Micro foundations for wage flexibility: wage insurance at the firm level *

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Abstract

To which extent do firms insulate their workers' wages from fluctuations in product markets? Which firm and worker attributes are associated with wage flexibility at the micro level? We first rely on Guiso *et al.* (2005) to estimate dynamic models of sales and wages, finding that in Portugal workers' wages respond to permanent shocks to firm performance, as opposed to transitory shocks. We then explore the factors associated with wage flexibility, finding that collective bargaining and minimum wages are associated with higher wage insurance by the firm, while the threat of firm bankruptcy reduces it. Managers receive less protection against permanent shocks than other workers.

KEYWORDS: wage shocks; risk sharing; rent sharing.
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I. Introduction

The impact of high wage flexibility reducing economic fluctuations and improving macroeconomic performance has been highlighted in the literature, where wage flexibility has invariably been evaluated as the responsiveness of wages to aggregate conditions, namely the unemployment rate. However, in the terminology of Faggio and Nickell (2005), wage flexibility has two different aspects: the responsiveness of wages to labor market conditions, and the responsiveness of wages within a firm to idiosyncratic shocks to its productivity or its output. They concentrate on the first aspect. The second aspect can be understood as the micro foundations for wage flexibility, the issue under analysis in the current study. We focus on Portugal, pointed out as one of the OECD economies with highest wage flexibility, despite its labor market regulations.

More precisely, we will provide an answer to the questions: What is the responsiveness of wages to shocks to firm output? I.e., to which extent do firms provide wage insurance to their workers, insulating them from fluctuations in product markets? Which firm and worker attributes are associated with a higher degree of wage flexibility at the firm level? A very precise hypothesis has been stated by Faggio and Nickell (2005): national collective bargaining is associated with lower responsiveness of wages to labor market conditions. We will check whether workers covered by national bargaining agreements also see their wages react less to firm level idiosyncratic shocks than workers covered by more decentralized agreements. At first sight that might be expected, but it is not necessarily the case. Indeed, Teulings (1997) has argued that in a corporatist setting for wage bargaining, firms can delegate on trade unions the task of adjusting contracts to macro level shocks, while then promoting adjustments to firm idiosyncratic shocks. Also, Cardoso and Portugal (2005) have shown that firms are able to overcome the constraints imposed by collective bargaining by adjusting the actual wage paid on top of the bargained wage. We will also inspect the impact of other labor market regulations, namely the minimum wage, on wage flexibility. Other hypotheses can be derived from the wage insurance literature, which has shown that the share of risk borne by the firm and the worker depends on factors such as: the persistence of the shocks hitting the firm; workers' and firms' preferences, namely their degree of risk-aversion; the sensitivity of firm output to worker effort; the likelihood of bankruptcy.

An empirical test on such theories depends crucially on the quality and detail of the data available. We use a longitudinal matched employer-employee dataset of remarkable quality, which matches all the firms and workers in the manufacturing and services private sectors. Given its nature, problems commonly faced by longitudinal data sets, such as panel attrition and under- or over-representation of certain groups, are avoided. Also, the legal requirement for the data to be posted in a visible location within the company contributes to its reliability, reducing measurement errors.

Guiso *et al.* (2005) have devised an empirical strategy to quantify the impact of temporary and permanent firm-level shocks on wages, which relies on longitudinal matched employer-employee data to estimate dynamic panel data models. We will follow their strategy to quantify the wage response to firm-level permanent and transitory shocks. We will then explore the forces that shape wage flexibility at the firm level, in particular the role of the institutional setting.

After the brief revision of the literature that follows, section III describes the institutional framework for wage setting in Portugal and section IV describes the data. Sections V to VIII summarize the empirical model and present the results, before concluding comments are presented in section IX.

II. Wage insurance in the previous literature

Insurance models can explain why wages do not adjust as much as predicted by spot market theory, after changes in the demand for the firm output. The underlying idea is that firms, being risk neutral, commit to paying a pre-defined wage to their risk averse workers, independently of product market fluctuations. Such strategy is profit maximizing because risk-averse workers will accept a non-stochastic wage lower than the expected value of a stochastic wage. Early models have been developed by Baily (1974), Gordon (1974), and Azariadis (1975). Other models predict relatively smaller insurance provision. Gamber (1988) allows for firm bankruptcy, which constrains the capacity of the firm to provide insurance to the workers, and distinguishes between temporary and permanent shocks, in a two-period model. In his model, real wages react more to permanent shocks than to temporary ones. In case of temporary shocks, the firm wishing to smooth the wage of the worker over time can promote a relatively small wage adjustment in the period the shock occurs, deferring the rest of the adjustment to the following period.

A central issue that follows concerns the enforceability of insurance contracts. For example, if worker performance is not verifiable, the firm may gain from declaring that it is below its actual level and reneging the contract, thus paying a wage lower than the insurance wage. Similarly, if worker mobility is allowed, the worker might gain from reneging the contract and accepting a better outside offer. Implicit contract theory has established conditions under which it is in the firm's and in the worker's interest to stick to the contract. Basically, workers and firms will respect the contract as long as its long run gains outweigh the short term benefit from reneging it. The insurance wage could therefore fluctuate between the level strictly required to prevent the firm from dismissing the worker and, by a similar reasoning, the level strictly required to prevent the worker from quitting. The latter case holds when contracts are not binding on the worker, whereas the former holds when contracts are not binding on the firm.[1]

Empirical studies relied initially on aggregate industry data (Gamber 1988,

[1]For an early overview of contract theory, see Rosen (1985). Weiss (1984) has considered the role of mobility costs preventing workers from quitting and thus enabling firms to provide wage insurance; Holmstrom (1981) and Thomas and Worrall (1988) model the consequences of the loss of reputation by firms that renege on a contract; in the model by Harris and Holmstrom (1982), firms learn about worker ability and adjust the wage to the outside market to prevent the worker from quitting.

Christofides and Oswald 1992, Blanchflower *et al.* 1996), progressing to use firm-level averages (Hildreth and Oswald 1997, Nickell and Wadhwani 1990). Beaudry and DiNardo (1991) use individual worker data, but their indicator of market conditions is computed at the aggregate or industry level. Similarly, Weinberg (2001) uses individual data, but relies on a measure of shocks defined at the industry level, to analyze wage and employment fluctuations at the industry level in response to demand shocks. Devereux (2005) relies on panel data on workers to quantify the impact of industry-level demand shocks on wages, finding that industry wages respond positively to changes in industry employment. Faggio and Nickel (2005) use worker longitudinal data to quantify the impact of changes in labor market conditions at the regional level on wages. Finally, Guiso *et al.* (2005) have set a new benchmark in the analysis of this issue. The ingenious empirical identification strategy followed relies on longitudinal matched employer-employee data to estimate dynamic panel data models and quantify the impact of temporary and permanent firm-level shocks on wages. They found that firms provide full insurance against temporary shocks, while providing only partial insurance against permanent shocks.

The literature on wage insurance is linked to that on rent sharing, having in particular a common aim: to check the relationship wages - profits (or another indicator of performance). In one case it is highlighted that firm and workers share risks and in the other case it is highlighted that they share rents. The theoretical background is different, though. The wage insurance literature, relying mostly on implicit contracts theory, highlights: the individual nature of the contract signed between the firm and the worker, as opposed to the emphasis on the firm and union nature of bargaining; the differential risk aversion by workers and firms; demand shocks at the micro level that translate into idiosyncratic shocks to firm performance (given its idiosyncratic nature, not affecting the whole market, they are the type of risk that the firm can reduce by diversification). In the wage insurance setting, distortions to competitive mechanism are brought about mainly by incomplete credit and insurance markets. In the rent sharing literature, distortions to competitive mechanism are most often seen as a result of worker bargaining power and, less often, as stemming from efficiency wage considerations or frictions in the labor market.

A broader setting would consider jointly the occurrence of different levels of shocks to firm performance (aggregate, industry and firm level shocks), disentangling whether workers are insulated from each of those types of shocks and, if so, by which mechanisms: national legislation on worker protection, union action through collective bargaining contracts, or firm level policies. Such analysis could in particular address one issue not handled in the settings described. Indeed, wages may be independent of firm performance for two different reasons: either because the labor market is competitive and wages do not depend on idiosyncratic firm shocks, as they are set by aggregate conditions, or, in situations where wages are bargained over, because firms offer insurance. Below we will concentrate only on firm idiosyncratic shocks, distinguishing between their temporary or permanent nature to evaluate their impact on workers wages.

III. Wage setting institutions in Portugal

The Portuguese labor market is characterized by a high level of employment rigidity and high wage flexibility. In fact, its strict job protection legislation, covering issues such as advance notice required before dismissal, severance pay, and the rules on use of fixed-term or temporary contracts, invariably place the country among the OECD economies with highest employment rigidity (see for example OECD 1999). On the contrary, it ranks among the OECD economies with highest wage flexibility (see OECD 1992), since wages are highly responsive to the unemployment rate, despite the regulated framework.

Even though union membership has declined, from 61 percent in 1970 and 1980 to 32 percent in 1990 (OECD 1994: 184), collective bargaining covers almost all of the workforce. This wide coverage results from widespread mechanisms of extension of contracts: most often, employers who subscribe to an agreement apply it to all of their workforce, irrespective of the worker union membership status; employers or workers representatives can join an existing agreement, subscribing to a contract they had initially not signed; moreover, the Government can impose mandatory extensions of existing contracts, when workers are not covered by a trade union, when one of the parties refuses to negotiate or negotiation is obstructed in any other way. As a rule, wage negotiations are held yearly and the wage updates take effect in January each year.

Studies at the micro level have identified sources of wage flexibility under this regulated setting. In particular, Cardoso and Portugal (2005) have found that wages set by collective bargaining reflect to a high extent the degree of power of the partners negotiating, but subsequent firm-specific arrangements reduce the returns to union power, adjusting wages to the conditions that prevail at the micro level. Also, Cardoso (1999) had found that the returns to different worker attributes vary widely across firms.

Note therefore that both the theoretical underpinnings of wage insurance and empirical evidence highlight the firm as a relevant level of analysis to discuss the protection of workers' wages against market fluctuations.

IV. Data set

Quadros de Pessoal is a matched employer-employee data set gathered by the Ministry of Employment, based on an inquiry that every company with wage-earners is legally obliged to fill in. Public administration and domestic service are not covered, and the coverage of agriculture is low, given its low share of wage-earners. For the remaining sectors, the mandatory nature of the survey leads to an extremely high response rate. Each year, around two million workers and 100 to 200 thousand companies are covered. Data for 1991 to 2000 are used.

Reported data cover the firm and all the workers engaged in the firm in a reference week (whether wage-earner, unpaid family member or owner working in the firm). Reported variables include the firm's location, industry, employment, sales volume, ownership structure, and date of creation, and the worker's gender, schooling, age, occupation, seniority, several components of wage, duration of work, and collective bargaining contract.

A worker identification code, based on a transformation of the social security number, enables tracking him/her over time. Extensive checks have been performed to guarantee the accuracy of the data, using gender, date of birth, and highest schooling level achieved. A firm identification code enables tracking it over time. Based in particular on the location of the firm and its official identification codes, extensive controls are implemented by the data gathering agency to guarantee that a firm is not assigned a different number later on.

Details on the construction of the database, sample sizes, and descriptive statistics are presented in appendix.

V. Firm performance

We start by briefly describing the intuition behind the procedure in Guiso *et al.* (2005), which we will follow. First, consistent estimates of the residuals from a wage regression are retrieved; similarly, consistent estimates of the residuals from a regression of firm performance are retrieved. Given the set of controls included in each of these regressions, the residuals capture idiosyncratic shocks to workers wages and to firm performance. Then, we make use of both residuals and regress idiosyncratic shocks to wages on idiosyncratic shocks to firm's performance, evaluating the level of insurance provided by the firm to both temporary and permanent shocks. Finally, we check for heterogeneity in the degree of wage insurance provided, according to firm and worker attributes.

What accomplishments does this empirical method bring relative to less complex methods previously used in the literature? Mainly, it enables analyzing the provision of wage insurance at the firm level (against idiosyncratic shocks), distinguishing moreover between the impact of shocks with different degrees of persistence (temporary versus permanent).

Based on the specification used by Guiso *et al.* (2005), firms' performance is modeled as

$$sales_{jt} = \gamma_t + \rho sales_{j,t-1} + X'_{jt}\Gamma + \eta_j + \epsilon_{jt} \qquad (1)$$

where $sales_{jt}$ is the logarithm of sales of firm j in period t, X_{jt} is a vector of firm characteristics that includes a set of industry and location dummies, γ_t represents period t specific constant, ρ and Γ are parameters to be estimated, η_j is the firm specific effect, and ϵ_{jt} is the remaining component of the error term.

A major issue concerns the empirical measurement of fluctuations in product markets. The shock affecting the firm has been defined using: the industry output price (Gamber 1988) (Christofides and Oswald 1992); the industry profit (Blanchflower *et al.* 1996) (Christofides and Oswald 1992); firm profits, in studies that rely however on wage data also aggregated for the firm level (Hildreth and Oswald 1997) (Nickell and Wadhwani 1990). Abowd and Lemieux (1993) rely on a set of assumptions to compute firm-level quasi-rents per worker (average value added per worker evaluated at the workers' alternative wage), and use the price of exports and imports at the industry level to instrument it. In a similar vein, Abowd and Allain (1996) compute firm-level quasi-rents, but allow their impact on wages to vary depending on the size of the rents and on industry product market conditions. Kramarz (2003) also uses US manufacturing export prices to instrument firm-level quasi-rents, further allowing firm-level imports to have a direct impact on wages (justified by their influence on worker and firm bargaining powers). Guiso *et al.* (2005) use value added, arguing that it is the variable directly subject to stochastic fluctuations, being more reliable than profits. A similar option was taken by Estevão and Tevlin (2003), who nevertheless used industry data. Holzer and Montgomery (1993) used firm sales, with wages averaged for the firm level. We use sales as our indicator of firm performance, arguing that it captures demand uncertainty, as shocks in product demand are directly reflected in changes in sales. Given fluctuations in demand, output could remain unchanged if prices would adjust fully and instantaneously, but since that is not the case, output will undergo fluctuations (Baily 1974). Sales were deflated using the GDP deflator.

Estimation of equation (1) by OLS or the usual panel models, fixed or random effects, is inconsistent in the presence of the lagged dependent variable, since, by definition, $sales_{j,t-1}$ is correlated with η_j. We follow Arellano and Bond (1991), taking first differences to eliminate the fixed effect, and then estimating equation (1) using a generalized method of moments (GMM) procedure. The set of instruments include $sales_{j,t-3}$ and earlier levels of this variable. The remaining regressors are treated as exogenous, and introduced in levels as instruments. The results for the 1–step GMM estimation procedure are reported in Table 1.

The use of this method calls for some discussion. This solution has poor finite sample properties concerning bias and precision when the available instruments are weak. Blundell and Bond (1998) show that the solution of Arellano and Bond (1991) has a large downward bias when the time series are persistent and the number of periods is small, and argue for the implementation of a system GMM estimation, for first-differences and levels. In our case, this solution is not feasible given the structure of the error component ϵ_{jt} assumed later on.[2]

The persistence of sales over time is represented by a coefficient on lagged sales of .47. Our results indicate that industry dummies are jointly significant, just like time dummies and region dummies. According to the Sargan test, we do not reject the validity of our instruments at the 1% and 5% levels. The serial correlation in the first-differenced residuals indicates that we should be using lagged levels of sales dated $t-3$ and earlier, as we do.

In Table 2 we report the autocovariance structure for $\Delta\epsilon_{jt}$. The results confirm our choice of instruments. After 2 lags the covariance of first-differenced

[2]In Section 7 we define $\epsilon_{jt} = \zeta_{jt} + \tilde{\nu}_{jt} - \theta\tilde{\nu}_{j,t-1}$ and $\zeta_{jt} = \zeta_{j,t-1} + \tilde{u}_{jt}$, which implies that $Cov(\epsilon_{jt}, \Delta\epsilon_{j,t-\tau}) \neq 0$. This renders infeasible the implementation of the system GMM estimation. We thank Rob Alessie for the thorough discussion on the estimation alternatives.

Table 1: Sales regression

Variable	Estimate	
Log sales at t-1	.47	(.022)
Region dummies	8.53	[.074]
Industry dummies	72.54	[.000]
Year dummies	151.30	[.000]
Sargan	37.10	[.093]
Sargan-df	27.00	
AR(1)	-21.41	[.000]
AR(2)	5.24	[.000]
AR(3)	.72	[.473]
AR(4)	-.83	[.405]
AR(5)	-.15	[.879]
AR(6)	.67	[.506]
AR(7)	-.67	[.501]
Observations	94365	
Firms	17097	

The regression has been estimated by the first-differenced GMM procedure discussed in Arellano and Bond (1991). The instruments are discussed in the text. The dependent variable is log real sales. Robust standard errors reported in parentheses; p-values in brackets. For region, industry and year dummies, the joint $F - statistic$ is reported. Sargan-df stands for the degrees of freedom of the Sargan test. AR shows the test for serial correlation in the first-differenced residuals.

Table 2: Firms' autocovariances

τ	$E(\Delta\epsilon_{jt}, \Delta\epsilon_{j,t-\tau})$	Standard error
0	.7795	.0151
1	-.3096	.0080
2	-.0653	.0103
3	.0031	.0076
4	.0083	.0073
5	-.0051	.0070
6	-.0020	.0067
7	-.0009	.0067

The autocovariances are computed using all years pooled.

residuals is statistically insignificant. These results are of particular interest for the specification of the structure of the error term which will take place in Section 7.

VI. Worker earnings

Workers' wages are specified as

$$wage_{ijt} = K^{'}_{ijt}\Phi + \varphi_i + \alpha P_{jt} + \beta T_{jt} + \psi_{ijt} \tag{2}$$

where $wage_{ijt}$ stands for the logarithm of monthly wage of worker i engaged in firm j in period t, and K includes industry, region and year dummies, as well as age and age squared. The first component of the error term is the worker specific effect, φ_i. Following Guiso *et al.* (2005), we include in the wage regression the permanent and transitory components of firm specific shock, P_{jt} and T_{jt}, respectively, to be further explained in section 7. The parameters α and β capture the impact of these shocks on wages. Finally, ψ_{ijt} is the remaining

Table 3: Wage regression

Variable	Estimate	
Log wage at t-1	.69	(0.083)
Region dummies	13.11	[.108]
Industry dummies	24.54	[.220]
Year dummies	126.50	[.000]
Sargan	27.53	[.121]
Sargan-df	20.00	
AR(1)	-10.85	[.000]
AR(2)	5.18	[.000]
AR(3)	-1.84	[.066]
AR(4)	1.75	[.081]
AR(5)	-.65	[.515]
AR(6)	.61	[.544]
AR(7)	-1.21	[.223]
Observations	98655	
Individuals	30657	

The dependent variable is log real monthly wage. See the note to Table 1.

component of the error term not captured by the worker specific effect or the firm specificities.

To replicate Guiso *et al.*'s (2005) strategy to identify α and β we multiply equation (2) by $(1-\rho L)$, where L is the lag operator. The transformed wage equation is defined as

$$wage_{ijt} = \rho wage_{ij,t-1} + (1-\rho L)K_{ijt}^{'}\Phi + (1-\rho L)(\varphi_i + \alpha P_{jt} + \beta T_{jt} + \psi_{ijt}) \quad (3)$$

The direct implication is that we introduce state dependence on wages in the equation to be estimated. The presence of the lagged dependent variable on the right hand side as a result of this transformation brings about an endogeneity problem. In order to solve this issue, and as in the case of equation (1), we

Table 4: Workers' autocovariances

τ	$E(\Delta\omega_{jt}, \Delta\omega_{j,t-\tau})$	Standard error
0	.0536	.0012
1	-.0253	.0008
2	-.0034	.0009
3	-.0009	.0007
4	.0005	.0006
5	-.0001	.0008
6	.0010	.0010
7	-.0017	.0014

The autocovariances are computed using all years pooled. $\Delta\omega_{ijt}$ is the first-differenced composite residual from equation (2).

use Arellano and Bond first-differenced GMM procedure to obtain consistent estimates.

In the current section we concentrate on estimation and analysis of the first-differenced composite error term $\Delta\omega_{ijt}$ associated with the transformed wage equation, and delay to section 7 further analysis of the different components.[3]

We use levels of wage lagged 4 periods and earlier as instruments for first-differenced equations. The remaining regressors are assumed exogenous and introduced in levels. The results for the 1–step first-differenced GMM estimation are reported in Table 3.[4]

The coefficient on lagged wage is .69, indicating higher persistence than for sales. Industry dummies are not jointly significant, while region dummies are

[3]After we transform equation (2), the composite error term is defined as $\omega_{ijt} = (1 - \rho L)(\varphi_i + \alpha P_{jt} + \beta T_{jt} + \psi_{ijt})$.

[4]We have considered each employment spell as a pair worker-firm, since we are interested in the provision of wage insurance by a given firm, and not the overall insurance the worker may enjoy when switching firms.

marginally insignificant at the 10% level. The test for overidentifying restrictions does not reject our instruments. Table 4 reports the covariance structure of first-differenced residuals associated with equation (2), $\Delta\omega_{ijt}$. First-differencing implies that $\Delta\omega_{ijt}$ lacks φ_i, i.e. it is defined only as a function of the remaining three components of the error term in equation (2). The results support our choice of instruments in Table 3.

VII. Insurance provision by the firm

To quantify the insurance provided by firms to their workers we need first to estimate the sensitivity parameters, α and β, and then to estimate the different variance components of the error terms associated with equations (1) and (2). Throughout the section, we borrow the formulation and estimation strategy proposed by Guiso *et al.* (2005), adjusting for the specificities of our analysis. The main findings are reported in Table 5.

We start by showing in Panel A the covariance structures in the matched sample of firms and workers, which contains 71585 observations. The first two columns report results similar to those shown in Tables 2 and 4. The last column shows that the covariance between the worker's and the firm's lagged shocks is positive and significant, which is a first indication that firms do not provide full insurance to their workers.

To assess insurance within the firm we now focus our attention on the relation between changes in workers' residuals, $\Delta\omega_{ijt}$, and changes in the firms' residuals,

Table 5: Testing for insurance

A. Covariances			
τ	$E(\Delta\omega_{jt}, \Delta\omega_{j,t-\tau})$	$E(\Delta\epsilon_{jt}, \Delta\epsilon_{j,t-\tau})$	$E(\Delta\omega_{jt}, \Delta\epsilon_{j,t-\tau})$
0	.0545	.7174	-.0012
	(.0014)	(.0265)	(.0010)
1	-.0256	-.2912	.0035
	(.0009)	(.0143)	(.0010)
B. Sensitivity to permanent and transitory shocks			
	Permanent shock	Transitory shock	
Sensitivity	.0924	-.0011	
	(.0446)	(.0019)	
Observations	25667	55077	
J-test	[.5405]	[.1919]	
F-test	[.0019]	[.0000]	
Exogeneity test	[.0422]		

C. Variance components and insurance coverage			
	Firm		Worker
$\sigma^2_{\tilde{u}}$	.1325	σ^2_{ξ}	.0168
	(.0203)		(.0058)
$\sigma^2_{\tilde{v}}$	.3667	σ^2_{μ}	.0058
	(.0323)		(.0113)
θ	-.1775	λ	-.2155
	(.0394)		(.0281)
Ratio	.3004		

The covariances are computed for the matched sample, and using all years pooled. The estimation procedure and instruments used in part B are explained in the text. The $F-test$ refers to the first-stage regression. Standard errors are reported in parentheses; p-values in brackets. The ratio is defined in the text.

$\Delta\epsilon_{jt}$. Firms' error term, ϵ_{jt}, is formulated as the sum of two components: a random walk and a MA(1), such that $\epsilon_{jt} = \zeta_{jt} + \tilde{\nu}_{jt} - \theta\tilde{\nu}_{j,t-1}$, where $\zeta_{jt} = \zeta_{j,t-1} + \tilde{u}_{jt}$. By assuming that $E(\tilde{u}_{jt}^2) = \sigma_{\tilde{u}}^2$, $E(\tilde{\nu}_{jt}^2) = \sigma_{\tilde{\nu}}^2$ for all t, $E(\tilde{\nu}_{js}\tilde{\nu}_{jt}) = E(\tilde{u}_{js}\tilde{u}_{jt}) = 0$ for $s \neq t$, and $E(\tilde{\nu}_{js}\tilde{u}_{jt}) = 0$ for all s and t, we expect that after two periods the autocovariance of $\Delta\epsilon_{jt}$ goes to zero. Empirically, Table 2 gives support to this specification, since we observe that autocovariances are zero for lags above 2, and non-zero for two or less lags.

The permanent and transitory shocks, P_{jt} and T_{jt}, respectively, included in equation (2) can now be defined. By modeling firms' residual ϵ_{jt} as defined above, we allow for both permanent and transitory shocks on firms' performance. Rewriting equation (1) allows us to formulate $sales_{jt} = (1-\rho L)^{-1}\left(\gamma_t + X_{jt}'\Gamma + \eta_j\right) + (1-\rho L)^{-1}\epsilon_{jt}$. The first element on the right hand side of this equation represents a deterministic component, while the second element is $(1-\rho L)^{-1}\epsilon_{jt} = P_{jt} + T_{jt}$. As derived by Guiso et al., the following expressions model the two shock components: $P_{jt} = (1-\rho L)^{-1}\zeta_{jt}$ and $T_{jt} = (1-\rho L)^{-1}\Big((1-\theta L)\,\tilde{v}_{jt} - (1-\rho)^{-1}\rho\tilde{u}_{jt}\Big)$.

Although our results on autocovariances for $\Delta\epsilon_{jt}$ are not too different from Guiso et al. and support the structure adopted for the error term ϵ_{jt}, our findings for the autocovariances of $\Delta\omega_{ijt}$, Table 4, do not match theirs. Particularly, they find evidence consistent with a MA(3) process for $\Delta\omega_{ijt}$, while our results indicate that the covariances of $\Delta\omega_{ijt}$ are not statistically different from zero after 2 periods. However, the results we report in Table 3 indicate that (i) the first-differenced residuals in the wage regression can be correlated 3 periods apart, and (ii) the use of levels of wages lagged 4 periods and earlier as instruments is validated by the Sargan overidentification test. Combining these pieces of evidence, we follow Guiso et al., and define the last component of the error term in equation (2) as $\psi_{ijt} = \vartheta_{ijt} + \xi_{ijt} - \lambda\xi_{ij,t-1}$, with $\vartheta_{ijt} = \vartheta_{ij,t-1} + \mu_{ijt}$.

At the core of the estimation strategy lies an instrumental variables regression, whose specific instruments allow for the identification of the parameters of interest, *i.e.* α, the sensitivity of wages to permanent shocks, and β, the sensitivity of wages to transitory shocks. In both cases, the dependent variable is $\Delta\omega_{ijt}$, and the explanatory variable is $\Delta\epsilon_{jt}$. Consistent estimates of these variables are obtained from sales and wage regressions presented in Tables 1 and 3, respectively. Guiso *et al.* (2005) show that $(\sum_{\tau=-2}^{2} \Delta\epsilon_{j,t+\tau})^k$, with $k \geq 1$, is a valid set of instruments to estimate α, while the estimation of β can be based on the instruments $(\Delta\epsilon_{j,t+1})^m$, with $m \geq 1$.

To estimate both α and β we have used the feasible efficient GMM procedure, controlling for error correlation within firms.[5] In each regression the specific instruments are defined for k=m=1,..,9. For both regressions, a likelihood-ratio

[5] In the permanent shock regression we clearly reject the null hypothesis of homoscedastic error terms, which justifies the use of GMM. For example, the Pagan and Hall test discussed in Baum *et al.* (2003) has a p-value of .0148. For the transitory shock the evidence on heteroscedasticity is mixed. However, since our sample is large enough for asymptotic results to be valid, and given that IV gives inconsistent inference results if errors are in fact heteroscedastic, we adopted a conservative strategy and implemented the GMM procedure also in this case. The following conclusions on transitory shocks are not changed if we use generalized IV instead of GMM.

test rejects the null that the extra powers of the instruments are redundant.[6] The overidentifying restriction tests do not reject the validity of instruments used in both regressions, and from the $F - test$ we conclude that the instruments used in each regression are jointly significant. Finally, we performed the exogeneity test for $\Delta\epsilon_{jt}$ based on the difference in the Hansen-Sargan statistic between a model where it is assumed exogenous and our alternative model where we take it as endogenous. The test rejects the null that $\Delta\epsilon_{jt}$ is exogenous. This result implies that we also reject the equality between the sensitivity to both types of shocks, in line with Guiso *et al.* (2005).

We conclude from Panel B that workers' wages are not sensitive to transitory shocks on firms' performance, but they respond to firms' permanent shocks. The elasticity of wages to permanent shocks to firms' performance is .09 (compared to .07 in Guiso *et al.* (2005) for Italy).

Following the evidence provided by Altonji and Segal (1996), we estimated the different variance components using equally weighted minimum distance. Panel C reports the results. We can define the two variances associated with the shocks to sales as $\sigma_u^2 = \sigma_{\tilde{u}}^2/(1-\rho)^2$ and $\sigma_v^2 = (1+\theta^2)\sigma_{\tilde{v}}^2 + (\rho/(1-\rho))^2\sigma_{\tilde{u}}^2$. These are the variances of the permanent shock and the transitory shock, respectively. We estimate that σ_u^2 is .477, and σ_v^2 is .485, which amounts to a considerable variability. The moving average coefficient is about -.18. All three estimates are statistically significant. For workers the variance of transitory shocks, σ_ξ^2,

[6]The p-value of the tests is always below .001.

is .0168, while the variance of permanent shocks, σ_{μ}^2, is approximately .01, but statistically insignificant. The moving average parameter estimate is -.22, and significant. These results are consistent with our analysis from Panel B. Our results also show that the different variances are considerably higher for firms than for workers. All of our estimated variances are considerably larger than the ones found for Italy by Guiso *et al.*, just like the absolute value of the moving averages parameters. This can possibly reflect the higher wage flexibility in the Portuguese labor market.

To compute the portion of wage variability that can be attributed to firm's shock, the ratio $\sqrt{E\left\{\left[(\Delta\omega_{ijt})^2\right]|j\right\}}/\sqrt{E\left[(\Delta\omega_{ijt})^2\right]}$ is defined. We conclude that approximately 30% of the total variability in wages can be explained by firm-specific risk. For the Italian labor market, Guiso *et al.* conclude that this ratio is about 15%. Combining the evidence gathered so far, we conclude that Portuguese firms provide less insurance to their workers, when compared to Italian firms, a result in line with the high wage flexibility pointed out by studies on Portugal.

VIII. Forces shaping wage flexibility at the firm level

We now turn to the analysis of heterogeneity in insurance provision by firms. We consider different factors identified in the theoretical literature as shaping wage flexibility at the firm level. First of all, firms may be subject to institutional constraints. As argued by Faggio and Nickell (2005), national pay bargaining may insulate wages from firm idiosyncratic shocks. A similar role can be played by the minimum wage legislation, since firms with a large share of their workforce on minimum wage will have part of their wage policy set by the Government based on nation-wide trends. Firms that operate in more than one industry or region may be more able to diversify risk. On the contrary, a higher risk of going bankrupt will reduce the firm possibility to provide wage insurance. We consider also the occupation of the worker, with a dummy variable for managers meant to proxy two factors: the sensitivity of firm output to worker effort, with the wages of crucial workers more closely linked to firm performance, and therefore subject to less insurance provision; the capacity of the worker to bear risk, with managers likely to have more wealth and more access to financial markets where to diversify risk, and larger expertise in financial issues. The possibility of monitoring output has been pointed out as another factor that reduces the degree of insurance provided by the firm. Indeed, if the firm could monitor exactly the effort of the worker, it would not need to engage in a wage contract. Higher precision of the signal on the agent's effort will lead to less insurance (Guiso *et al.* (2005) have computed the noise on performance as the variability over time in the performance of the firm).

The results are reported in table 6, where $Manager$ is a dummy variable equal to one if he worker is a manager and *Decent. barg.* equals one if the worker is covered by firm-level bargaining, as opposed to a massive collective bargaining agreement.[7] *Bankruptcy* is the threat of bankruptcy[8], $NInd$ is the number of industries in which the firm operates, and $NEst$ its number of establishments, $FSize$ stands for (log of) firm employment, and $Foreign$ is a dummy variable for the foreign origin of the capital; $SDsales$ represents the volatility of firm sales[9], and $Shareminw$ is the share of workers in the firm earning the national minimum wage.

To estimate these regressions we implemented once again the GMM procedure used in Panel B of Table 5, and define the extra instruments as the previous instruments interacted with the new variables. The validity of the instruments used is not rejected in both regressions. Since we have multiple endogenous regressors, Shea's (1997) partial R^2 are reported.

Results indicate that firms with a larger share of their workforce earning the minimum wage are less able to translate permanent shocks in product demand into wage changes. Indeed, the minimum wage is set at the national level by Government regulation, taking into explicit account aggregate trends such as the overall economy inflation rate. However, when faced with transitory shocks, firms with different shares of minimum wage workers do not react differently in terms of wage insurance. The level at which collective bargaining takes place also has an impact on the degree of insurance provided by the firm when faced

[7] Worker covered by a firm-level agreement or collective bargaining agreement (which involves a restricted group of firms, not organized into an employer association), as opposed to *collective bargaining contracts*, which often cover a whole industry, or the mandatory regime imposed by the Government.

[8] The percentage of firms that go bankrupt in a given year and detailed region.

[9] Measured by the standard deviation of logarithm of sales for the years under analysis.

Table 6: Insurance heterogeneity

	Permanent shock	Transitory shock
$\Delta\epsilon_{jt}$	-.1628	-.0506
	(.1016)	(.0076)
	[.0281]	[.3192]
$\Delta\epsilon_{jt} * Manager$	.0194	-.0039
	(.0054)	(.0029)
	[.0157]	[.4370]
$\Delta\epsilon_{jt} * SDSales$	-.0078	.0023
	(.0081)	(.0013)
	[.0990]	[.4230]
$\Delta\epsilon_{jt} * Bankruptcy$	.0215	.0021
	(.0110)	(.0004)
	[.0298]	[.3736]
$\Delta\epsilon_{jt} * Foreign$	.0149	.0124
	(.0239)	(.0023)
	[.0380]	[.4229]
$\Delta\epsilon_{jt} * FSize$	-.0050	.0018
	(.0081)	(.0012)
	[.0486]	[.3717]
$\Delta\epsilon_{jt} * NInd$	.0101	.0063
	(.0245)	(.0041)
	[.0289]	[.4130]
$\Delta\epsilon_{jt} * Shareminw$	-.0380	.0095
	(.0229)	(.0410)
	[.3266]	[.1754]
$\Delta\epsilon_{jt} * Decent.barg.$	-.0017	.0171
	(.0298)	(.0030)
	[.0357]	[.5210]
Observations	25604	54873
J-test: $p - value$	.4309	.5447

The dependent variable is $\Delta\omega_{ijt}$. The instruments used in each regression are explained in the text. Robust standard errors reported in parentheses; Shea's (1997) partial R^2 in brackets. We account for within firm correlation of residuals. We report the J-test for the validity of the instruments.

with transitory shocks. More decentralized bargaining regimes are associated with less insurance, as opposed to massive collective wage setting agreements, which constraint the capacity of the firm to reflect demand shocks on wage changes.

Managers are less insured against permanent shocks than the rest of the workforce. This could be due to the fact that they may receive performance pay that links wages directly to the results of the company. Moreover, managers can be expected to be less risk-averse than other workers and as such would not have to be given the same level of insurance to exert effort. However, managers and workers with other occupations receive equal protection against transitory shocks.

Firms with a higher threat of bankruptcy are, as expected, less able to provide wage insurance and more constrained to reflect changes in product markets into changes in wages. That holds both for transitory and permanent shocks. Firms with higher variability in their sales offer less insurance against transitory changes in their performance. When faced with higher uncertainty in product markets, firms are bound to reflect more of the change in sales on wages, in the short-run. Foreign firms provide less insurance to transitory shocks.

IX. Conclusion

The impact of product market uncertainty on workers wages has been evaluated, relying on data of remarkable quality to estimate dynamic panel data models.

Results point to the rejection of the full insurance hypothesis. Workers' wages respond to permanent shocks to firm performance, whereas they are not sensitive to transitory shocks. In comparison to Italy, Portuguese firms provide less insurance to their workers. The higher responsiveness of wages to shocks at the firm level corroborates evidence previously reported on the high degree of wage flexibility in Portugal, when evaluated as the responsiveness of wages to macroeconomic conditions.

Another aim of the analysis was to check the impact of labor market regulations on the extent to which firms translate idiosyncratic shocks in product markets into shocks to the wages paid. We found that the national minimum wage and collective bargaining are indeed associated with the extent of wage insurance provided by the firm. Firms with a larger share of their workforce earning the minimum wage are less able to translate permanent shocks in product demand into wage changes. Also, massive collective wage setting agreements constraint the capacity of the firm to reflect idiosyncratic demand shocks into wage changes. This would be consistent with a corporatist wage setting view of the labor market, according to which the major role of these institutions would be to promote a smooth adjustment of wages to another type of shocks, those at the aggregate level.

Appendix: Longitudinal linked employer-employee data set

Checks on the consistency of data

After merging the worker data across years, inconsistencies were identified if the worker gender or date of birth was reported changing, or if the highest schooling level achieved was reported decreasing over time. In that case, the information reported over half the times has been taken as the correct one[10] (0.8%, 2.3%, and 5.2% of the observations have been corrected, respectively for gender, birth date and education). Workers with inconsistent data after the introduction of the previous corrections were dropped. The whole information on the worker was dropped, whichever the incorrect number of observations identified (1.7%, 1.1%, and 4.3% of the observations, respectively for gender, birth date and schooling). Workers with missing age or schooling after the introduction of the previous corrections were dropped (respectively 0.7% and 1.7% of the observations, corresponding to 2.1% and 2% of the workers).

Constraints imposed

The analysis focuses on workers and firms in manufacturing and services private sector in mainland Portugal.

On the worker side, we have retained wage-earners working full-time, aged 18 to 65, whose wage is not below the national minimum wage[11] (which led

[10] Note that this requirement is more demanding than just considering the modal value as the accurate one.
[11] May drop apprentices and handicapped workers.

to dropping 20%, 2%, and 3% of the dataset, respectively). Outliers in wage growth have been dropped[12], which corresponded to a very small share of the data base, 0.03%. Workers observed just once in the database cannot be considered in the estimation of the models used (and thus 5% have been dropped). This is the full set of workers, which comprises over ten million observations. Due to the large size of the full data set it was not feasible to run the worker computations on the full data set and we have therefore used a 2 percent random sample of workers (keeping all the yearly observations for the selected workers). Descriptive statistics on this sample, comprising 205,352 yearly observations on 42,008 workers, are presented in table A1.[13]

On the firm side, we have kept firms operating full-year, and whose sales are not missing or outlier[14] (thus dropping 3%, 9%, and 0.2% of the firms, respectively).[15] Firms that were ever larger than 20 workers have been kept for analysis, since they are more likely to be run in entrepreneurial terms. Given the very small size structure of the firms in the Portuguese economy, this led to keeping 12% of the firms. The set of firms under analysis comprises 131,118 yearly observations on 18,368 firms. Descriptive statistics are reported in table A2.[16]

[12]Log difference in real wages either greater than 2 or smaller than -.5

[13]The dynamics in the models under estimation determine that a smaller number of individuals will be considered in the regressions.

[14]Log difference in real wages either greater than 5 or smaller than -5.

[15]Firms in the first few months of their existence, not yet one year, were excluded, to avoid capturing sales fluctuations that are due to part-year operation.

[16]The dynamics in the models under estimation determine that a smaller number of firms will be considered in the regressions.

Descriptive statistics

Gross monthly earnings were computed as $monthw = bw + sen + reg$,where bw stands for base-wage, sen are seniority-indexed components of pay, and reg are other regularly paid components. Wages were deflated using the Consumer Price Index.

table A1. Descriptive statistics on workers

Variable	Mean	St. Dev.
Log real monthly wage (PTE)	11.63	0.50
Age	36.20	10.91
Gender (female)	0.39	
Education		
4 years	0.46	
6 years	0.22	
9 years	0.13	
High School	0.14	
University	0.05	
Occupation		
managers	0.02	
professionals	0.02	
middle manag, technic.	0.09	
administrative	0.15	
service, sales	0.11	
skilled	0.27	
machine operat., assembly	0.14	
unskilled	0.15	
unknown	0.05	
Industry		
food, bev, tob.	0.05	
textiles	0.17	
wood	0.04	
chemicals	0.05	
mineral products	0.15	
construction	0.10	
trade	0.21	
restaurants, hotels	0.05	
transport, communic.	0.04	
banking, insurance, business serv.	0.09	
other serv.	0.05	
Region		
North Coast	0.34	
Center Coast	0.16	
Lisbon	0.40	
Inland	0.08	
Algarve	0.03	
Type of collective bargaining agreement		
Decentralized	.06	
Massive	.94	
N	205352	

table A2. Descriptive statistics on firms

Variable	Mean	St. Dev.
Log real sales (1000 PTE)	12.93	1.45
Number workers in firm	58.22	170.80
Number of industries in firm	1.09	0.38
Share firms bankrupt in province	0.09	0.04
Variability firm sales over time: sd log real sales	0.50	0.51
Share of workers earning the minimum wage	0.03	0.11
Industry		
food, bev, tob.	0.05	
textiles	0.19	
wood	0.05	
chemicals	0.06	
mineral products	0.15	
construction	0.11	
trade	0.20	
restaurants, hotels	0.04	
transport, communic.	0.04	
banking, insurance, business serv.	0.06	
other serv.	0.05	
Region		
North Coast	0.34	
Center Coast	0.18	
Lisbon	0.37	
Inland	0.08	
Algarve	0.03	
Origin of capital		
national	0.94	
foreign	0.06	
N	131118	

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