to reach the first best capital stock. This means that the optimal compensation scheme $\{w_l^*, w_h^*\}$ is such that $w_l^* < \bar{w} < w_h^*$ if and only if firms are credit constrained and cannot issue contingent debt.

Then assuming that $\left. \frac{\partial R(\eta_l)}{\partial \eta_l} \right|_{\eta_l=1} < 0$ (firms are credit constrained), due to the fact that φ is a strictly decreasing function of η_l and a strictly increasing function of \bar{r} , the optimal wage $\{w_l^*, w_h^*\}$ is such that $w_h^* - w_l^* = \frac{1-\eta_l^2}{\eta_l} \bar{w}$ is a decreasing function of the interest rate \bar{r} . In other words a larger interest rate reduces optimal wage procyclicality.

7.3. Dynamics of the economy.

When firms are credit constrained and provide fixed compensation schemes, firms individual expected profits $E\Pi_f$ write as

$$E\Pi_f = \frac{\alpha EA - [A_l - (1-\alpha)EA]}{\left[\frac{\bar{w}}{(1-\alpha)EA} \right]^{\frac{1-\alpha}{\alpha}} \bar{r} - [A_l - (1-\alpha)EA]} \bar{r} k_i$$

In the case they are credit constrained and provide contingent compensation schemes and assuming that the borrowing constraint is binding in the bad state of nature¹⁷, firms individual expected profits $E\Pi_c$ writes as

$$E\Pi_c = \frac{\alpha EA - \left[A_l - (1-\alpha)EA \frac{2\eta_l^2}{1+\eta_l^2} \right]}{\left[\frac{\bar{w}}{(1-\alpha)EA} \right]^{\frac{1-\alpha}{\alpha}} \left[\frac{1+\eta_l^2}{2\eta_l} \right]^{\frac{1-\alpha}{\alpha}} \bar{r} - \left[A_l - (1-\alpha)EA \frac{2\eta_l^2}{1+\eta_l^2} \right]} \bar{r} k_i$$

¹⁷This needs that $\eta_l^2 \geq \frac{1-\alpha-\delta}{1-\alpha+\delta}$.

Then firms prefer the fixed compensation strategy if and only if $E\Pi_c < E\Pi_f$ which simplifies as

$$\left[\frac{\bar{w}}{(1-\alpha)EA} \right]^{\frac{1-\alpha}{\alpha}} \bar{r} > (1-\alpha)EA \frac{1-\eta_l^2}{1+\eta_l^2} \frac{\alpha EA}{[EA - A_l] \left[\frac{1+\eta_l^2}{2\eta_l} \right]^{\frac{1-\alpha}{\alpha}} - \left[\alpha EA + (1-\alpha)EA \frac{2\eta_l^2}{1+\eta_l^2} - A_l \right]}$$

Moreover when firms choose the fixed compensation scheme, the wage rate \bar{w} at the equilibrium of the labor market is $\bar{w} = (1-\alpha)EA(k+d)^\alpha$ where d is such $\bar{r}d = [A_l - (1-\alpha)EA](k+d)^\alpha$. Therefore all firms choose the contingent compensation strategy if and only if firms own capital level k is such that $k < k_c$ with

$$k_c = \frac{1 - \frac{A_l - (1-\alpha)EA}{(1-\alpha)EA} \frac{1+\eta_l^2}{1-\eta_l^2} \left(\left[\frac{1+\eta_l^2}{2\eta_l} \right]^{\frac{1-\alpha}{\alpha}} - 1 \right)}{\left[1 + \frac{EA - A_l}{(1-\alpha)EA} \frac{1+\eta_l^2}{1-\eta_l^2} \left(\left[\frac{1+\eta_l^2}{2\eta_l} \right]^{\frac{1-\alpha}{\alpha}} - 1 \right) \right]^{\frac{1}{1-\alpha}}} \frac{EA - A_l}{\bar{r}} \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1-\alpha}}$$

Then the equilibrium on the labor market is such that $Ew_s = (1-\alpha)EA(k+d_2)^\alpha$ and the individual rationality condition is such that $Ew_s = \frac{1}{2} \left(\eta_l + \frac{1}{\eta_l} \right) \bar{w}$. Therefore when firms provide contingent compensation schemes the wage bill w_s distributed to workers when the shock A_s happens is

$$w_s = \eta_s \frac{2\eta_l}{1+\eta_l^2} (1-\alpha)EA(k+d_2)^\alpha$$

On the contrary firms are able to reach their first best capital labor ratio with a fixed compensation scheme if and only if

$$\left[\frac{\bar{w}}{(1-\alpha)EA} \right]^{\frac{1-\alpha}{\alpha}} \bar{r} \geq \alpha EA$$

Once again since $\bar{w} = (1-\alpha)EA(k+d)^\alpha$ and d is such that $\bar{r}d = [A_l - (1-\alpha)EA](k+d)^\alpha$ these three equations yield the lower bound on firms own capital level k_f

$$k_f = \frac{EA - A_l}{\bar{r}} \left[\frac{\alpha EA}{\bar{r}} \right]^{\frac{\alpha}{1-\alpha}}$$

7.4. Contingent debts and wage contract insurance.

We extend here the micro model to the case where firms can issue contingent debt. As previously firms decisions about capital and labor are sequential. Debt contracts are contingent in the sense that there is at least one state of the world where firms are not able to pay for the face value of their financial liabilities. Since there are two states of the world, let us suppose that firms are not able to pay for the face value of their financial debts in the bad state of nature. Therefore The program of firm i first consists in choosing the number of worker l_i such that it solves

$$\begin{aligned} \max_{l_i} E\Pi(l_i) &= \frac{1}{2} [A_h (k_i + d_i)^\alpha l_i^{1-\alpha} - w_h l_i - r d_i] \\ \text{s.t. } E \log(w_s) &\geq \log(\bar{w}) \end{aligned}$$

The solution to this problem (firm i optimal demand for labor) then writes as

$$(1 - \alpha) A_h (k_i + d_i)^\alpha l_i^{-\alpha} = w_h$$

Now the problem consisting for firm i in determining its optimal amount of debt finance d_i . If firm i chooses to issue risk free contracts only then its program and the solution are identical to those derived in the micro model. On the contrary if firm i chooses to issue contingent contracts then the program of firm i is

$$\text{s.t. } \begin{cases} \max_{d_i} E\Pi(d_i) = \frac{1}{2} [A_h (k_i + d_i)^\alpha l_i^{1-\alpha} - w_h l_i - r d_i] \\ (1 - \alpha) A_h (k_i + d_i)^\alpha l_i^{-\alpha} = w_h \\ \bar{r} d_i = \frac{1}{2} r d_i + \frac{1}{2} [A_l (k_i + d_i)^\alpha l_i^{1-\alpha} - w_l l_i - c(k_i + d_i)] \\ A_l (k_i + d_i)^\alpha l_i^{1-\alpha} - w_l l_i < \bar{r} d_i \end{cases}$$

The first condition represent firm i optimal labor demand, the second condition represents the no arbitrage condition with which financiers price the interest rate on contingent financial contracts. The term $2c(k_i + d_i)$ represents the ex post verification cost financier pay for when the firm declares that it cannot pay for the face value of debt. The assumption that this cost is lenar in the amount of capital invested in the firm is

simply made to simplify the analysis. Finally the last condition (inequality) states that when the bad state of nature happens, firms are not able to pay for their debts even with the lowest interest rate possible (the risk free one in fact). Simplifying this program then amounts to

$$\begin{aligned} & \max_{d_i} \frac{1}{2} \left[\left[\frac{(1-\alpha)A_h}{w_h} \right]^{\frac{1-\alpha}{\alpha}} [A_h - (1-\alpha)A_h] (k_i + d_i) - rd_i \right] \\ \text{s.t. } & \bar{r}d_i = \frac{1}{2}rd_i + \frac{1}{2} \left[\left[\frac{(1-\alpha)A_h}{w_h} \right]^{\frac{1-\alpha}{\alpha}} \left[A_l - \frac{w_l}{w_h} (1-\alpha)A_h \right] - 2c \right] (k_i + d_i) \end{aligned}$$

Firms demand for capital is then optimal if and only if

$$\bar{r} + c = \left[EA - \frac{Ew_s}{w_h} (1-\alpha)A_h \right] \left[\frac{(1-\alpha)A_h}{w_h} \right]^{\frac{1-\alpha}{\alpha}}$$

Then the optimal expected profits of firm i depend only upon the compensation scheme $\{w_l, w_h\}$. Therefore the optimal wage contract is such that

$$\begin{aligned} & \max_{\{w_l, w_h\}} \left[EA - \frac{Ew_s}{w_h} (1-\alpha)A_h \right] \left[\frac{(1-\alpha)A_h}{w_h} \right]^{\frac{1-\alpha}{\alpha}} \\ \text{s.t. } & \log w_l + \log w_h = 2 \log \bar{w} \end{aligned}$$

Introducing the individual rationality constraint into the expected profit expression, we end up with a function of w_h only. Then taking the value of the derivative of this expression w.r.t. w_h for $w_h = \bar{w}$ we get an expression $(\frac{1-\alpha}{\alpha} \frac{A_h - EA}{\bar{w}^\alpha})$ which is always positive. In other words, the possibility for firms to issue contingent debt does not modify the result: When firms are credit constrained, they optimally choose to provide workers with contingent compensation schemes.