

Working Papers
Number 12/03

A Fair Wage Model of Unemployment with Inertia in Fairness Perceptions

Economic Analysis
Madrid, 28 March 2012

A Fair Wage Model of Unemployment with Inertia in Fairness Perceptions*

George Chouliarakis^{a, b} and Mónica Correa-López^{c, d}

March 2012

Abstract

Theories of psychology and empirical evidence suggest that the reference transactions against which workers judge fairness exhibit inertia. This paper shows that a fair-wage model with inertia in fairness perceptions provides a plausible explanation for the observed negative correlation between changes in productivity growth and equilibrium unemployment over the medium run, a stylized fact that remains elusive to most other classes of models. It also shows that skill-biased productivity shocks and shocks to workers' taste for equal pay have permanent effects on unemployment and the skill premium. Thus, skill-biased shocks to productivity increase unemployment among the low-skilled while, if high-skilled workers are less inequity-averse, they reduce unemployment among the high-skilled.

Keywords: Fairness; Unemployment; Skill Premium; Fair Wage-Effort Hypothesis; Inequity Aversion; Personnel Management.

JEL: D03; E24; J31; M12.

* Corresponding author: monica.correa@bbva.com; Phone No.: 00 34 91 374 6401; Fax No.: 00 34 91 374 3025.

a,d: Department of Economics, School of Social Sciences, The University of Manchester, Oxford Road, Manchester M13 9PL, U.K.

b: Centre for Growth and Business Cycle Research, School of Social Sciences, The University of Manchester, Oxford Road, Manchester M13 9PL, U.K.

c: Economic Research Department, BBVA Research, P/Castellana 81, 28046 Madrid, Spain

1. Introduction

Efficiency wage models of the labour market have long established the importance of fairness considerations in explaining a number of key labour market stylized facts such as real wage rigidity, involuntary unemployment as an equilibrium phenomenon, wage compression, the inverse correlation between unemployment and skills, and the existence of wage distributions for workers of identical characteristics.¹

The fundamental assumption of fair-wage models is that workers may withhold effort if their actual wage falls short of what they perceive to be a fair wage rate. The fair wage can be defined in a number of ways but often depends on the wage of other workers at the same and other firms as well as on past wages and on labour market conditions.

In their seminal 1990 paper, Akerlof and Yellen develop a fair-wage model with two groups of labour: a skilled and an unskilled group. The fair wage of the unskilled group is the average of the wage of the skilled group in the same firm and the wage they would be paid if the market cleared. The unskilled group would supply the optimal amount of effort only if it were paid the wage it considers fair. Profit maximizing employers have therefore a strong motive to pay the fair wage. As, by assumption, the fair wage exceeds the market-clearing wage there is involuntary unemployment among unskilled workers.

Despite the presence of involuntary unemployment, employers are unwilling to hire underbidders i.e. unemployed workers who are willing to work for less, because of the lack of a credible commitment mechanism whereby, if hired, underbidders would eschew fairness considerations. In Solow's words, "if I were to hire them after a slight wage cut to replace some of my current workers, the newcomers will pretty soon supply less than the optimal amount of effort because they would feel aggrieved at getting less than a fair wage. They are, after all, exactly like their currently employed sisters-in-law, by definition".² As a result, unemployment in equilibrium is, to a good extent, involuntary.

Experimental evidence and survey research have borne out the main predictions of Akerlof and Yellen's fair wage hypothesis and leave little doubt about the importance of fairness concerns in determining labour market outcomes. Fehr, Kirchsteiger, and Riedl (1993) tested the fair wage hypothesis in the context of a competitive market experiment where market prices were determined in an auction with buyers as price makers. Upon acceptance of an offer, sellers determined the quality of the good. The experiment showed that most buyers offered prices that were, on average, substantially above the market-clearing level on the expectation that sellers would reciprocate, i.e., they would respond by supplying higher quality levels. This expectation was, on average, confirmed and, as the experiment was repeated, there was no tendency for prices to converge toward the market-clearing level.

Blinder and Choi (1990) interviewed managers of nineteen firms in New Jersey and Pennsylvania in an attempt to elicit their reaction to the central ideas of competing theories of wage stickiness. A significant majority of respondents (79 percent) indicated that taking advantage of labour market slack to reduce wages would be considered by their workers as unfair or very unfair while a vast majority (95 percent) agreed that an unfair wage policy would cause a fall in morale and be reciprocated by a decline in work effort.³

Bewley (1998, 1999) carried out a ground-breaking survey among managers, union leaders, business consultants and counsellors of unemployed people in the Northeast of the United States in order to find out why wages failed to decline during the recession of the early nineties. The answers were clear and unequivocal: employers were reluctant to cut wages because they believed that doing so would hurt employee morale and lead to lower productivity, lending, thus, further support to the Akerlof-Yellen fair wage hypothesis.⁴

Further survey evidence is given by Campbell and Kamlani (1997) who also investigated the reasons for wage rigidity on the basis of a sample of 184 American firms. Respondents identified fear of reduced effort as a major reason behind firms' reluctance to reduce wages while they considered wage reductions to be particularly harmful to the morale and effort levels of low-skilled workers.⁵

1: See Akerlof and Yellen (1988).

2: Solow (1990) p.36.

3: Thus, the evidence discussed here concerns the link between wage cuts reducing morale and leading to falling productivity.

4: Note that Bewley (1999) presents evidence in favour of a fair wage specification that includes past wages and wages of other employees in the same work site but excludes labour market conditions.

5: The other major reason respondents identify is fear that the more productive workers would quit.

Fehr and Schmidt (1999) formalised the notion of fairness as inequity aversion and provided an explanation for wage rigidity.⁶ Inequity averse individuals are those who, by willing to give up some material payoff, resist inequitable outcomes.⁷ Fehr and Schmidt (1999) consider an experimental labour market game in which one firm makes a wage offer to a number of identical workers in order to hire one of them. There is responder competition *with ex-post effort choice*. That is, once the accepting worker has been randomly selected, she chooses the effort level that affects both her own payoff (negatively) and the payoff of the firm (positively). Fehr and Schmidt (1999) show that if the firm offers a high wage and workers are sufficiently inequity averse, the accepting worker is willing to raise effort above the minimum level. The reason is that, at the minimum effort level, the payoff of the worker would be above the payoff of the firm and, since the worker is inequity averse, she would respond by raising effort and thus moving in the direction of a more equitable outcome. Inequity aversion generates a positive correlation between wages and effort and provides the incentive for the firm to pay wages above the competitive level. In the choice of effort, the fairness mechanism that underlies the experimental labour market game discussed in Fehr and Schmidt (1999) is akin to the fairness mechanism that is present in Akerlof and Yellen (1990), in the former, the worker's reference outcome is the payoff of the firm while, in the latter, the worker's reference outcome is the average of the wage of the peers of the other skill group and the own market-clearing wage.

Despite the evident contribution of the Akerlof-Yellen fair wage model in simultaneously explaining a number of labour market puzzles, an important limitation of the model lies in its lack of fair wage dynamics as workers' perception of fairness exhibits no inertia. Yet, there are good grounds to believe that past interactions have a significant and lasting influence on the reference transaction against which workers judge fairness. In an important contribution, Kahneman, Knetsch and Thaler (1986) provide evidence suggesting that incumbent workers assess the fairness of proposed wage changes in their ongoing employment relative to the status quo. In particular, they show that an incumbent worker's reference standard is last period's contract, influencing, thus, future wage outcomes independently from the prevailing market conditions.⁸ In the context of a laboratory experiment, Falk, Fehr and Zehnder (2006) show that the temporary introduction of a minimum wage has long-term effects on workers' perception of what is a fair transaction by generating feelings of entitlement which persist even after the removal of the minimum wage. In their own words "once workers have been exposed to a minimum wage, they become used to receiving a relatively high wage. This experience may create entitlements, i.e., workers think they have a right to receive high wages and are willing to defend them. As a consequence, they set relatively high reservation wages even after the elimination of the minimum wage".⁹

The idea that the dynamics of workers' perceptions of fairness exhibit inertia is consistent with the view that reference transactions are largely shaped by norm. Kahneman, Knetsch and Thaler (1986) suggest that the reference transaction "provides a basis for fairness judgements because it is normal, not necessarily because it is just".¹⁰ Hicks (1975) argues that "the system of wages should be well established, so that it has the sanction of custom. It then becomes what is expected and what is expected is fair".¹¹ As shaped by norms, reference transactions are historically rooted and evolve slowly.¹² Alternatively, perceptions of fairness may exhibit inertia because information about the current wage of the reference group and the own market-clearing wage may diffuse slowly across workers. The sources of slow diffusion could well be formal or informal restrictions on wage disclosure or signal extraction costs regarding the prevailing macroeconomic conditions. Kőszegi and Rabin (2006) develop an applicable theory of reference dependence where the person's reference point is determined by the expectations she held in the recent past about outcomes. The authors emphasise that better model predictions are made when the reference point in preferences depends upon personal expectations. If a worker's reference transaction is determined by recently formed expectations, these may be shaped by slow-evolving norms or slow-diffusing information. Overall, taking into account the dynamic behaviour of workers' perceptions of fairness

6: Their model belongs to the social-preferences literature that assumes individuals may be self-interested as well as show concern about the payoffs of others. Related models can be found in Bolton and Ockenfels (2000) and Charness and Rabin (2002). See also the literature survey in Camerer (2003, 2005).

7: In Fehr and Schmidt (1999), individuals are loss averse in social comparisons, more particularly, inequity aversion is self-centered and asymmetric. Thus, individuals show a stronger aversion to disadvantageous inequality, i.e. a situation in which the individual's payoff is lower than the payoff of the reference group, than to advantageous inequality, i.e. a situation in which the individual's payoff is higher than the payoff of the reference group.

8: Note that a similar effect can be observed in the fairness judgement of price changes. Bolton, Warlop and Alba (2003) find that, in repeated transactions, the price that the firm charged last was the relevant reference price, much more so than the price the competitors were offering.

9: Falk, Fehr and Zehnder (2006) p.1377.

10: Kahneman, Knetsch and Thaler (1986) p.730.

11: Hicks (1975) p.65.

12: Norms are defined as entitlements and obligations as in Schlicht (1998).

could enhance the realism of the fair wage model and expand the range of stylized facts that this model can explain. Importantly, as this paper shows, it enables the fair wage model to account for one of the significant empirical regularities of the past forty years, i.e. the well-documented negative correlation between equilibrium unemployment and the change in productivity growth. On the observed correlation between changes in productivity growth and equilibrium unemployment, see Grubb, Jackman and Layard (1982), Lynch and Nickell (2001), Staiger, Stock and Watson (2001), Ball and Mankiw (2002), and Hatton (2007).

Our goal in this paper is to contribute to the development of the fair wage hypothesis by reconsidering the dynamic behaviour of workers' perceptions of fairness and, thus, to explore the labour market implications of such inertial behaviour. More particularly, we extend the seminal work of Akerlof and Yellen (1990) to allow workers to update their perception of fair wages following a Poisson process.¹³ Thus, in each period, a fraction of workers updates their reference transactions and recalculates optimal plans according to the current state of their reference standards. Other workers, however, continue to formulate their respective fair wages based on past standards. Inertia is therefore present up until the entire workforce adapts to the new reference transactions. The model that we develop leads to a number of novel and appealing predictions. It can account for the medium-run and long-run effects of aggregate and skill-biased productivity shocks, labour supply shocks, and shocks to workers' taste for equal pay on equilibrium unemployment and the wage premium. For a plausible set of parameter values, the model simulations generate results that conform to reality.

In addition, the paper relates the fair wage hypothesis (Akerlof and Yellen, 1990) to the inequality aversion theory (Fehr and Schmidt, 1999). In the standard fair-wage model, the skill endowment of the workforce places skilled labour in an advantageous inequality position and unskilled labour in a disadvantageous inequality position.¹⁴ Also, if workers' utility functions are formulated as simple linear functions of the respective fair wages, the fairness specifications capture workers' asymmetric aversion to inequitable outcomes as unskilled workers mark their competitive wage up while skilled workers mark their competitive wage down. We extend the formulation of fair wages to accommodate alternative degrees of inequity aversion and, by so doing, we identify conditions upon which, in addition to the presence of involuntary unemployment among the unskilled, there is involuntary unemployment among skilled workers. Our analysis shows that the main implication of the benchmark model, with regard to the medium-run and long-run unemployment effects of a change in productivity growth, is robust to this kind of extension. Finally, notice that by bringing together the notion of inequity aversion, on one hand, and the inertial behaviour of workers' perceptions of fairness, on the other, the paper provides an "analysis of the short-run impact of equity considerations" whose relevance was pointed out in Fehr and Schmidt (1999).¹⁵

Recent contributions to the development of the Akerlof and Yellen (1990) approach are found in applications especially in the field of macroeconomics (e.g., Danthine and Kurmann, 2007), in international economics (e.g., Egger and Kreickemeier, 2009a, 2009b) and in labour economics (e.g., Charness and Kuhn, 2007; Lee and Rupp, 2007). Our paper is also complementary to Ball and Moffitt's (2001) empirical analysis that studies the benign conjunction of low inflation and low unemployment in the US and Chile during the late-1990s. To this end, the authors estimate an accelerationist Phillips curve in which they add a new variable, the growth of aspiration wages, which, in turn, they define as "an exponentially weighted average of past real-wage increases".

13: Akin to the sticky-information rule in Mankiw and Reis (2002, 2003). This is an approximation to modelling sluggish belief adjustment. As in Mankiw and Reis (2002), our analysis does not explore the determinants of fairness perception adjustment, thus, e.g., the updating of fairness perceptions is modelled as a process that depends upon the time-invariant exogenous arrival rate. An important advantage of this approximation is that it allows us to work in the context of an analytically tractable model in order to focus on the question at hand. Alternatively, recent work in Menzies and Zizzo (2005) considers inferential expectations where a departure from rational expectations is justified since "economic agents hold beliefs that are subject to falsification by new information" p.3. In Menzies and Zizzo (2005, 2009), belief formation is modelled as a statistical hypothesis test and inferential expectations reflect the conservatism to changing beliefs even in the presence of new information.

14: In the experimental labour market game discussed in Fehr and Schmidt (1999) workers are identical and the firm, by posting a high wage and thus not exploiting the competition among workers, is placed in a disadvantageous inequality position. The firm does so in the expectation that the sufficiently inequity-averse worker reciprocates and raises effort above the minimum level. In the fair wage model that is considered below, firms, in order to extract optimal effort levels, have an incentive to pay fair wages. Inequity aversion is thus explored among workers of heterogeneous skill characteristics such that unskilled workers are, by assumption, the disadvantaged group. Workers reciprocate with maximum effort only if they receive fair wages.

15: As Fehr and Schmidt (1999) note: "An obvious limitation of our model is that it cannot explain the evolution of play over time in the experiments discussed. (...) This limitation of our model also precludes a rigorous analysis of the short-run impact of equity considerations." p.851.

In this important empirical paper, Ball and Moffitt (2001) make no attempt to develop a formal model of wage aspirations or, even more, justify their inertial dynamics on the basis of the optimising behaviour of firms and workers. Thus, our model can also be seen as providing the theoretical microfoundations supporting Ball and Moffitt's (2001) empirical analysis.

The remainder of the paper is organised as follows. Section 2 introduces a fair-wage model of the labour market with workers of heterogenous skill characteristics and no inertia in fairness perceptions. In the context of this model, Section 3 explores the effects of various shocks on the equilibrium rate of unemployment and the wage premium. Section 4 extends the model by allowing for inertia in the evolution of what workers consider a fair wage and then explores the dynamic adjustment of the labour market in response to a number of technology and preference shocks. Section 5 extends the formulation of fair wages to accommodate alternative degrees of workers' aversion to inequitable outcomes and analyses the robustness of the labour market response to productivity shocks. Section 6 concludes.

2. A fair-wage labour market model

2.1. Assumptions

Heterogeneous labour

We consider an economy with two types of labour, type 1 and type 2¹⁶. Both types of labour are supplied inelastically, as denoted by the pair of labour force values $\{\bar{L}_1, \bar{L}_2\}$, and behave according to the fair wage-effort hypothesis (Akerlof and Yellen, 1990). In particular, the effort levels $\{e_1, e_2\}$ that the respective labour types may exert in the workplace are given, at any discrete time t , by:

$$e_1 = \min\{\omega_1 / \omega_1^*, 1\}, \tag{1}$$

$$e_2 = \min\{\omega_2 / \omega_2^*, 1\}, \tag{2}$$

where $\{\omega_1, \omega_2\}$ is the pair of actual wages received by type 1 and type 2 labour, and where $\{\omega_1^*, \omega_2^*\}$ is the pair of endogenously determined fair wages of type 1 and type 2 labour. In Eqs. (1) and (2), the fair wage-effort hypothesis states that if the actual wage paid to a worker of a given type is at least equal to her fair wage, the worker contributes the maximum effort level of 1. However, if the actual wage received by the worker falls below what she considers fair, the worker reduces effort in proportion.

Type 1, or high-skilled, workers are defined as the labour group that receives a higher actual wage in equilibrium. Type 2, or low-skilled, workers are defined as the labour group that receives a lower actual wage in equilibrium.

The fairness rule

What does a worker consider fair to receive at any date t ? We assume that the fair wage, or reference transaction, of a worker of type 1 at date t is given by:

$$\omega_1^* = (\omega_2)^\beta (\omega_1^c)^{1-\beta}, \tag{3}$$

where ω_2 is the actual wage received by type 2 workers of the same firm, ω_1^c is the market-clearing wage of type 1 labour, and the parameter $\beta \in (0, 1)$ captures the relative weight attached to each argument in the determination of the fair wage. A symmetric specification to Eq. (3) corresponds to the fair wage of a worker of type 2 at date t .

As in Akerlof and Yellen (1990), Eq. (3) states that, on the one hand, fairness is influenced by the wage of the peers of the other labour type. In this context, β can be interpreted as a parameter that measures workers' preference for equal pay. On the other hand, the fair wage is influenced by the 'own' market-clearing wage which reflects the current state of the 'own' labour market. A rule with a high value of β can be thought of as being informed by sociological theories of equity. Likewise, a rule with a low value of β can be thought of as being informed by market-clearing theories.

¹⁶: Throughout the analysis, subscripts 1 and 2 refer, respectively, to type 1 and type 2 labour market variables.

Firms' environment

Firms operate in a perfectly competitive product-market environment and they set wages in order to maximise profits subject to the effort functions (1) and (2). Each firm has a production function of the Cobb-Douglas form in the two types of effective labour input:

$$y_t = (A_{1t} e_{1t} L_{1t})^\alpha (A_{2t} e_{2t} L_{2t})^{1-\alpha} \quad (4)$$

where y_t denotes final output, $\{e_{1t} L_{1t}, e_{2t} L_{2t}\}$ are units of effective labour input of type 1 and type 2, $\{A_{1t}, A_{2t}\}$ are positive coefficients, and the parameter $\alpha \in (0, 1)$ measures the relative weight attached to each type of labour input in production. Eq. (4) is a simplified version of the constant-elasticity-of-substitution (CES) aggregate of skilled and unskilled labour used, among others, by Katz and Autor (1999), Hornstein et al. (2005), Caselli and Coleman (2006), and Autor et al. (2008). Unlike Akerlof and Yellen (1990) and Agénor and Aizenman (1997), that use a quadratic, additive production technology in the two labour types, Eq. (4) permits a simpler parameterization of productivity shocks and allows the log-linearization of the model. The specification in Eq. (4) imposes an elasticity of substitution between type 1 and type 2 labour equal to one. It also allows the two types of labour to be gross complements in the sense that the cross-input effect on the marginal product is positive.¹⁷ As Agénor and Aizenman (1997), we consider the (gross) complementarity case of labour types in the production of the final good. Throughout the analysis, we impose the parameter restrictions $A_{1t} > A_{2t}$ and $\alpha > 1 - \alpha$, such that the contribution of type 1 labour to the level of technology is greater than the contribution of type 2 labour.¹⁸ In the spirit of Autor et al. (2008), the parameter α can be interpreted as the share of activity allocated to high-skilled workers.

The production function in Eq. (4) lets us parameterize productivity along two dimensions. Changes in the coefficients $\{A_{1t}, A_{2t}\}$ capture skill-neutral technological progress. Specifically, an increase in either or both coefficients has a positive effect on the marginal products of both types of labour, leaving the relative productivity of the two labour types unaffected.¹⁹ On the other hand, skill-biased technical change is captured by exogenous increases in the parameter α . That is, we assume that the exogenous variables and the parameters of the model are such that the productivity of type 1 labour increases in α and the productivity of type 2 labour decreases in α .²⁰ Note that in a two-sector economy with heterogenous labour and shirking à la Shapiro and Stiglitz (1984), Agénor and Aizenman (1997) also model a skill-biased technological shock as a simultaneous pro-skilled, anti-unskilled change in technology.

Let us define the pair of market-clearing wages $\{\omega_{1t}^c, \omega_{2t}^c\}$ as the wages that clear the market for labour of a given type in a neoclassical economy where all workers elicit maximum effort regardless of the actual wage they receive (Akerlof and Yellen, 1990). When effort is maximum, profit optimization yields the standard labour demand functions:

$$\omega_{1t} = \left(\frac{L_{2t}}{L_{1t}} \right)^{1-\alpha} \alpha A_{1t}^\alpha A_{2t}^{1-\alpha} \quad (5)$$

$$\omega_{2t} = \left(\frac{L_{2t}}{L_{1t}} \right)^\alpha (1-\alpha) A_{1t}^\alpha A_{2t}^{1-\alpha} \quad (6)$$

notice that, in a neoclassical equilibrium with maximum effort, the actual wage of type 1 labour will be higher than the actual wage of type 2 labour if and only if the inequality restriction $\alpha / (1 - \alpha) > L_{1t}/L_{2t}$ holds.

The market-clearing wage of type 1 labour, ω_{1t}^c , is that wage which is sufficiently low to deliver full employment of type 1 labour, holding constant the level of employment of type 2 labour. And vice versa for the market-clearing wage of type 2 labour. Then, the pair of market-clearing wages at date t can be also written as:

$$\omega_{1t}^c = \omega_{1t} (1 - u_{1t})^{1-\alpha} \quad (7)$$

$$\omega_{2t}^c = \omega_{2t} (1 - u_{2t})^\alpha \quad (8)$$

17. In particular, the cross-input effect on the marginal product is given by: $\partial^2 y_t / \partial e_{2t} L_{2t} \partial e_{1t} L_{1t} = \alpha(1 - \alpha) A_{1t}^\alpha A_{2t}^{1-\alpha} (e_{1t} L_{1t})^{\alpha-1} (e_{2t} L_{2t})^{1-\alpha} > 0$.

18. A straightforward way to notice these contributions amounts to writing the production function in Eq. (4) as

$y_t = A_t (e_{1t} L_{1t})^\alpha (e_{2t} L_{2t})^{1-\alpha}$, where the index of technology is $A_t = A_{1t}^\alpha A_{2t}^{1-\alpha}$.

19. The relative productivity of effective labour of type 1 is simply $(\alpha / (1 - \alpha)) (e_{1t} L_{1t} / e_{2t} L_{2t})$.

20. The productivity of effective labour of type 1 increases in parameter α under the restriction $1 + \alpha \ln(A_{1t}/A_{2t}) - \alpha \ln(e_{2t} L_{2t} / e_{1t} L_{1t}) > 0$. Similarly, the productivity of effective labour of type 2 decreases in parameter α under the restriction $1 - (1 - \alpha) \ln(A_{1t}/A_{2t}) - (1 - \alpha) \ln(e_{1t} L_{1t} / e_{2t} L_{2t}) > 0$.

where $u_{1t} = (\bar{L}_{1t} - L_{1t})/\bar{L}_{1t}$ is the unemployment rate of type 1 labour and $u_{2t} = (\bar{L}_{2t} - L_{2t})/\bar{L}_{2t}$ is the unemployment rate of type 2 labour. Eqs. (7) and (8) simply state that the larger the deviation of the actual wage from the market-clearing wage of a given labour type, the higher the rate of unemployment of that type.

We finally assume that the firm has a preference to pay fair wages when profits are invariant to the firm's wage choice, i.e. when the minimum of the marginal cost per unit of effective labour is not unique.

2.2. Equilibrium

The equilibrium of the model is a symmetric and integrated equilibrium, in which firms pursue identical hiring strategies given the complementarity of labour types in production. In equilibrium all firms hire workers of *both* types.²¹ Yet, labour market outcomes differ between groups. In particular, type 1 labour is fully employed while type 2 labour experiences some unemployment. Workers of type 1 are paid their market-clearing wage, which is above their fair wage, and workers of type 2 are paid their fair wage, which is above their market-clearing wage.

The above characterization of the integrated equilibrium solution is easily justified along the lines in Akerlof and Yellen (1990).²² Thus, a *hypothetical* equilibrium solution in which both types of labour are fully employed and elicit maximum effort is not an integrated equilibrium solution. In such a hypothetical solution, workers of type 2 would receive an actual wage that would be below what they would consider fair. As a result, their effort level would fall, thus raising the marginal cost of effective labour above the marginal product and creating positive unemployment of type 2 workers. Similarly, a *hypothetical* equilibrium solution in which both types of labour experience some unemployment and elicit maximum effort is *not* an integrated equilibrium solution. In such a hypothetical solution, firms would always be better-off by cutting the actual wage of type 1 labour, hence by eliminating unemployment of type 1 workers, while maintaining their effort at maximum level. Overall, the integrated equilibrium solution combines full employment of type 1 labour and some unemployment of type 2 labour. In the integrated equilibrium outcome, the actual wage of type 1 workers is equal to their market-clearing wage and the actual wage of type 2 workers is equal to their fair wage. Both types of labour elicit the maximum level of effort in equilibrium.

The next section derives the integrated equilibrium solution of the labour market and explores the comparative static effects of technology, fairness, and labour supply shocks when there is no inertia in fairness perceptions.

3. Technology, fairness, and labour supply shocks in the absence of inertia in perceptions of fairness

In an economy in which workers' reference transactions evolve quickly, the labour market equilibrium is given by the solution to the system of the three conditions described by the integrated equilibrium. As it shall become clear later, it will be useful to work with the following log-linear approximation of the three equilibrium conditions:

$$\ln \omega_t = \ln \alpha + \alpha \ln A_{1t} + (1 - \alpha) \ln A_{2t} + (1 - \alpha) \ln \frac{\bar{L}_{2t}}{L_{1t}} - (1 - \alpha) u_{2t}; \quad (9)$$

21: Asymmetric and segregated equilibria are likely to occur when labour types are substitutes in production. In a partially segregated outcome, some firms hire both types of labour while other firms hire only type 2 labour. In a fully segregated outcome, each firm may hire either type 1 labour or type 2 labour.

22: See Akerlof and Yellen (1990) for a detailed discussion.

$$\ln w_{2t} = \ln w_{1t} - \frac{\alpha(1-\beta)}{\beta} u_{2t}; \tag{10}$$

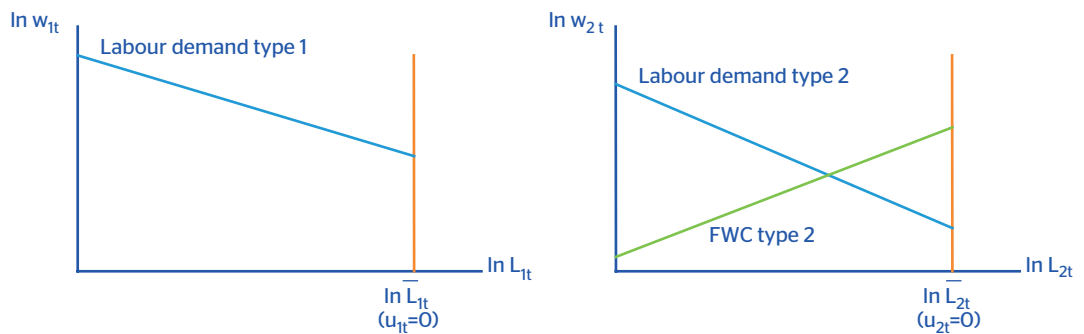
$$\ln w_{2t} = \ln(1-\alpha) + \alpha \ln A_{1t} + (1-\alpha) \ln A_{2t} - \alpha \ln \frac{\bar{L}_{2t}}{L_{1t}} + \alpha u_{2t}; \tag{11}$$

where Eq. (9) is the market-clearing wage of type 1 workers, Eq. (10) is the fair wage of type 2 workers, or, using Akerlof and Yellen's (1990) terminology, the fair wage constraint (FWC), and Eq. (11) is the labour demand schedule for type 2 workers. More particularly, Eq. (9) is obtained from Eq. (5), once the right-hand-side of the latter is re-written in terms of u_{2t} and the full employment outcome of type 1 labour is introduced. Similarly, Eq. (10) is obtained by introducing Eq. (8) into the symmetric specification of the fair wage rule in Eq. (3) and by writing the left-hand-side of the resulting expression in terms of w_{2t} . Finally, Eq. (11) follows from Eq. (6) once the right-hand-side of the latter is re-written in terms of u_{2t} and the full employment outcome of type 1 labour is introduced. The resulting system of equations is log-linearized.

Note that introducing $u_{2t} = (\bar{L}_{2t} - L_{2t})/\bar{L}_{2t}$ in conditions (10) and (11) yields, respectively, the standard definitions of the fair wage constraint, or labour supply schedule, and the labour demand schedule in the employment-wage space for type 2 labour. A graphical illustration of the equilibrium conditions is given below.

Figure 1

Labour market equilibrium



Source: Authors' own representation

Eqs. (9)-(11) form a system of structural equations whose solution yields the equilibrium rate of unemployment of type 2 labour and the pair of equilibrium wages of type 1 and type 2 labour written as a function of the exogenous variables and the parameters of the model. In particular, the equilibrium rate of unemployment is given by:²³

$$u_{2t} = \frac{\beta}{\beta + \alpha(1-\beta)} \left(\ln \alpha - \ln(1-\alpha) + \ln \frac{\bar{L}_{2t}}{L_{1t}} \right); \tag{12}$$

The comparative static effects of technology, fairness, and labour supply shocks on the equilibrium rate of unemployment are summarised in Proposition 1 next.

Proposition 1

The equilibrium rate of unemployment of low-skilled labour, u_{2t} , increases with: (i) an increase in the technology parameter α ; (ii) an increase in the fairness parameter β ; and (iii) an increase in the relative supply of low-skilled workers. Note that the change in the equilibrium rate of unemployment is positive, $\Delta u_{2t} > 0$, if the growth rate of the relative supply of low-skilled labour is positive, and vice versa.

Proof. See Appendix 1

23: Notice that the unemployment rate is nonnegative given that the inequality restriction $\alpha/(1-\alpha) > \bar{L}_r/L_{2t}$ holds.

The results established in Proposition 1 are intuitive. Thus, a productivity shock biased in favour of high-skilled workers raises the unemployment rate of low-skilled workers. The skill-biased shock raises the productivity of type 1 labour, hence it raises the actual wage received by type 1 workers in equilibrium. The effect of the shock on the labour market for type 2 workers is twofold. On the one hand, type 2 workers' labour demand schedule shifts downwards, as the productivity of type 2 labour falls. On the other hand, the fair wage constraint shifts upwards, as type 2 workers consider it fair to receive a higher wage in the presence of a wage rise for type 1 labour, and it becomes steeper, as the fair wage is now more sensitive to changes in unemployment. Overall, the equilibrium rate of unemployment of low-skilled labour increases as a result of the skill-biased productivity shock.

In Eq. (12), we also notice that the unemployment rate of low-skilled workers does not depend upon the coefficients $\{A_{1t}, A_{2t}\}$. That is, productivity growth does not affect the equilibrium rate of unemployment, unless it is biased.²⁴

A fairness shock that raises the workers' preference for equal pay shifts the fair wage constraint of type 2 labour upwards. This is because low-skilled workers consider it fair to receive a wage closer to the wage received by high-skilled workers. In addition, the fair wage constraint flattens, as the fair wage becomes less responsive to changes in unemployment. Overall, the shift in the fair wage constraint induced by the shock results in a rise in the equilibrium rate of unemployment of low-skilled workers.

The model predicts that an increase in the supply of high-skilled workers reduces unemployment among the low-skilled, and that an increase in the supply of low-skilled workers increases unemployment among the low-skilled. Intuitively, we note that an increase in the supply of type 1 workers reduces their productivity in equilibrium while it increases the productivity of type 2 workers. The fair wage constraint shifts downwards, as type 2 workers adjust their fair wage in the presence of a cut in the wage of type 1 labour. The overall effect of the shock brings about a reduction in equilibrium unemployment of type 2 labour. The opposite effects are played out following a rise in the supply of type 2 workers.

Regarding the determination of wages, the relative wage of type 1 labour in equilibrium is given by:

$$\ln \frac{\omega_{1t}}{\omega_{2t}} = \frac{\alpha(1-\beta)}{\beta + \alpha(1-\beta)} \left(\ln \alpha - \ln(1-\alpha) + \ln \frac{\bar{L}_{2t}}{L_{1t}} \right). \quad (13)$$

Note that expression (13) can be interpreted as the skilled-unskilled wage premium or, simply, the skill premium. Appendix 1 reports the expressions for the wage of type 1 labour and the wage of type 2 labour in equilibrium. Proposition 2 establishes the effects of technology, fairness, and labour supply shocks on the relative wage of type 1 labour.

Proposition 2

In equilibrium, the relative wage of high-skilled labour, or skill premium, increases with: (i) an increase in the technology parameter α ; (ii) a decrease in the fairness parameter β ; and (iii) an increase in the relative supply of low-skilled workers. In equilibrium, the growth rate of the relative wage of high-skilled labour is positive if the growth rate of the relative supply of low-skilled labour is positive, and vice versa.

Proof. See Appendix 1

The intuitive explanations underpinning the results summarised in Proposition 2 follow easily from the discussion of Proposition 1. A technology shock that works in favour of the high-skilled raises the skill premium. In addition, the model predicts that, other things being equal, an increase in the workers' preference for wage equality would be successful in achieving a lower degree of wage dispersion at the cost of higher equilibrium unemployment among the low-skilled. Finally, Eq. (13) shows that the wage gap does not depend on skill-neutral productivity growth, thus it does not change in response to aggregate productivity shocks.

We next investigate the dynamic adjustment of the labour market to various shocks as predicted by our fairness model when workers' perceptions of fairness exhibit inertia.

24: 24Note that the parameter α is time-invariant and only subject to one-off exogenous changes.

4. The dynamic adjustment of unemployment and wages when fairness perceptions exhibit inertia

This section explores the dynamic effects of technology, fairness, and labour supply shocks on equilibrium unemployment and the skill premium under the assumption that perceptions of fairness in the labour market change slowly. In particular, we assume that firms' relevant reference transactions exhibit no inertia and set wages as dictated by the integrated equilibrium conditions while workers may set their fair wage based on past reference standards. Workers may do so because past interactions have a significant and lasting influence on the reference transaction against which they judge fairness or because collecting and processing information about the wage of their reference group or about prevailing macroeconomic conditions involves significant costs. For these reasons, it is fair to assume that, at each date t , only a fraction of workers formulate their respective fair wages based on current reference standards while the rest formulate their respective fair wages based on past standards. In the long-run, the whole of the workforce will update the perceptions of what is considered to be fair and, in the absence of further shocks, the model will converge to that of further shocks, the model will converge to that of Section 3.²⁵

In particular, the updating of fairness perceptions is an event governed by an independent Poisson process with arrival rate $\lambda : \lambda \in (0, 1)$. In each period, a fraction λ of the workforce updates the determinants of the fair wage and the fraction $(1 - \lambda)$ continues formulating the fair wage based on past reference standards. We assume that updating to the new reference standards occurs simultaneously in workers of a given type who belong to the same firm and that the arrival rate λ is time-invariant. Thus, the fair wage of type 2 labour working for a competitive firm takes, in period t , the log-linear form:

$$\ln \omega_{2t}^* = E_{t-j} (\beta \ln \omega_{jt} + (1 - \beta) \ln \omega_{2t}^c), \quad (14)$$

where the fair wage of type 2 labour is formulated as the expected value of the fair wage in period t based on reference transactions set j periods ago, $j \in [0, \infty)$. A symmetric expression to (14) describes the fair wage of type 1 labour in period t . In Eq. (14), we notice that, out of steady-state, the integrated equilibrium solution delivers wage dispersion among low-skilled workers who belong to different firms²⁶.

The aggregate fair wage of type 2 labour is the average of fair wages of type 2 labour in the economy, i.e.:

$$\ln \omega_{2t}^* = \lambda \sum_{j=0}^{\infty} (1 - \lambda)^j E_{t-j} (\beta \ln \omega_{jt} + (1 - \beta) \ln \omega_{2t}^c). \quad (15)$$

Suppose now that there is a shock at $t = 0$. The aggregate fair wage of type 2 labour at any date $t \geq 0$ can be written as:

$$\ln \omega_{2t}^* = (1 - (1 - \lambda)^{t+1}) (\beta \ln \omega_{jt} + (1 - \beta) \ln \omega_{2t}^c) + (1 - \lambda)^{t+1} \ln \tilde{\omega}_{2t}^* \quad (16)$$

where $\tilde{\omega}_{2t}^*$ is the actual wage of type 2 labour in the initial (pre-shock) steady-state. In Eq. (16), we note that the higher the probability per unit of time of updating the fair wage now, that is the higher the value of λ , the smaller the weight of the initial steady-state in the determination of the current (post-shock) aggregate fair wage. Thus, a lower degree of inertia in the labour market is associated with fast evolving fairness perceptions.

25: In a perfectly competitive product market environment, all firms readily observe any change in economic conditions and adjust their optimal behaviour accordingly, otherwise firms would not survive in the market. A greater degree of inertia could be introduced in the model by allowing for relevant fairness judgements on the part of firms, yet this might require introducing a source of imperfect competition in the product market (e.g. product differentiation) to ensure firm survival. We have abstracted from introducing further complexity in the product market in order to focus on the labor market effects of inertia in perceptions of fairness on the part of workers.

26: Wage dispersion among homogenous workers is also found in, e.g. Egger and Kreickemeier (2009a) in the context of a model that incorporates workers' fair wage preferences into a general equilibrium framework. Firm heterogeneity and labour market imperfections are combined to deliver a fair wage that depends upon the productivity of the firm. Thus, more productive firms would pay higher wages to otherwise identical workers.

Introducing the log-linear definition of the competitive wage, i.e. $\ln \omega_{2t}^c = \ln \omega_{2t}^* - \alpha u_{2t}$ in Eq. (16) and solving yields the dynamic fair wage constraint of type 2 labour at any date $t \geq 0$:

$$\ln \omega_{2t}^* = \frac{(1 - (1 - \lambda)^{t+1})}{(1 - \beta)(1 - \lambda)^{t+1} + \beta} (\beta \ln \omega_{1t} - \alpha(1 - \beta)u_{2t}) + \frac{(1 - \lambda)^{t+1}}{(1 - \beta)(1 - \lambda)^{t+1} + \beta} \ln \tilde{\omega}_{2t}^* \quad (17)$$

Overall, the dynamic adjustment path of labour market variables following a shock at date $t = 0$ is given by the solution to the system of equilibrium conditions formed by Eq. (9), Eq. (11), and Eq. (17)²⁷. In particular, the time path of equilibrium unemployment of low-skilled labour is described by the following expression:

$$u_{2t} = \frac{1}{\alpha + \beta(1 - \alpha)(1 - (1 - \lambda)^{t+1})} \left[\beta(1 - (1 - \lambda)^{t+1}) \ln \alpha - ((1 - \beta)(1 - \lambda)^{t+1} + \beta) \ln(1 - \alpha) - \alpha(1 - \lambda)^{t+1} \ln A_{1t} - (1 - \alpha)(1 - \lambda)^{t+1} \ln A_{2t} + ((\alpha - \beta)(1 - \lambda)^{t+1} + \beta) \ln \frac{\bar{L}_{2t}}{L_{1t}} + (1 - \lambda)^{t+1} \ln \tilde{\omega}_{2t}^* \right]$$

where $t \geq 0$. In the long-run, i.e. when $t \rightarrow \infty$, the total of the labour force will adapt to the new reference standards and the equilibrium path of unemployment will converge to its steady-state value given by Eq. (12). In the interest of brevity, we omit the expressions for the dynamic adjustment path of wages. These are easily derived by introducing the path of equilibrium unemployment in the solution to the system of equations formed by Eq. (9), Eq. (11), and Eq. (17).

4.1. Calibration

The solution to the system of equilibrium conditions given by Eq. (9), Eq. (11), and Eq. (17) allows us to examine the dynamic adjustment paths of equilibrium unemployment and the skill premium following a shock at date $t = 0$. In order to proceed, one has to choose plausible baseline values for the exogenous variables and the parameters of the model. In particular, we choose the efficiency levels of skilled and unskilled labour computed by Caselli and Coleman (2002) for the U.S. economy in the year 1992. Thus, we set $\ln A_{1t} = 3.32$ and $\ln A_{2t} = 2.80$. Similarly, the labour supplies of skilled and unskilled labour recorded in the U.S. in the year 1992 are taken from Krusell et al. (2000). Hence, we set $\ln(\bar{L}_{2t}/L_{1t}) = -0.55$. Skilled labour encompasses those individuals with at least a college degree while unskilled labour encompasses the rest of the labour force. To ensure consistency, note that Krusell et al. (2000) is the source used by Caselli and Coleman (2002) in the identification of efficiency levels.

The parameter λ is the rate at which workers' perceptions of fairness change. In order to proxy for it, we use the arrival rate of information to workers that Mankiw and Reis (2007) estimate using U.S. quarterly data for the period 1954Q3 – 2006Q1. In particular, their estimate of $\lambda = 0.195$ indicates that workers update their information about every five quarters or, in other words, that a fifth of workers update their information sets every quarter. Thus, adopting Mankiw and Reis' (2007) terminology, workers are 'quite inattentive' or, in terms of fairness considerations, workers are 'quite conservative' in that their reference transactions evolve relatively slowly over time.

Potential baseline values for the remaining two parameters, α and β , are less well-documented in the literature. The parameter α can be interpreted as the share of work activities allocated to skilled labour (Autor et al., 2008). In the numerical simulations, we set the baseline value of $\alpha = 0.7$. Similarly, we consider appropriate to choose a low value for the taste for equal pay parameter β in the case of the U.S. labour market. In particular, we work with the baseline value of $\beta = 0.1$. Robustness checks of the main results are carried out for alternative values of these parameters²⁸. Finally, note that the assumed baseline values meet the restrictions of the model.

For detailed analytical descriptions of the shocks, see Appendix 2.

27: Note that, in the integrated equilibrium solution, it must also hold that $\omega_{1t}^c > \omega_{2t}^c$ and that $\omega_{1t}^c > \omega_{1t}^*$, $\forall t \geq 0, \forall j \in [1, \infty)$.
28: Robustness results are available from the authors upon request.

4.2. The dynamic adjustment of labour market variables to technology, fairness, and labour supply shocks

We next explore the dynamic responses of the equilibrium unemployment rate of low-skilled labour and the relative wage of high-skilled labour to various exogenous shocks. In each case, the shocks are assumed to be sudden, unexpected, and permanent. The period in the model is taken to equal one quarter.

Given the baseline values and the simulation assumptions, the steady-state equilibrium rate of unemployment in this model, i.e. the rate of unemployment that would prevail once the flow of updated information about the current state of the fair wage components does not induce the fair wage to change, is equal to 4 percent. Similarly, the skill-unskilled wage premium in steady-state equilibrium is equal to 29 percent.

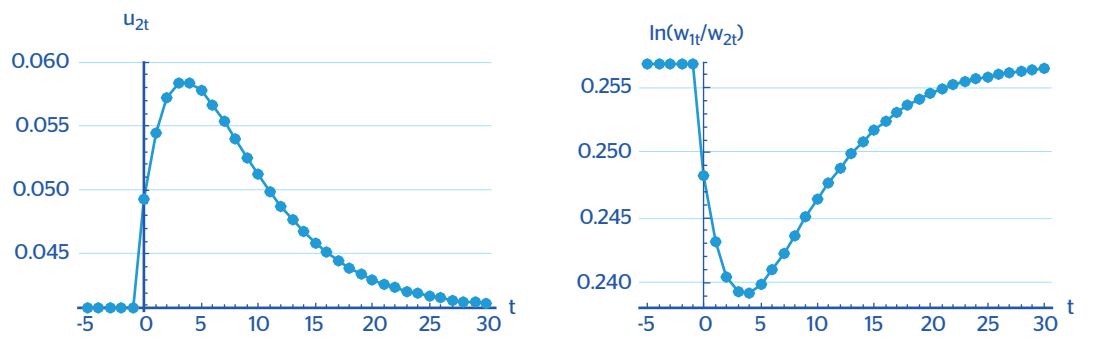
An aggregate productivity slowdown

Suppose that, at date $t = 0$, the annualised rate of growth of trend productivity falls by 3 percentage points, or 0.75 percentage points per quarter. That is, the exogenous shock induces a permanent deceleration in trend productivity growth. Furthermore, assume that the aggregate productivity slowdown is skill-neutral, i.e. the parameter α is unaffected by the shock.

Fig. 2 shows the adjustment paths followed by equilibrium unemployment and the skill premium as predicted by the model.

Figure 2

Equilibrium unemployment and the skill premium after a skill-neutral trend productivity slowdown



Source: Authors' own calculations

There are three stylized facts that become apparent in Fig. 2. These are summarised in the following Proposition.

Proposition 3

An aggregate skill-neutral productivity slowdown raises temporarily the equilibrium rate of unemployment of low-skilled labour above its steady-state value. The adjustment lags indicate that there is a medium-run effect on equilibrium unemployment of a skill-neutral shock to productivity growth. The relative wage of high-skilled labour, or skill premium, falls temporarily as a result of the productivity slowdown before it converges back to its long-run trend.

In Fig. 2, the maximum impact of the productivity slowdown on equilibrium unemployment occurs at about four quarters, by which date the equilibrium unemployment rate of low-skilled labour has reached 5.8 percent starting from an initial steady-state value of 4 percent. The increase in equilibrium unemployment gradually dissipates thus u_{2t} converges back to steady-state after thirty quarters. The dynamic profile of the skill premium is similar to that of equilibrium unemployment, although with the opposite sign. Note that the relative wage converges to its initial steady-state value after thirty quarters²⁹.

29: Throughout the dynamic adjustment path of wages, we have also checked that the two further conditions for integrated equilibrium are not violated, namely $\omega_{jt}^f > \omega_{jt}^g$ and $\omega_{jt}^f > \omega_{jt}^g, \forall t \geq 0, \forall j \in [1, \infty)$.

The key intuitive explanation that underpins the patterns of adjustment depicted in Fig. 2 becomes apparent by inspecting the dynamic fair wage constraint given by Eq. (17). In the aftermath of the shock, the growth rate of the aggregate wage of type 2 labour is above its new warranted growth rate. This is because the productivity slowdown takes time to feed into the fair wages of type 2 labour. As a result of the marginal cost raising above the marginal product, the equilibrium rate of unemployment of type 2 labour increases. Thus, at the firm level, while some firms optimally adjust their labour market outcomes for type 1 and type 2 workers to the productivity shock, others take optimal decisions facing a fair wage that behaves according to the initial (pre-shock) steady-state. In the latter group of firms, and for as long as their workforce does not adapt to the new reference transaction, the growth rate of the wage of low-skilled labour is above the growth rate of the wage of high-skilled labour, which induces the dynamic adjustment path of the skill premium depicted in Fig. 2. The medium-run effects of the shock disappear as low-skilled workers update their perceptions of fairness reflecting the true state of the components of their respective fair wage, thus equilibrium unemployment and the skill premium return gradually to steady-state.

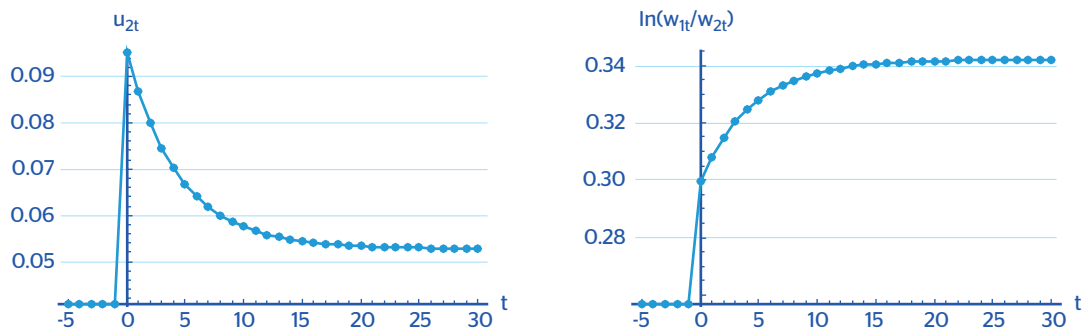
A skill-biased productivity shock

Suppose that, in period $t = 0$, the parameter α increases exogenously while the coefficients $\{A_{1t}, A_{2t}\}$ stay constant at their respective baseline values. Therefore, the shock has an impact on the level of technology, A_t , and not on its trend growth rate. In the context of our model, the skill-biased productivity shock captures an increase in the absolute efficiency of high-skilled labour and a reduction in the absolute efficiency of low-skilled labour. In particular, suppose that the parameter increases from the baseline value $\alpha = 0.7$ to the value $\alpha = 0.72$ at date $t = 0$.

Fig. 3 illustrates the dynamic convergence paths of equilibrium unemployment and the relative wage to the new steady-state equilibrium.

Figure 3

Equilibrium unemployment and the skill premium after a skill-biased productivity shock



Source: Authors' own calculations

Proposition 4 next outlines the stylized facts that are easily discernible in Fig. 3.

Proposition 4

A skill-biased productivity shock causes an instantaneous increase in the equilibrium rate of unemployment of low-skilled labour. Subsequently, the equilibrium rate of unemployment converges monotonically from above to the new, higher steady-state value. The relative wage of high-skilled labour converges monotonically from below to a higher steady-state equilibrium value.

Fig. 3 shows that the skill-biased productivity shock has a large, instant impact on the equilibrium rate of unemployment of low-skilled labour, which jumps from an initial steady-state value of 4 percent to a value of 9.5 percent at date $t = 0$. Thereafter, the unemployment rate converges steadily to its new steady-state equilibrium value of 5.2 percent. The rise in the relative wage of high-skilled labour yields a 40 percent wage gap in the new steady-state equilibrium, thus 11 percentage points up from the initial steady-state value³⁰.

30: Note that, throughout the dynamic adjustment path of wages, we have also checked that the two further conditions for integrated equilibrium hold, that is $\omega_{it}^c > \omega_{it}^*$ and $\omega_{it}^c > \omega_{it}^*$, $\forall t \geq 0, \forall j \in \{1, \dots, n\}$.

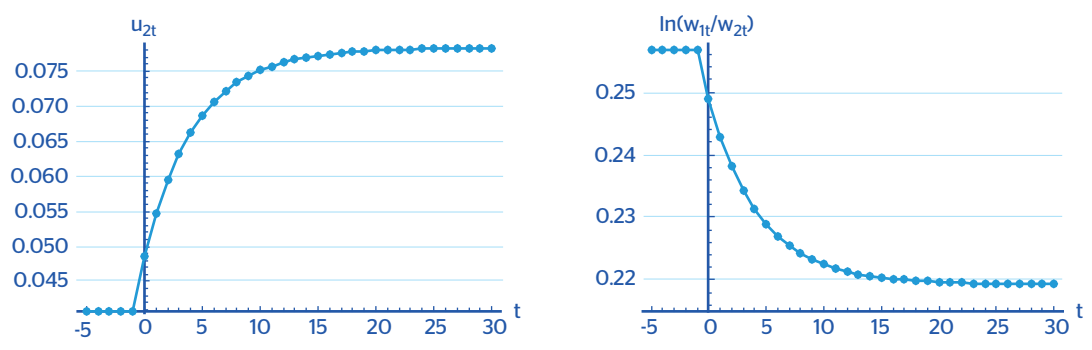
The instantaneous impact of the skill-biased productivity shock on the equilibrium rate of unemployment of type 2 labour is caused by the time the fair wages of type 2 labour take to reflect the effects of the skill-biased change in productivity. Thus, firms whose workers have not updated their reference standards face a fair wage that is constant at the pre-shock steady-state value while the labour demand schedule has shifted downwards, which induces the large increase in unemployment³¹. The whole of the workforce will eventually adapt to the new reference standards and equilibrium unemployment will adjust gradually down towards the new, higher steady-state level. The same explanation underpins the adjustment process of the skill premium to the new steady-state equilibrium.

A change in workers' taste for fairness

Suppose that, in period $t = 0$, workers' taste for equal pay changes and this change spreads gradually across the workforce at arrival rate λ . One might like to think of the shock as a result of a shift towards greater equality in labour market outcomes. Assume, in particular, that the parameter β increases from the baseline value $\beta = 0.1$ to the value $\beta = 0.2$.

Fig. 4 represents the convergence paths followed by equilibrium unemployment and the relative wage as predicted by the model.

Figure 4
The labor market adjustment to an increase in the fairness parameter



Source: Authors' own calculations

Proposition 5 summarises two results that are apparent in Fig. 4.

Proposition 5

A fairness shock that raises the workers' taste for equal pay yields an instant increase in the equilibrium rate of unemployment of low-skilled labour. Thereafter, the equilibrium rate of unemployment converges monotonically from below to the new steady-state equilibrium value. The fairness shock reduces steadily the relative wage of the high-skilled until the new steady-state equilibrium value is reached.

In Fig. 4, the fairness shock has a contemporaneous effect on the equilibrium rate of unemployment of low-skilled labour of about 0.8 percentage points. At five quarters, the equilibrium rate of unemployment is roughly 2.8 percentage points above the initial steady-state value of 4 percent.

Or, in other words, it is more than half-way through the total adjustment induced by the shock, which amounts to 3.8 percentage points. Thus, the dynamic profile depicted in Fig. 4 suggests that equilibrium unemployment would converge fairly fast and smoothly to the new, substantially higher, steady-state equilibrium. A similar conclusion is obtained from the dynamic profile of the skill premium. That is, the fairness shock would promptly and steadily reduce the relative wage of the high-skilled. In our example, the steady-state wage gap falls 5 percentage points, i.e. from 29 to 24 percent, and the shock is mostly felt within the first five quarters³².

Intuitively, the dynamic responses of equilibrium unemployment and the relative wage are explained by the gradual spread of the change in workers' taste for equal pay. In the context of inertia in fairness perceptions, the fairness shock shifts the dynamic fair wage constraint in Eq. (17) upwards, but at a pace dictated by the rate at which workers' perception of fairness change.

31: Notice that the size of the unemployment effect of the shock on impact is orientative and explained by the fact that all firms readily observe the skill-biased shock - thus shifting the labour demand schedules for skilled and unskilled workers in opposite directions - coupled with the unresponsiveness of fair wages to the shock.

32: We have checked that the two further conditions for integrated equilibrium hold throughout the dynamic adjustment path of wages.

A labour supply shock

Finally, suppose that, in period $t = 0$, the rate of growth of the labour supply rises exogenously. The exogenous labour supply shock may be caused by a permanent change in either demographic or migration trends. Consider, in particular, an initial steady-state situation in which the supply of labour, both high-skilled and low-skilled, was growing at an annualised rate of 1 percent, or 0.25 percent per quarter. At date $t = 0$, the quarterly growth rate of the supply of low-skilled labour rises to 0.3 percent while the growth of the supply of high-skilled labour remains at 0.25 percent. Therefore, the exogenous labour supply shock induces a permanent rise in the growth rate of the relative supply of low-skilled workers³³.

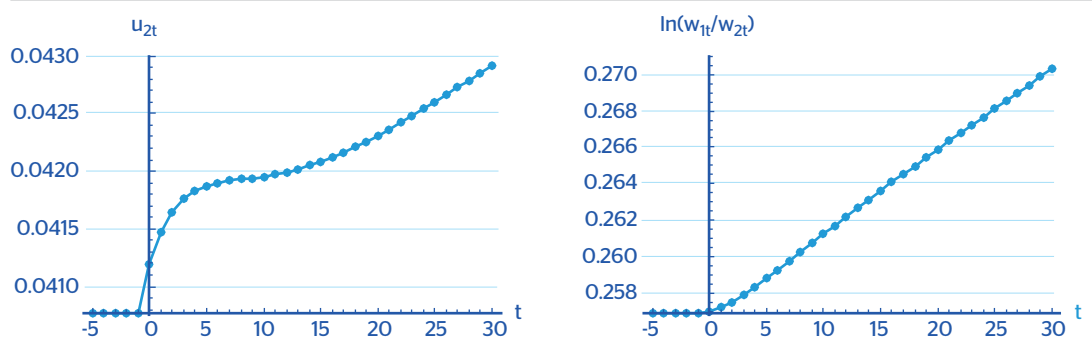
Fig. 5 depicts the convergence paths of equilibrium unemployment and the relative wage to the new steady-state. Proposition 6 outlines a number of stylized facts that follow from the figure.

Proposition 6

A permanent rise in the growth rate of the relative supply of low-skilled labour increases the equilibrium rate of unemployment of low-skilled labour and the skill premium. At steady state, ceteris paribus, the rates of change of equilibrium unemployment and the skill premium are positive.

Figure 5

Equilibrium unemployment and the skill premium after a relative labour supply shock



Source: Authors' own calculations

Fig. 5 shows small effects of the relative labour supply shock on equilibrium unemployment, i.e. at five quarters the equilibrium rate of unemployment is just 0.18 percentage points above the initial steady-state value³⁴. Intuitively, a permanent acceleration in the growth rate of the relative supply of type 2 workers produces an upward shift in the demand for type 1 labour and a downward shift in the demand for type 2 labour. The dynamic FWC shifts upwards, as type 2 workers adjust their fair wage claims in the presence of a rise in the wage of type 1 labour. Initially, equilibrium unemployment increases at a fast pace. This is explained by the share of low-skilled workers who have not updated their perceptions with regard to the overall adverse effects of the shock on their fair wage, coupled with the larger increases in the supply of low-skilled workers resulting from the shock. Once the flow of updated information spreads across the workforce, the large initial response of unemployment is absorbed and equilibrium unemployment converges towards its long-run trend rate. The adjustment pattern of the skill premium is underpinned by the rise of the skilled wage and the decline, at first sluggish, of the unskilled wage. In the new steady-state situation, all workers in the economy adapt to the positive growth rate of the relative supply of low-skilled labour and a steady increase in unemployment and the skill premium would characterize the labour market.

Section 5 next explores the implications of inequity aversion theory, as in Fehr and Schmidt (1999), in the context of the fair-wage labour market model when perceptions of fairness exhibit inertia.

33: See Appendix 2 for a detailed description of the shock.

34: Note that, throughout the dynamic adjustment path of wages, we have also checked that the two further conditions for integrated equilibrium are not violated, namely $\omega_{1t}^c > \omega_{2t}^c$ and $\omega_{1t}^s > \omega_{2t}^s$, $\forall t: t \geq 0, \forall j: j \in [1, \infty)$.

5. Inequity aversion and the fair-wage labour market model

In a 1999 paper, Fehr and Schmidt provide a utility-based formalisation of the notion of fairness. The authors model fairness as inequity aversion, more particularly, inequity averse subjects are those that are willing to relinquish some material payoff in order to induce a more equitable outcome. In addition to fairness-motivated subjects, there are purely self-interested individuals interacting in games. Fehr and Schmidt (1999) show that the presence of heterogeneous preference types can account for the puzzling evidence that results from a wide-range of games and that the economic environment itself determines the preference type that dominates equilibrium behaviour.

In Fehr and Schmidt (1999), inequity aversion is self-centered, thus individuals care about their respective relative material payoffs rather than inequity among other individuals. Furthermore, individuals show a stronger aversion to disadvantageous inequality, i.e. a situation in which the individual payoff is lower than the payoff of the reference group, than to advantageous inequality, i.e. a situation in which the individual payoff is higher than the payoff of the reference group. In other words, individuals are loss averse in social comparisons, thereby negative deviations from the reference payoff are perceived more harmful than positive deviations. The fair-wage labour market model developed above is an ideal framework to exploit the notion of asymmetric inequity aversion in workers of heterogeneous skill characteristics and study how it interacts with fair wage dynamics. In order to do so, we extend the fair-wage model allowing for two alternative scenarios.

5.1. Asymmetry in the taste for equal pay parameter across labour groups

Let us assume that the fair wage of a worker of type 2 at date t is given by:

$$\omega_{2t}^* = (\omega_{1t})^{\beta_2} (\omega_{2t}^c)^{1-\beta_2}, \tag{18}$$

and that a symmetric specification to Eq. (18) characterises the fair wage of a worker of type 1 at date t . In the modified fairness rule, the parameter β is labour-group specific and, by assumption, $\beta_2 > \beta_1$. In this scenario, Eq. (18) simply states that, given the 'own' labour market conditions, workers of type 2 are more inequity averse than workers of type 1 since, by placing a greater weight on the wage of the other labour type, their objective in fairness terms is to reduce the skill premium that places them in a disadvantageous inequality position. The opposite holds true for type 1 workers who, by being in an advantageous inequality position, do not feel as strongly the pull of a non-egalitarian outcome.

Incorporating the modified fairness rules in the fair-wage labour market model does not alter the integrated equilibrium solution, that combines full employment of type 1 labour and some unemployment of type 2 labour while both types elicit maximum effort. Once again, the actual wage of type 1 workers is above what they consider fair and the actual wage of type 2 workers is equal to their fair wage. Hence, the analysis developed in the previous sections still holds with the qualification that, in the equilibrium conditions and solution, the taste for equal pay parameter would correspond to β_2 , i.e. the preference parameter of low-skilled workers.

5.2. A less inequity-averse skilled labour

The standard Akerlof-Yellen fairness rule introduced in Eq. (3) assumes that skilled workers place the upper-bound of their fair wage at their competitive wage outcome, i.e. at the minimum wage that they can obtain if they contribute the maximum level of effort. In contrast, fairness considerations lead unskilled workers to place the lower-bound of their fairness rule at their competitive wage outcome. Yet, there may be situations in the labour market whereby skilled workers may consider fair to receive a wage that is above their market-clearing level. For example, in the presence of institutions, such as hiring, training and firing costs, employed skilled workers may feel entitled to receive a wage higher than the competitive wage³⁵. Once skilled workers are paid above market-clearing, this may build, as an entitlement, into the formulation of their fair wage. In order to accommodate this situation, we assume that the fairness rule of skilled labour takes the form:

$$\omega_{1t}^* = (\omega_{2t})^{\beta} ((1+\mu) \omega_{1t}^c)^{1-\beta}, \tag{19}$$

35: One can think of employed skilled workers acting as insiders in the labour market (see, for example, Lindbeck and Snower (2001))

i.e. type 1 workers do not cap their fairness rule at ω_{1t}^c , but at a mark-up $\mu \in (0, 1)$ over ω_{1t}^c , while the fairness rule of type 2 labour is given by Eq. (18) and the parameter assumption $\beta_2 > \beta_1$ still holds³⁶.

In this scenario, the integrated equilibrium solution combines some unemployment of both type 1 and type 2 labour. Workers of type 1 are paid their fair wage, which is above their market-clearing wage, likewise, workers of type 2 are also paid their fair wage, which is above their market-clearing wage. Both types of labour elicit the maximum level of effort in equilibrium. Notice that, in this equilibrium, skilled workers are less inequity-averse since, on the one hand, the entitlement effect delivers unemployment among workers of the same type and, on the other, their fair wage rises relative to the unskilled wage.

In the absence of inertia in fairness perceptions, the labour market equilibrium is given by the solution to the following system of structural equations:

$$\ln \omega_{1t} = \ln \alpha + \alpha \ln A_{1t} + (1 - \alpha) \ln A_{2t} + (1 - \alpha) \ln \frac{\bar{L}_{2t}}{L_{1t}} - (1 - \alpha)(u_{2t} - u_{1t}); \quad (20)$$

$$\ln \omega_{1t} = \ln \omega_{2t} + \frac{(1 - \beta_1)}{\beta_1} \ln(1 + \mu) - \frac{(1 - \alpha)(1 - \beta_1)}{\beta_1} u_{1t}; \quad (21)$$

$$\ln \omega_{2t} = \ln(1 - \alpha) + \alpha \ln A_{1t} + (1 - \alpha) \ln A_{2t} - \alpha \ln \frac{\bar{L}_{2t}}{L_{1t}} + \alpha(u_{2t} - u_{1t}); \quad (22)$$

$$\ln \omega_{2t} = \ln \omega_{1t} - \frac{\alpha(1 - \beta_2)}{\beta_2} u_{2t}; \quad (23)$$

where Eq. (20) is the labour demand schedule for type 1 workers, Eq. (21) is the fair wage constraint of type 1 workers, Eq. (22) is the labour demand schedule for type 2 workers, and Eq. (23) is the fair wage constraint of type 2 workers. Unlike the integrated equilibrium solution of Section 3, the system of equilibrium conditions now includes the fair wage constraint of type 1 labour. More particularly, Eq. (21) is obtained by introducing Eq. (7) into the specification of the fair wage rule in Eq. (19) and by writing the left-hand-side of the resulting expression in terms of w_{1t} . In the interest of brevity, we omit complex algebraic expressions and focus on the numerical calibrations of the solution throughout the rest of the analysis³⁷.

When fairness perceptions exhibit inertia, the dynamic adjustment path of labour market variables following a shock at date $t = 0$ is given by the solution to the system of equilibrium conditions formed by Eq. (20), Eq. (22), the *dynamic fair wage constraint* of type 2 labor in Eq. (17) - once the preference parameter β is replaced by β_2 -, and the *dynamic fair wage constraint* of type 1 labor that takes the form:

$$\begin{aligned} \ln \omega_{1t}^* &= \frac{(1 - (1 - \lambda)^{t+1})}{(1 - \beta_1)(1 - \lambda)^{t+1} + \beta_1} (\beta_1 \ln \omega_{2t} + (1 - \beta_1) \ln(1 + \mu) - (1 - \alpha)(1 - \beta_1)u_{1t}) \\ &+ \frac{(1 - \lambda)^{t+1}}{(1 - \beta_1)(1 - \lambda)^{t+1} + \beta_1} \ln \tilde{\omega}_{1t}^* \end{aligned} \quad (24)$$

where $\tilde{\omega}_{1t}^*$ is the actual wage of type 1 labour in the initial (pre-shock) steady-state situation. In the long-run, the whole of the workforce will update the fair wage perceptions and, in the absence of further shocks, the model will converge to that described by Eqs. (20)-(23).

Next, we explore the dynamic responses of the equilibrium unemployment rates and the skill premium to both an aggregate productivity slowdown and a skill-biased productivity shock. Unless otherwise stated, the description of the shock is identical to that provided in Section 4.2. Furthermore, we set the baseline values of $\beta_1 = 0.1$, $\beta_2 = 0.2$ and $\mu = 0.04$ ³⁸. Hence, we consider that the functioning of the U.S. labour market is largely influenced by market-clearing theories and that high-skilled workers choose a relatively low mark-up, i.e. 4 percent, over the competitive level.

36: Note that the mark-up parameter μ may reflect the insider power that employed skilled workers may feel entitled to.

37: Once again, we work with the log-linear approximation of the four equilibrium conditions. Notice that a special solution in which $u_{1t} = 0$ and $u_{2t} > 0$ is feasible; workers of type 1 would receive their market-clearing wage and equilibrium would require the restriction $\ln \omega_{1t} = \ln \omega_{2t} + (1 - \beta_1)/\beta_1 \ln(1 + \mu)$ to hold.

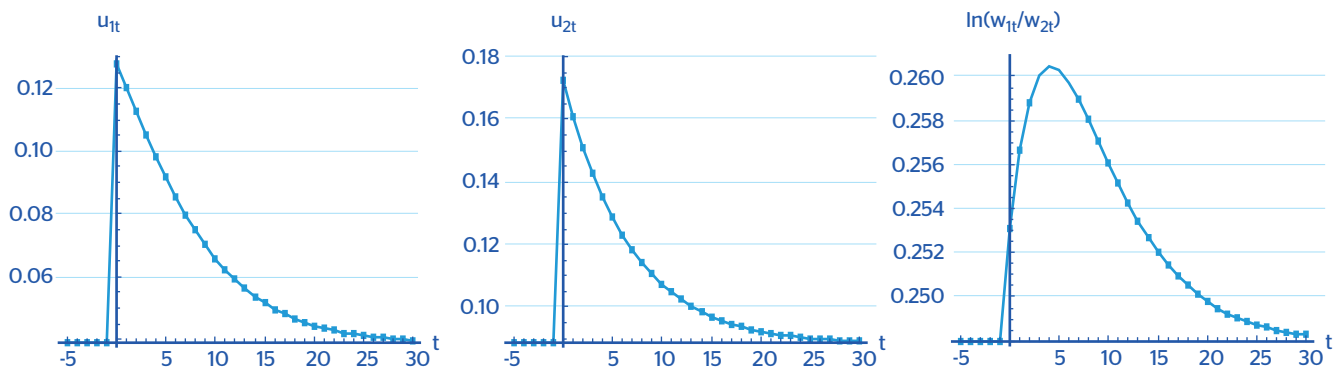
38: Alternative parameter values yield qualitatively similar results to the ones presented next.

Given the baseline values and the simulation assumptions, the steady-state equilibrium rates of unemployment of skilled and unskilled labour are, respectively, 3.9 and 8.8 percent. Similarly, the skill-unskilled wage premium in steady-state equilibrium is equal to 28 percent.

An aggregate productivity slowdown

Fig. 6 shows the predicted adjustment paths followed by unemployment and the skill premium after a permanent deceleration in trend productivity growth at date $t = 0$.

Figure 6
Inequity aversion and labour market equilibrium after a productivity slowdown



Source: Authors' own calculations

Proposition 7 summarises the stylized facts that follow from Fig. 6.

Proposition 7

An aggregate skill-neutral productivity slowdown raises temporarily the equilibrium rates of unemployment of both high-skilled and low-skilled labour above their respective steady-state values. The adjustment lags indicate that there is a medium-run effect on the unemployment rate of each labour type of a skill-neutral productivity shock. The skill premium increases temporarily as a result of the productivity slowdown before it converges back to its long-run trend.

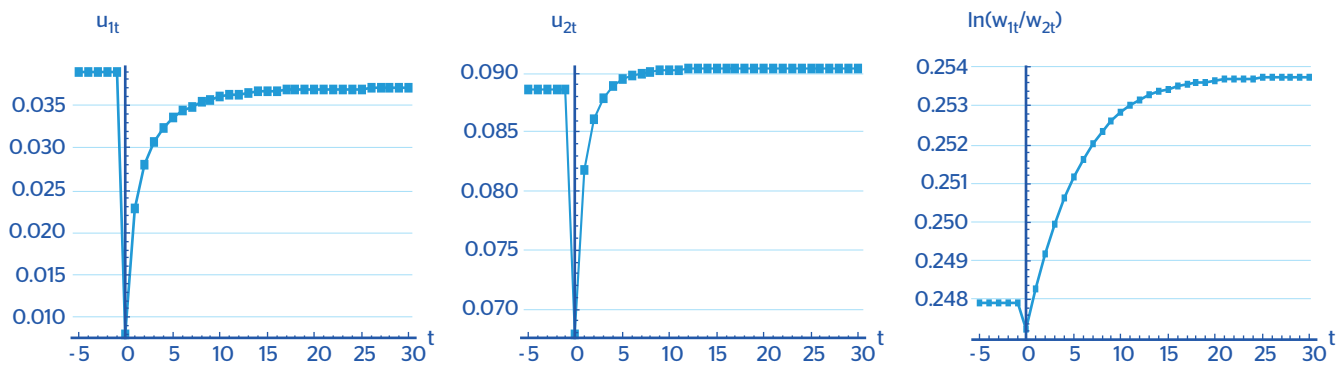
In the aftermath of the shock, the growth rates of the aggregate wages of type 1 and type 2 labour would be above their new warranted growth rates, as the dynamic fair wage constraints dictate. As a result of the marginal costs raising above the marginal products, the equilibrium rates of unemployment of high-skilled and low-skilled labour increase. As labour types are complements in production, the increases in unemployment instantaneously shift downward the labour demand schedules for each type of labour, prompting the jump in unemployment rates observed in Fig. 6 at $t = 0$. For as long as the workforce does not adapt to the new reference transactions, the wage of high-skilled labour keeps above its attained pre-shock level while the wage of low-skilled labour keeps below its attained pre-shock level. The adjustment of the low-skilled wage to the shock is explained by the high sensitivity of the demand for low-skilled labour to higher unemployment among the high-skilled, as shown in Eq. (22). The latter effect dominates the wage-increasing effect that is dictated by the dynamic fair wage constraint and underlies the dynamic adjustment path of the skill premium depicted in Fig. 6. The medium-run effects of the shock disappear as workers update their perceptions of fairness reflecting the true state of the components of their respective fair wages, thus equilibrium unemployment rates and the skill premium return gradually to steady-state.

A skill-biased productivity shock

Fig. 7 illustrates the dynamic convergence paths of equilibrium unemployment and the relative wage after a shock at date $t = 0$ when the parameter α increases from the baseline value $\alpha = 0.7$ to the value $\alpha = 0.702$ ³⁹.

39: Note that the solution of the model becomes more sensitive to the parameter α .

Figure 7
Inequity aversion and labour market equilibrium after a skill-biased productivity shock



Source: Authors' own calculations

Proposition 8 next outlines the stylized facts that are easily obtained from the figure.

Proposition 8

A skill-biased productivity shock causes an instantaneous decrease in the equilibrium rates of unemployment of high-skilled and low-skilled labour. Subsequently, the equilibrium rate of unemployment of high-skilled (respectively, low-skilled) labour converges monotonically from below to the new, lower (respectively, higher) steady-state equilibrium value. The skill premium converges monotonically from below to a higher steady-state equilibrium value.

The skill-biased productivity shock reduces the unemployment rate of type 1 labour, as the demand for the now more efficient high-skilled workers shifts upwards. In the aftermath of the shock, the aggregate wage of type 1 labor is below its new warranted level, as a result, the marginal product of type 1 labor is above the marginal cost causing a significant reduction in type 1 unemployment at $t = 0$. Due to labour complementarities in production, the latter effect encourages the demand for type 2 workers - as much as to temporarily dominate the permanent reduction in the demand for the now less efficient low-skilled labor - which prompts the reduction in unemployment of type 2 depicted in Fig. 7. As the fair wages of type 1 labour adapt to new reference standards, type 1 unemployment increases towards a lower steady-state value while type 2 unemployment increases towards a higher steady-state value. The skill premium increases permanently reflecting the increase in the relative efficiency of high-skilled workers.

6. Conclusions

Theories of psychology, theories of the formation and evolution of norms, and a good deal of empirical evidence suggest that the reference transactions against which workers judge fairness exhibit inertia. This paper shows that a fair-wage model with inertia in fairness perceptions can explain a number of stylized facts that remain elusive to most other classes of models. In particular, it provides a plausible explanation for the observed negative correlation between changes in productivity growth and equilibrium unemployment over the medium run, a well-documented stylized fact that partly underpins the rise in European and US unemployment during the seventies and the fall in US unemployment during the late nineties. In addition, the model shows that skill-biased productivity shocks have permanent effects on the equilibrium unemployment rate and the skill premium. In particular, a skill-biased productivity shock increases unemployment among the lowskilled while, if high-skilled workers are less inequity-averse, it reduces unemployment among the high-skilled. The model also shows that a shift towards equal pay may be successful in achieving more wage compression at the cost of a permanent increase in equilibrium unemployment among the low-skilled.

Acknowledgements

The authors are grateful to PKG Harischandra and seminar participants at the European Association of Labour Economists Conference, Tallinn, Estonia, September 2009 for helpful comments and suggestions.

References

- Agénor, P.R. and Aizenman, J.** (1997) Technological change, relative wages, and unemployment, *European Economic Review*, 41, 187-205.
- Akerlof, G.A. and Yellen, J.L.** (1988) Fairness and unemployment, *American Economic Review (Papers and Proceedings)*, 78, 44-9.
- Akerlof, G.A. and Yellen, J.L.** (1990) The fair wage-effort hypothesis and unemployment, *The Quarterly Journal of Economics*, 105, 255-83.
- Autor, D.H., Katz, L.F., and Kearney, M.S.** (2008) Trends in U.S. wage inequality: Revising the revisionists, *The Review of Economics and Statistics*, 90, 300-23.
- Ball, L. and Mankiw, G.** (2002) The NAIRU in theory and practice, *Journal of Economic Perspectives*, 16, 115-36.
- Ball, L. and Moffitt, R.** (2001) Productivity growth and the Phillips curve, in: Krueger, A. and Solow, R. (Eds.), *The Roaring Nineties: Can Full Employment Be Sustained?*, *The Russell Sage Foundation and the Century Foundation Press*, New York.
- Bewley, T.** (1998) Why not cut pay?, *European Economic Review*, 42, 459-90.
- Bewley, T.** (1999) *Why Wages Don't Fall During a Recession*, Cambridge, Mass: *Harvard University Press*.
- Blinder, A. and Choi, D.** (1990) A shred of evidence on theories of wage stickiness, *The Quarterly Journal of Economics*, 105, 1003-15.
- Bolton, G. E. and Ockenfels, A.** (2000) ERC: A Theory of Equity, Reciprocity, and Competition, *American Economic Review*, 90, 166-93.
- Bolton, L. E., Warlop, L., and Alba, J. W.** (2003) Consumer Perceptions and Price (Un)fairness, *Journal of Consumer Research*, 29, 474-91.
- Camerer, C.F.** (2003) *Behavioral Game Theory: Experiments on Strategic Interaction*, Princeton: *Princeton University Press*.
- Camerer, C.F.** (2005) Behavioral Economics, prepared for the World Congress of the Econometric Society 2005, mimeo, available at <http://www.hss.caltech.edu/~camerer/camerer.html>.
- Campbell, C. and Kamlani, K.** (1997) The reasons for wage rigidity: Evidence from a survey of firms, *The Quarterly Journal of Economics*, 112, 759-89.
- Caselli, F. and Coleman, W.J.** (2002) The U.S. technology frontier, *American Economic Review (Papers and Proceedings)*, 92, 148-52.
- Caselli, F. and Coleman, W.J.** (2006) The world technology frontier, *American Economic Review*, 96, 499-522.
- Charness, G. and Kuhn, P.** (2007) Does Pay Inequality Affect Worker Effort? Experimental Evidence, *Journal of Labor Economics*, 25, 693-723.
- Charness, G. and Rabin, M.** (2002) Understanding social preferences with simple tests, *The Quarterly Journal of Economics*, 117, 817-69.
- Danthine, J-P. and Kurmann, A.** (2007) The Macroeconomic Consequences of Reciprocity in Labor Relations, *Scandinavian Journal of Economics*, 109, 857-81.
- Egger, H. and Kreickemeier, U.** (2009a) Firm Heterogeneity and the Labor Market Effects of Trade Liberalization, *International Economic Review*, 50, 187-216.
- Egger, H. and Kreickemeier, U.** (2009b) Redistributing Gains from Globalisation, *Scandinavian Journal of Economics*, 111, 765-88.
- Falk, A., Fehr, E., and Zehnder, C.** (2006) Fairness Perceptions and Reservation Wages-The Behavioral Effects of Minimum Wage Laws, *The Quarterly Journal of Economics*, 121, 1347-81.
- Fehr, E., Goette, L., and Zehnder, C.** (2009) A Behavioral Account of the Labor Market: The Role of Fairness Concerns, *Annual Review of Economics*, 1, 355-84.

- Fehr, E., Kirchsteiger, G., and Riedl, A.** (1993) Does fairness prevent market clearing? An experimental investigation, *The Quarterly Journal of Economics*, 108, 437-59.
- Fehr, E. and Schmidt, K. M.** (1999) A Theory of Fairness, Competition, and Cooperation, *The Quarterly Journal of Economics*, 114, 817-68.
- Grubb, D., Jackman, R., and Layard, R.** (1982) Causes of the current stagflation, *Review of Economic Studies*, 49, 707-30.
- Hatton, T.J.** (2007) Can productivity growth explain the NAIRU? Long-run evidence from Britain, 1871-1999, *Economica*, 74, 475-91.
- Hicks, J. R.** (1975) *The Crisis in Keynesian Economics*, Oxford: Blackwell.
- Hornstein, A., Krusell, P., and Violante, G.** (2005) The effects of technical change on labor market inequalities, in: Aghion, P. and Durlauf, S. (Eds.), *The Handbook of Economic Growth*, Amsterdam: Elsevier.
- Kahneman, D., Knetsch, J., and Thaler, R.** (1986) Fairness as a constraint on profit seeking: Entitlements in the market, *American Economic Review*, 76, 728-41.
- Katz, L.F. and Autor, D.H.** (1999) Changes in the wage structure and earnings inequality, in: Ashenfelter, O., Card, D. (Eds.), *Handbook of Labor Economics* 3, Amsterdam: North Holland.
- Koszegi, B. and Rabin, M.** (2006) A Model of Reference-Dependent Preferences, *The Quarterly Journal of Economics*, 121, 1133-65.
- Krusell, P., Ohanian, L.E., Ríos-Rull, J.V., and Violante, G.L.** (2000) Capital-skill complementarity and inequality: A macroeconomic analysis, *Econometrica*, 68, 1029-53.
- Lee, D. and Rupp, N.G.** (2007) Retracting a Gift: How Does Employee Effort Respond to Wage Reductions?, *Journal of Labor Economics*, 25, 725-61.
- Lindbeck, A. and Snower, D.** (2001) Insiders versus Outsiders, *Journal of Economic Perspectives*, 15, 165-188.
- Lynch, L. and Nickell, S.** (2001) Rising productivity and falling unemployment: Can the US experience be sustained and replicated?, in: Krueger, A. and Solow, R., (Eds.), *The Roaring Nineties: Can Full Employment Be Sustained?*, The Russell Sage Foundation and the Century Foundation Press, New York.
- Mankiw, N.G. and Reis, R.** (2002) Sticky information versus sticky prices: A proposal to replace the New Keynesian Phillips curve, *The Quarterly Journal of Economics*, 117, 1295-1328.
- Mankiw, N.G. and Reis, R.** (2003) Sticky information: A model of monetary non-neutrality and structural slumps, in: Aghion, P., Frydman, R., Stiglitz J., and Woodford, M. (Eds.), *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps*, Princeton: Princeton University Press.
- Mankiw, N.G. and Reis, R.** (2007) Sticky information in general equilibrium, *Journal of the European Economic Association*, 5, 603-13.
- Menzies, G.D. and Zizzo, D. J.** (2005) Inferential Expectations, Australian National University Centre for Applied Macroeconomic Analysis Discussion Paper No. 12.
- Menzies, G.D. and Zizzo, D. J.** (2009) Inferential Expectations, *The B.E. Journal of Macroeconomics (Advances)*, 9, Article 42.
- Schlicht, E.** (1998) *On Custom in the Economy*, Oxford, UK: Clarendon Press.
- Shapiro, C. and Stiglitz, J. E.** (1984) Equilibrium Unemployment as a Worker Discipline Device, *American Economic Review*, 74, 433-444.
- Solow, R.** (1990) *The Labour Market as a Social Institution*, Cambridge, Mass: Blackwell.
- Staiger, D., Stock, J., and Watson, M.** (2001) Prices, wages, and the US NAIRU in the 1990s, in: Krueger, A. and Solow, R. (Eds.), *The Roaring Nineties: Can Full Employment Be Sustained?*, The Russell Sage Foundation and the Century Foundation Press, New York.

Appendix 1

Proof of Propositions 1 and 2

The partial derivative of equilibrium unemployment in Eq. (12) with respect to α is given by:

$$\frac{\partial u_{2t}}{\partial \alpha} = \frac{\beta}{\beta + \alpha(1 - \beta)} \left(\frac{1}{\alpha(1 - \alpha)} \right) - \frac{\beta(1 - \beta)}{(\beta + \alpha(1 - \beta))^2} \left(\ln \alpha - \ln(1 - \alpha) + \ln \frac{\bar{L}_{2t}}{L_{1t}} \right)$$

which is positive under the parameter assumptions of the model. In particular, the shock is a proskilled, anti-unskilled technology shift such that the marginal product of type 1 labour increases in , the marginal product of type 2 labour decreases in , and the fair wage constraint shifts upwards in the employment-wage space.

Similarly, the partial derivative of equilibrium unemployment with respect to parameter β is given by:

$$\frac{\partial u_{2t}}{\partial \beta} = \frac{\alpha}{(\beta + \alpha(1 - \beta))^2} \left(\ln \alpha - \ln(1 - \alpha) + \ln \frac{\bar{L}_{2t}}{L_{1t}} \right)$$

which is positive under the parameter assumptions of the model. In particular, the shock shifts the fair wage constraint upwards in the employment-wage space. Finally, the positive relationship between equilibrium unemployment and the relative supply of low-skilled labour is easily inferred from Eq. (12).

The partial derivative of the skill premium in Eq. (13) with respect to parameter α is given by:

$$\frac{\partial \ln \frac{\omega_{1t}}{\omega_{2t}}}{\partial \alpha} = \frac{(1 - \beta)}{(\beta + \alpha(1 - \beta))^2} \left(\beta \left(\ln \alpha - \ln(1 - \alpha) + \ln \frac{\bar{L}_{2t}}{L_{1t}} \right) + \alpha(\beta + \alpha(1 - \beta)) \left(\frac{1}{\alpha} + \frac{1}{1 - \alpha} \right) \right)$$

which is positive under the parameter assumptions of the model.

Similarly, the partial derivative of the skill premium in Eq. (13) with respect to parameter β is given by:

$$\frac{\partial \ln \frac{\omega_{1t}}{\omega_{2t}}}{\partial \beta} = - \frac{\alpha}{(\beta + \alpha(1 - \beta))^2} \left(\ln \alpha - \ln(1 - \alpha) + \ln \frac{\bar{L}_{2t}}{L_{1t}} \right)$$

which is negative under the parameter assumptions of the model. The positive relationship between the skill premium and the relative supply of low-skilled labour is easy to infer from Eq. (12).

List of equilibrium outcomes

The expressions for the wage of type 1 labour and the wage of type 2 labour in equilibrium are given by:

$$\ln \omega_{1t} = \frac{1}{\beta + \alpha(1 - \beta)} \left(\alpha \ln \alpha + \beta(1 - \alpha) \ln(1 - \alpha) + \alpha(1 - \beta)(1 - \alpha) \ln \frac{\bar{L}_{2t}}{L_{1t}} \right) + \alpha \ln A_{1t} + (1 - \alpha) \ln A_{2t}$$

$$\ln \omega_{2t} = \frac{1}{\beta + \alpha(1 - \beta)} \left(\beta \alpha \ln \alpha + (\beta(1 - \alpha) + \alpha(1 - \beta)) \ln(1 - \alpha) - \alpha^2(1 - \beta) \ln \frac{\bar{L}_{2t}}{L_{1t}} \right) + \alpha \ln A_{1t} + (1 - \alpha) \ln A_{2t}$$

Note that wage growth depends upon the parameters $\{\alpha, \beta\}$, skill-neutral productivity growth, and relative labour supply growth.

Appendix 2

Description of shocks

An aggregate productivity slowdown: Consider an initial steady-state situation in which productivity was growing quarterly at a rate of 0.75 percent. At date $t = 0$, an unexpected and permanent negative productivity shock reduces the quarterly growth rate of productivity to 0 percent. In order to introduce the shock in the model, we set $\ln A_{1t} = 3.3275 + 0.0075t$ and $\ln A_{2t} = 2.8075 + 0.0075t$ for $t \leq -1$, and $\ln A_{1t} = 3.32$ and $\ln A_{2t} = 2.80$ for $t \geq 0$. The rest of the exogenous variables and parameters of the model take their respective baseline values. Thus, the dynamic path of equilibrium unemployment is given by:

$$u_{2t} = \frac{0.029 + 0.805^t(0.005 + 0.006t)}{0.73 - 0.024(0.805)^t} \text{ where } t \geq 0$$

and the dynamic response of the relative wage follows immediately from the solution of the model.

A skill-biased productivity shock: Consider an initial steady-state situation in which productivity was experiencing zero growth, i.e. the coefficients $\{A_{1t}, A_{2t}\}$ were constant at their respective baseline values. In period $t = 0$, an unexpected, one-off, permanent increase in the parameter α raises the level of aggregate efficiency or productivity, defined as $\ln A_t = \alpha \ln A_{1t} + (1 - \alpha) \ln A_{2t}$, by increasing (respectively, reducing) the contribution of high-skilled (low-skilled) labour. In particular, suppose that parameter α increases from a value of $\alpha = 0.7$ to a value of $\alpha = 0.72$ in period $t = 0$.

The rest of the exogenous variables and parameters of the model take their respective baseline values. The convergence path of equilibrium unemployment to its new steady-state value is given by:

$$u_{2t} = -1.309 + \frac{1}{0.734 - 0.022(0.805)^t} \text{ where } t \geq 0$$

and the convergence path of the relative wage follows immediately from the solution of the model.

A fairness shock: Consider an initial steady-state situation in which the exogenous variables and parameters of the model were taking their respective baseline values. In period $t = 0$, an unexpected, one-off, permanent shock to the fairness parameter β raises its value from $\beta = 0.1$ to $\beta = 0.2$. The rest of the exogenous variables and parameters of the model are unaffected by the shock and stay constant at their respective baseline values. The convergence path of equilibrium unemployment to its new steady-state equilibrium is:

$$u_{2t} = 0.516 + \frac{1}{-2.282 + 0.145(0.805)^t} \text{ where } t \geq 0$$

and the convergence path of the relative wage follows immediately from the solution of the model.

A labour supply shock: Consider an initial steady-state situation in which the supply of labour, both high-skilled and low-skilled, was growing quarterly at a rate of 0.25 percent, or 1 percent annualised growth. That is, in the initial steady-state situation, the relative supply of low-skilled workers was constant. At date $t = 0$, a permanent labour supply shock increases the quarterly growth rate of the supply of low-skilled workers to 0.3 percent while the supply of high-skilled workers grows still at 0.25 percent. In order to introduce the shock, we set $\ln(L_{2t}/L_{1t}) = -0.55$ for $t \leq -1$ and $\ln(L_{2t}/L_{1t}) = -0.55 + 0.0005t$ for $t \geq 0$. The rest of the exogenous variables and parameters of the model take their respective baseline values throughout. The dynamic path of equilibrium unemployment is given by:

$$u_{2t} = 0.03 + \frac{-0.304 - 0.304t}{-30.227 + (0.805)^t} - 0.01t \text{ where } t \geq 0$$

and the dynamic response of the relative wage follows immediately from the solution of the model.

Working Papers

09/01 **K.C. Fung, Alicia García-Herrero and Alan Siu:** Production Sharing in Latin America and East Asia.

09/02 **Alicia García-Herrero, Jacob Gyntelberg and Andrea Tesei:** The Asian crisis: what did local stock markets expect?

09/03 **Alicia García-Herrero and Santiago Fernández de Lis:** The Spanish Approach: Dynamic Provisioning and other Tools.

09/04 **Tatiana Alonso:** Potencial futuro de la oferta mundial de petróleo: un análisis de las principales fuentes de incertidumbre.

09/05 **Tatiana Alonso:** Main sources of uncertainty in formulating potential growth scenarios for oil supply.

09/06 **Ángel de la Fuente y Rafael Doménech:** Convergencia real y envejecimiento: retos y propuestas.

09/07 **KC FUNG, Alicia García-Herrero and Alan Siu:** Developing Countries and the World Trade Organization: A Foreign Influence Approach.

09/08 **Alicia García-Herrero, Philip Woolbridge and Doo Yong Yang:** Why don't Asians invest in Asia? The determinants of cross-border portfolio holdings.

09/09 **Alicia García-Herrero, Sergio Gavilá and Daniel Santabárbara:** What explains the low profitability of Chinese Banks?

09/10 **J.E. Boscá, R. Doménech and J. Ferri:** Tax Reforms and Labour-market Performance: An Evaluation for Spain using REMS.

09/11 **R. Doménech and Angel Melguizo:** Projecting Pension Expenditures in Spain: On Uncertainty, Communication and Transparency.

09/12 **J.E. Boscá, R. Doménech and J. Ferri:** Search, Nash Bargaining and Rule of Thumb Consumers.

09/13 **Angel Melguizo, Angel Muñoz, David Tuesta y Joaquín Vial:** Reforma de las pensiones y política fiscal: algunas lecciones de Chile.

09/14 **Máximo Camacho: MICA-BBVA:** A factor model of economic and financial indicators for short-term GDP forecasting.

09/15 **Angel Melguizo, Angel Muñoz, David Tuesta and Joaquín Vial:** Pension reform and fiscal policy: some lessons from Chile.

09/16 **Alicia García-Herrero and Tuuli Koivu:** China's Exchange Rate Policy and Asian Trade.

09/17 **Alicia García-Herrero, K.C. Fung and Francis Ng:** Foreign Direct Investment in Cross-Border Infrastructure Projects.

09/18 **Alicia García Herrero y Daniel Santabárbara García:** Una valoración de la reforma del sistema bancario de China.

09/19 **C. Fung, Alicia García-Herrero and Alan Siu:** A Comparative Empirical Examination of Outward Direct Investment from Four Asian Economies: China, Japan, Republic of Korea and Taiwan.

09/20 **Javier Alonso, Jasmina Bjeletic, Carlos Herrera, Soledad Hormazábal, Ivonne Ordóñez, Carolina Romero y David Tuesta:** Un balance de la inversión de los fondos de pensiones en infraestructura: la experiencia en Latinoamérica.

09/21 **Javier Alonso, Jasmina Bjeletic, Carlos Herrera, Soledad Hormazábal, Ivonne Ordóñez, Carolina Romero y David Tuesta:** Proyecciones del impacto de los fondos de pensiones en la inversión en infraestructura y el crecimiento en Latinoamérica.

10/01 **Carlos Herrera:** Rentabilidad de largo plazo y tasas de reemplazo en el Sistema de Pensiones de México.

- 10/02 **Javier Alonso, Jasmina Bjeletic, Carlos Herrera, Soledad Hormazabal, Ivonne Ordóñez, Carolina Romero, David Tuesta and Alfonso Ugarte:** Projections of the Impact of Pension Funds on Investment in Infrastructure and Growth in Latin America.
- 10/03 **Javier Alonso, Jasmina Bjeletic, Carlos Herrera, Soledad Hormazabal, Ivonne Ordóñez, Carolina Romero, David Tuesta and Alfonso Ugarte:** A balance of Pension Fund Infrastructure Investments: The Experience in Latin America.
- 10/04 **Mónica Correa-López y Ana Cristina Mingorance-Arnáiz:** Demografía, Mercado de Trabajo y Tecnología: el Patrón de Crecimiento de Cataluña, 1978-2018.
- 10/05 **Soledad Hormazabal D.:** Gobierno Corporativo y Administradoras de Fondos de Pensiones (AFP). El caso chileno.
- 10/06 **Soledad Hormazabal D.:** Corporate Governance and Pension Fund Administrators: The Chilean Case.
- 10/07 **Rafael Doménech y Juan Ramón García:** ¿Cómo Conseguir que Crezcan la Productividad y el Empleo, y Disminuya el Desequilibrio Exterior?
- 10/08 **Markus Brückner and Antonio Ciccone:** International Commodity Prices, Growth, and the Outbreak of Civil War in Sub-Saharan Africa.
- 10/09 **Antonio Ciccone and Marek Jarocinski:** Determinants of Economic Growth: Will Data Tell?
- 10/10 **Antonio Ciccone and Markus Brückner:** Rain and the Democratic Window of Opportunity.
- 10/11 **Eduardo Fuentes:** Incentivando la cotización voluntaria de los trabajadores independientes a los fondos de pensiones: una aproximación a partir del caso de Chile.
- 10/12 **Eduardo Fuentes:** Creating incentives for voluntary contributions to pension funds by independent workers: A primer based on the case of Chile.
- 10/13 **J. Andrés, J.E. Boscá, R. Doménech and J. Ferri:** Job Creation in Spain: Productivity Growth, Labour Market Reforms or both.
- 10/14 **Alicia García-Herrero:** Dynamic Provisioning: Some lessons from existing experiences.
- 10/15 **Arnoldo López Marmolejo and Fabrizio López-Gallo Dey:** Public and Private Liquidity Providers.
- 10/16 **Soledad Zignago:** Determinantes del comercio internacional en tiempos de crisis.
- 10/17 **Angel de la Fuente and José Emilio Boscá:** EU cohesion aid to Spain: a data set Part I: 2000-06 planning period.
- 10/18 **Angel de la Fuente:** Infrastructures and productivity: an updated survey.
- 10/19 **Jasmina Bjeletic, Carlos Herrera, David Tuesta y Javier Alonso:** Simulaciones de rentabilidades en la industria de pensiones privadas en el Perú.
- 10/20 **Jasmina Bjeletic, Carlos Herrera, David Tuesta and Javier Alonso:** Return Simulations in the Private Pensions Industry in Peru.
- 10/21 **Máximo Camacho and Rafael Doménech:** MICA-BBVA: A Factor Model of Economic and Financial Indicators for Short-term GDP Forecasting.
- 10/22 **Enestor Dos Santos and Soledad Zignago:** The impact of the emergence of China on Brazilian international trade.
- 10/23 **Javier Alonso, Jasmina Bjeletic y David Tuesta:** Elementos que justifican una comisión por saldo administrado en la industria de pensiones privadas en el Perú.
- 10/24 **Javier Alonso, Jasmina Bjeletic y David Tuesta:** Reasons to justify fees on assets in the Peruvian private pension sector.
- 10/25 **Mónica Correa-López, Agustín García Serrador and Cristina Mingorance-Arnáiz:** Product Market Competition and Inflation Dynamics: Evidence from a Panel of OECD Countries.

- 10/26 **Carlos A. Herrera:** Long-term returns and replacement rates in Mexico's pension system.
- 10/27 **Soledad Hormazábal:** Multifondos en el Sistema de Pensiones en Chile.
- 10/28 **Soledad Hormazábal:** Multi-funds in the Chilean Pension System.
- 10/29 **Javier Alonso, Carlos Herrera, María Claudia Llanes y David Tuesta:** Simulations of long-term returns and replacement rates in the Colombian pension system.
- 10/30 **Javier Alonso, Carlos Herrera, María Claudia Llanes y David Tuesta:** Simulaciones de rentabilidades de largo plazo y tasas de reemplazo en el sistema de pensiones de Colombia.
- 11/01 **Alicia García Herrero:** Hong Kong as international banking center: present and future.
- 11/02 **Arnoldo López-Marmolejo:** Effects of a Free Trade Agreement on the Exchange Rate Pass-Through to Import Prices.
- 11/03 **Angel de la Fuente:** Human capital and productivity
- 11/04 **Adolfo Albo y Juan Luis Ordaz Díaz:** Los determinantes de la migración y factores de la expulsión de la migración mexicana hacia el exterior, evidencia municipal.
- 11/05 **Adolfo Albo y Juan Luis Ordaz Díaz:** La Migración Mexicana hacia los Estados Unidos: Una breve radiografía.
- 11/06 **Adolfo Albo y Juan Luis Ordaz Díaz:** El Impacto de las Redes Sociales en los Ingresos de los Mexicanos en EEUU.
- 11/07 **María Abascal, Luis Carranza, Mayte Ledo y Arnoldo López Marmolejo:** Impacto de la Regulación Financiera sobre Países Emergentes.
- 11/08 **María Abascal, Luis Carranza, Mayte Ledo and Arnoldo López Marmolejo:** Impact of Financial Regulation on Emerging Countries.
- 11/09 **Angel de la Fuente y Rafael Doménech:** El impacto sobre el gasto de la reforma de las pensiones: una primera estimación.
- 11/10 **Juan Yermo:** El papel ineludible de las pensiones privadas en los sistemas de ingresos de jubilación.
- 11/11 **Juan Yermo:** The unavoidable role of private pensions in retirement income systems.
- 11/12 **Angel de la Fuente and Rafael Doménech:** The impact of Spanish pension reform on expenditure: A quick estimate.
- 11/13 **Jaime Martínez-Martín:** General Equilibrium Long-Run Determinants for Spanish FDI: A Spatial Panel Data Approach.
- 11/14 **David Tuesta:** Una revisión de los sistemas de pensiones en Latinoamérica.
- 11/15 **David Tuesta:** A review of the pension systems in Latin America.
- 11/16 **Adolfo Albo y Juan Luis Ordaz Díaz:** La Migración en Arizona y los efectos de la Nueva Ley "SB-1070".
- 11/17 **Adolfo Albo y Juan Luis Ordaz Díaz:** Los efectos económicos de la Migración en el país de destino. Los beneficios de la migración mexicana para Estados Unidos.
- 11/18 **Angel de la Fuente:** A simple model of aggregate pension expenditure.
- 11/19 **Angel de la Fuente y José E. Boscá:** Gasto educativo por regiones y niveles en 2005.
- 11/20 **Máximo Camacho and Agustín García Serrador:** The Euro-Sting revisited: PMI versus ESI to obtain euro area GDP forecasts.
- 11/21 **Eduardo Fuentes Corripio:** Longevity Risk in Latin America.
- 11/22 **Eduardo Fuentes Corripio:** El riesgo de longevidad en Latinoamérica.
- 11/23 **Javier Alonso, Rafael Doménech y David Tuesta:** Sistemas Públicos de Pensiones y la Crisis Fiscal en la Zona Euro. Enseñanzas para América Latina.

- 11/24 **Javier Alonso, Rafael Doménech y David Tuesta:** Public Pension Systems and the Fiscal Crisis in the Euro Zone. Lessons for Latin America.
- 11/25 **Adolfo Albo y Juan Luis Ordaz Díaz:** Migración mexicana altamente calificada en EEUU y Transferencia de México a Estados Unidos a través del gasto en la educación de los migrantes.
- 11/26 **Adolfo Albo y Juan Luis Ordaz Díaz:** Highly qualified Mexican immigrants in the U.S. and transfer of resources to the U.S. through the education costs of Mexican migrants.
- 11/27 **Adolfo Albo y Juan Luis Ordaz Díaz:** Migración y Cambio Climático. El caso mexicano.
- 11/28 **Adolfo Albo y Juan Luis Ordaz Díaz:** Migration and Climate Change: The Mexican Case.
- 11/29 **Ángel de la Fuente y María Gundín:** Indicadores de desempeño educativo regional: metodología y resultados para los cursos 2005-06 a 2007-08.
- 11/30 **Juan Ramón García:** Desempleo juvenil en España: causas y soluciones.
- 11/31 **Juan Ramón García:** Youth unemployment in Spain: causes and solutions.
- 11/32 **Mónica Correa-López and Beatriz de Blas:** International transmission of medium-term technology cycles: Evidence from Spain as a recipient country.
- 11/33 **Javier Alonso, Miguel Angel Caballero, Li Hui, María Claudia Llanes, David Tuesta, Yuwei Hu and Yun Cao:** Potential outcomes of private pension developments in China.
- 11/34 **Javier Alonso, Miguel Angel Caballero, Li Hui, María Claudia Llanes, David Tuesta, Yuwei Hu and Yun Cao:** Posibles consecuencias de la evolución de las pensiones privadas en China.
- 11/35 **Enestor Dos Santos:** Brazil on the global finance map: an analysis of the development of the Brazilian capital market
- 11/36 **Enestor Dos Santos, Diego Torres y David Tuesta:** Una revisión de los avances en la inversión en infraestructura en Latinoamérica y el papel de los fondos de pensiones privados.
- 11/37 **Enestor Dos Santos, Diego Torres and David Tuesta:** A review of recent infrastructure investment in Latin America and the role of private pension funds.
- 11/38 **Zhigang Li and Minqin Wu:** Estimating the Incidences of the Recent Pension Reform in China: Evidence from 100,000 Manufacturers.
- 12/01 **Marcos Dal Bianco, Máximo Camacho and Gabriel Pérez-Quiros:** Short-run forecasting of the euro-dollar exchange rate with economic fundamentals.
- 12/02 **Guoying Deng, Zhigang Li and Guangliang Ye:** Mortgage Rate and the Choice of Mortgage Length: Quasi-experimental Evidence from Chinese Transaction-level Data.
- 12/03 **George Chouliarakis and Mónica Correa-López:** A Fair Wage Model of Unemployment with Inertia in Fairness Perceptions.

The analysis, opinions, and conclusions included in this document are the property of the author of the report and are not necessarily property of the BBVA Group.

BBVA Research's publications can be viewed on the following website: <http://www.bbvarresearch.com>

Contact details

BBVA Research
Paseo Castellana, 81 - 7th floor
28046 Madrid (Spain)
Tel: +34 91 374 60 00 and +34 91 537 70 00
Fax: +34 91 374 30 25
bbvarresearch@bbva.com
www.bbvarresearch.com