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Job duration and inequality

Siyan Chen and Saul Desiderio

Abstract

As suggested by recent empirical evidence, one of the causes behind the widespread rise of inequality experienced by OECD countries in the last few decades may have been the increased flexibility of labor markets. The authors explore this hypothesis through the analysis of a stock-flow consistent agent-based macroeconomic model able to reproduce with good statistical precision several empirical regularities. To this scope they employ three different sensitivity analysis techniques, which indicate that increasing job contract duration (i.e. decreasing flexibility) has the effect of reducing income and wealth inequality. However, the authors also find that this effect is diminished by tight monetary policy and low credit supply. This result suggests that the final outcome of structural reforms aimed at changing labor flexibility can depend on the macroeconomic environment in which these are implemented.

Authors
Siyan Chen, Shantou University, China
Saul Desiderio, Shantou University, China, saul@stu.edu.cn

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1 Introduction

The widespread rise of income and wealth inequality is certainly one of the most conspicuous economic phenomena of the last few decades. As convincingly suggested by Piketty (2014), this tendency could even be an intrinsic feature of capitalist economies due to the continuous process of capital accumulation and reinvestment. To same conclusions seems to lead Scheidel (2017), who points out that historic periods of substantial reduction in inequality have always been caused by such catastrophic events as wars, revolutions, state collapses and plagues. Besides the intrinsic mechanisms of the capitalist economic system, however, also more accidental causes may well have played an important role in increasing inequalities in recent periods. Among them are certainly skill-biased technological progress and globalization, which have conspired to reduce the income share represented by wages, especially those of low-skilled workers (Atkinson, 2015, ch. 3; Autor *et al.*, 2008). In addition, crisis of Welfare State and fiscal policies generally more oriented to less progressive tax regimes have also contributed to the general surge in inequality (OECD, 2011; Forster and Toth, 2015).

Less attention has been drawn by labor market reforms, which indeed have been much debated but not because of their potential negative impact on inequality, at least until recently. This kind of reforms is in general aimed at removing frictions and rigidities impeding the smooth functioning of demand and supply of labor and therefore the achievement of full employment. In particular, an important goal pursued by labor market reforms in OECD Countries has been that of increasing the degree of flexibility of employment relationships between employer and employee (OECD, 1994).

Essentially, we can distinguish two types of flexibility: internal and external (Atkinson, 1985). The former indicates adjusting working times and *intra*-firm workforce reallocation, whereas the latter refers basically to temporary (fixed-duration) job contracts and *inter*-firm workforce reallocation.

External flexibility enabled by temporary jobs is pursued because it decreases firing costs. As a consequence, from a microeconomic standpoint it may help worker reallocation among firms, with positive effects on productivity; and from a macroeconomic perspective it may increase the willingness to hire by firms, thus reducing unemployment. The idea that temporary jobs can reduce unemployment consolidated during the 90's of the XX century, when the highly deregulated American job market used to record unemployment rates substantially lower than those produced by the much more regulated (i.e. "rigid") European counterparts. Besides obvious political and theoretical reasons based on the neoclassical analysis of the labor market, this view was also supported by a number of empirical studies (such as for instance Lazear, 1990; OECD, 1994; Scarpetta, 1996; Siebert,

1997), which systematically found positive correlations between unemployment and measures of labor market rigidity.

As temporary job contracts are supposed to foster growth and reduce unemployment, they can therefore also be thought to be conducive to lower inequality. However, more recent empirical studies have cast doubts on the reliability of earlier works, and the evidence about labor market rigidities and unemployment (and, as a consequence, about rigidities and inequality) is now at best equivocal. Indeed, several recent studies suggest that more rigid labor regulations may actually decrease inequality (for a review of recent works see e.g. Brancaccio *et al.*, 2018).

The presence of such contrasting evidence hints that the truth might simply lie in the middle. In other words, both very flexible and very rigid labor markets might hamper growth and increase inequality. A second possible reason is that the impact of labor flexibility on the economy could be influenced by other factors. If such an interaction exists, therefore, labor market reforms may have very different effects according to the particular economic environment in which they are implemented. Thus, the aim of this paper is to investigate the plausibility of such hypotheses, with a focus on the effects of temporary job contracts on personal income and wealth inequality.

Our investigation will be carried out through an extensive analysis of a stock-flow consistent agent-based macro model already presented in Chen and Desiderio (2018). Stock-flow consistency, which has witnessed increasing application in agent-based literature in recent years (e.g. Cincotti et al., 2010; Delli Gatti and Desiderio, 2015; Riccetti et al., 2015; Caiani et al., 2016; Dosi *et al.*, 2017), basically consists in the implementation of precise accounting rules, and is of particular importance to our scope as it provides a correct link between income and wealth.

The analysis of inequality in the context of agent-based macroeconomics has gained momentum in recent years. For instance, Desiderio and Chen (2016), Riccetti *et al.* (2016) and Russo *et al.* (2016) study how functional and personal income distributions are affected by financial factors, while Dosi *et al.* (2013), Dosi *et al.* (2015) and Chen and Desiderio (2018) analyze the interaction between inequality and monetary policy. A work that gets closer to the present paper is Dosi *et al.* (2017), where the authors find a negative correlation between labor market rigidity and inequality, probably caused by the positive effect that longer job contracts exert on employment through an increased macroeconomic coordination. This result was also found in Desiderio *et al.* (2015), where short contract duration generally increases the likelihood of having coordination failures and, thus, unemployment. Results of this kind were partly found also in mainstream labor search-and-matching literature, which however has the limitation of taking a microeconomic perspective and thus of ignoring the interconnections among different markets (e.g. Cahuc and Postel-Vinay, 2002).

In the model that we use here, firms, households and one bank interact on the markets for labor, credit and a consumption good. Households have two income sources: labor income (wages) and capital income (interests). The former comes from temporary jobs and the latter is the result of the investment of households' accumulated savings in financial assets sold by the bank. Temporary jobs will be the major concern of our analysis, as changes in the job contract length (that is the external flexibility of the labor market) will affect unemployment and worker reallocation among firms. Both unemployment and reallocation are important drivers of income inequality. Whereas the role of the former is pretty obvious, the way the latter works is less straightforward. When in fact job contracts are shorter, in our model firms have to increase wages more often in order to hoard labor. As a consequence, competition among firms on the labor market increases and high-wage employers will be more successful than others. This will contribute to rise both average wage and wage dispersion.

The rest of the paper is organized as follows. In Section 2 we present the model along with its basic properties. In spite of its relative simplicity, we will show that our model is able to match a good deal of empirical evidence, performing particularly well in replicating business cycle stylized facts. In Section 3 we will study the relationship between job contract duration and inequality using three techniques: a local sensitivity analysis (LSA), a global sensitivity analysis (GSA) and a third kind involving only two parameters at time that we take the liberty to label 'pairwise' sensitivity analysis (PSA). The latter two will be carried out employing the approach proposed by Chen and Desiderio (2018), which economizes on the computational effort necessary to perform sensitivity analysis. In general, we will see that the three techniques point at a decreasing relationship between contract duration and inequality, although non-linearities cannot be ruled out. Moreover, PSA reveals that contract duration interacts with other parameters as formerly guessed, in particular with the policy rate and the bank lending attitude. Basically, what we find is that, *ceteris paribus*, a tighter monetary policy and a lower credit supply reduce the ability of longer job contracts to curb inequality. The last finding suggests that the final effect of institutional reforms may depend also on the macroeconomic context and warns against piecemeal policy making. Although this is a mere computational result, it is also an empirically testable prediction that deserves to be further investigated. Finally, Section 4 concludes.

2 The model and its properties

The model is the abstraction of a closed economy populated by firms, households and one commercial bank, while Government and central bank are not explicitly modeled. There are three markets: for labor, consumption goods and bank loans,

	Households	Firms	Bank	Total
Deposits	D_h	D_f	$-(D_h+D_f)$	0
Reserves			H	H
Loans		$-L$	L	0
Total	E_h	E_f	E_b	H

Table 1: Balance sheets

plus an implicit market for bank deposits. Agents enter markets according to a decentralized search-and-matching process, and their behavior follows simple adaptive rules based on small amount of private information. Households represent the supply side in the labor market and the demand side in the goods market. Firms are on the demand side in the labor and credit market and on the supply side in the goods market. Both households and firms hold deposits at the bank. On its turn, the bank receives deposits and extend loans to firms. In what follows we will first describe the agents and then the markets. Finally, we will present some simulation results.

2.1 The agents

In this section we are going to give a general description of the agents' characteristics and of the sequence of actions they take every period.

Agents' state variables can be represented at any point in time by their balance sheets (stocks), which reflect all the market transactions undertaken (flows). The relationship between stocks and flows is regulated by rules that follow coherent accounting principles. This stock-flow consistency is implemented as it increases the degree of realism and reliability of the model. In particular, it is very important for our analysis because it assures that income and wealth inequality are not affected by an incorrect updating of individual variables. Aggregate balance sheets are reported in Table 1. Items with positive sign are assets, whereas those with negative sign are liabilities.

Households and firms' deposits (liquid assets) are denoted by D_h and D_f respectively, whereas L represents bank loans and H is the monetary base (M_0). The difference between assets and liabilities constitutes the net worth (equity), which is denoted by E_h, E_f and E_b for households, firms and bank respectively. In the aggregate assets and liabilities must sum to zero, thus the accounting identity

$$E_h + E_f + E_b = H \tag{1}$$

holds. We suppose that there is no currency, and that transactions are settled directly by bank deposits. For the sake of simplicity we can therefore set $H = 0$.

	Households	Firms	Bank	Total
Goods	$-C$	$Y = C + I$		I
Wages	wN	$-wN$		0
New loans		ΔL	$-\Delta L$	0
Loan interests		$-iL$	iL	0
Deposit interests	rD_h		$-rD_h$	0
New deposits	$-\Delta D_h$	$-\Delta D_f$	ΔD	0
Savings	S_h	S_f	S_b	I

Table 2: Flow of funds

The evolution of the balance sheets is due to market transactions. The corresponding flows are reported in Table 2, where items representing outflows are identified by the minus sign: C is consumption spending, wN is the wage bill, Y is total production, I is the change in inventories, i is the loan interest rate and r is the return on bank deposits. As the economy is closed, savings must be equal to investments, that is

$$S = S_h + S_f + S_b = I, \tag{2}$$

where $S_h = \Delta E_h$; $S_f = \Delta E_f$; $S_b = \Delta E_b$. However, we assume that firms do not retain unsold goods ($I = 0$). As a consequence, total savings are always equal to zero.

Market transactions are the outcome of the actions that agents repeat every period $t = 1...T$. The sequence of these actions is summarized below:

1. The labor market opens. Firms decide prices, quantities and wage offers, then post vacancies. Unemployed workers send applications to a fixed number of potential employers, choosing the one offering the highest wage.

    (a) The credit market opens. Firms whose internal financial resources are insufficient to pay wages try to get a loan from the bank. The bank pays interests on households' deposits. The credit market closes.

    Firms whose resources are still insufficient fire or do not hire some workers. Workers who succeed to get a job sign a contract with their new employer for D periods. Firms pay wages. The labor market closes.

2. The consumption goods market opens. Households allocate their total wealth to consumption and savings and buy goods from a fixed number of randomly picked firms. Firms collect revenues. The consumption goods market closes.

3. After markets close, all agents update their balance sheets. Firms pay interests and principal to the bank. Firms that cannot validate their debt commitments go bankrupt and are replaced by an equal number of new firms. In case of bankruptcies, the bank registers a bad debt.

2.2 The labor market

The actors of the labor market are firms and households. Firms demand labor and offer wages, households supply labor services. Households are constituted by a single worker who offers one unit of labor per period.

Labor demand

Firm i produces using labor and a technology with constant returns α. For simplicity, we assume that technology is uniform across firms and time. Ruling out technological progress implies that our model is best interpreted as a description of the economic activity at business cycles frequencies.

For a given desired level of production Y_{it}^*, labor demand is obtained as

$$N_{it}^d = \frac{Y_{it}^*}{\alpha}. \tag{3}$$

Then, the firm posts vacancies V_{it} given by the difference between the desired workforce and the operating workforce N_{it-1}, that is the workers still employed at firm i at the beginning of period t.

Because of market imperfections, firm i possesses some degree of market power, which allows it to decide how much to pay its employees. The wage offered by the firm at time t is determined by the following adaptive rule:

$$w_{it} = \begin{cases} w_{it-1}(1+\xi_{it}) & \text{if } V_{it} > 0 \\ w_{it-1} & \text{if } V_{it} = 0 \end{cases} \tag{4}$$

where w_{it-1} is the wage offered to the workers employed at time $t-1$ and the variable ξ_{it} is an idiosyncratic shock uniformly distributed on the support $(0, h_\xi)$. Because of labor homogeneity, we assume that at time t all the workers employed by firm i receive the same wage w_{it}. This means that the wage of previously-hired workers is also updated to the new wage.

Through Eq. (4) we basically incorporate into the model the abundant empirical evidence on the downward rigidity of nominal wages. Numerous surveys have shown in fact that even during recessions firms prefer layoffs to wage cuts, mainly because the latter could increase workers' turnover and decrease labor effort from remaining workers (Campbell and Kamlani, 1997; Bewley, 1999; Daly *et al.*, 2013).

Labor supply

For simplicity we suppose that only unemployed workers search for a new job. Job search takes three steps. First, one by one each unemployed worker j enters the labor market in random order, and contacts a fixed number M of firms sending as many applications. If his/her contract has just expired, one of the applications is sent to his/her last employer. Parameter M, therefore, tunes labor market frictions due to search costs. Second, once the M contacted firms have revealed their wage offers, those paying wages below worker j's reservation wage are discarded. The worker's reservation wage is given by

$$w_{jt}^r = \begin{cases} w_{jt-1} & \text{if employed in } t-1 \\ w_{jt-1}^r(1-\chi_{jt}) & \text{if unemployed in } t-1, \end{cases} \tag{5}$$

where χ_{jt} is a random shock uniformly distributed on the support $(0, h_\chi)$. Eq. (5) therefore implies that workers who have experienced longer spells of unemployment will have in general lower reservation wages and will be more prone to accepting lower wages. Finally, the applicant worker chooses, among the remaining firms that still have open vacancies, the one offering the highest salary. The newly employed worker and the firm sign a fixed-term job contract lasting D periods.

Workers with an active contract can be fired only in case the firm's funds are not sufficient to pay for the wage bill. If this is not the case, therefore, on average every period a share $1/D$ of job contracts expires, and the newly-unemployed workers will search for a new employer. Consequently, although on-the-job search is ruled out, the reciprocal of the contract duration D can be interpreted as the probability for a worker to change job.

2.3 The credit market

Firms and bank participate to the credit market.

Credit demand

After the closure of the labor market firm i needs to pay a wage bill W_{it}. At the beginning of period t firm i is endowed with liquid resources D_{it}, i.e. its bank deposits. Following the "pecking order" theory on business capital structure (e.g. Myers and Majluf, 1984), we assume the wage bill to be first financed by internal resources and then, if these are not enough, by external funds provided by the bank. The demand for new bank loans is therefore given by

$$B_{it}^d = \max(W_{it} - D_{it}, 0), \tag{6}$$

with the corresponding interest rate r_{it} given by Eq. (8).

As we explain in detail below, the firm may be rationed by the bank if its credit rating CR_{it} is too low. As a consequence, the amount of new credit B_{it} actually supplied by the bank may be lower than credit demand. In this case, total financial resources are not sufficient to pay for the wage bill, and the firm is allowed to fire redundant workers at zero costs.

Credit supply

The bank acts as a reduced-form financial system and has three functions: it is the center of the payment system, supplies credit to firms and pays interests on households' deposits.

If a firm experiences a shortage of financial resources to pay wages, it will ask for a bank loan B_{it}^d (see Eq. (6)). The bank signs with firm i a long-term debt contract, stating the interest rate r_{it} and the share τ of the principal to be repaid every period. For simplicity we suppose that the share τ is the same for every borrower.

The flow of new credit B_{it} is granted by the bank to firm i according to the following adaptive rule:

$$B_{it} = \begin{cases} B_{it}^d & \text{if } CR_{it} > \theta \\ 0 & \text{if } CR_{it} \leq \theta, \end{cases} \qquad (7)$$

where CR_{it} is the firm's credit rating and θ is the parameter which regulates the bank's lending attitude. The higher the parameter θ, therefore, more frequently credit rationing will occur.

The firm's credit rating at time t is defined as 1 minus its probability of default. To keep things simple, we suppose that the bank computes the probability of bankruptcy simply as the firm's relative frequency of default over the window of the last Φ periods, where Φ is a parameter. For example, if the firm has defaulted twice during the periods $t - \Phi, ..., t - 1$, we have $CR_{it} = (\Phi - 2)/\Phi$. Hence, the bank will resume lending to firm i only if the latter's credit rating increases above the threshold θ.

The interest rate r_{it} is determined as a mark-up over the policy rate i_t set by the central bank:

$$r_{it} = i_t(1 + \mu(\lambda_{it})). \qquad (8)$$

The mark-up in turn is an increasing function $\mu(\cdot)$ of the borrower's leverage λ_{it}. Function $\mu(\cdot)$ is the hyperbolic tangent, whereas the firm's leverage is defined as

$$\lambda_{it} = \frac{L_{it} + B_{it}^d}{D_{it}}. \qquad (9)$$

Equation (8) is based on the "external finance premium" theory (Bernanke and Gertler, 1989; 1990), stating that in presence of asymmetric information the interest rate increases with the borrower's financial fragility (here straightforwardly captured by the leverage λ_{it}).

Finally, the bank pays out interests on households' deposits at the current policy rate i_t.

2.4 The consumption goods market

The players on the consumption goods market are firms (supply) and households (demand).

Goods supply

Firms produce the same homogeneous consumption good but, because of imperfect competition caused by uncertainty and consumer search costs, they have some degree of market power. Firm i's strategy at the beginning of each period t is therefore the couple (P_{it}, Y_{it}^*), where P_{it} is the price and Y_{it}^* is the desired production level. We suppose that firm i can adjust either the price or the desired production level, but not both. The assumption of ruling out simultaneous changes of price and quantity is a rather strong simplification, which nonetheless can be justified on the basis of the empirical evidence on price and quantity adjustment of firms over the business cycle (Kawasaki *et al.*, 1982; Bhaskar *et al.*, 1993).

Firms' knowledge of market conditions is always imperfect because of uncertainty and, consequently, they need to form expectations D_{it}^e on current demand. We assume that the goods are perishable, which means that firms cannot take inventories to the next period to satisfy future demand. We can therefore think of our model as a representation of a modern service-based economy. As a consequence, the desired quantity of goods to supply Y_{it}^* is always set at the level of expected demand D_{it}^e. However, actual production Y_{it} may differ from the desired level Y_{it}^* if firms are constrained on the credit market and/or on the labor market.

The relevant information at time t for firm i to choose its strategy consists of the average market price P_{t-1} and of the individual excess demand/supply recorded in the previous period and captured by unsold inventories I_{it-1}. Although goods cannot be stored, inventories are used by firms as market signals: if inventories are positive, the firm argues that demand for its good has been overestimated, otherwise the firm infers that demand has been underestimated or exactly estimated.

The firm adjusts the price according to the following adaptive rule:

$$P_{it} = \begin{cases} P_{it-1}(1 + \eta_{it}) & \text{if } I_{it-1} = 0 \text{ and } P_{it-1} < P_{t-1} \\ P_{it-1}(1 - \eta_{it}) & \text{if } I_{it-1} > 0 \text{ and } P_{it-1} \geq P_{t-1} \end{cases} \tag{10}$$

where η_{it} is an idiosyncratic random variable uniformly distributed on the support $(0, h_\eta)$. The logic of this rule is that excess demand ($I_{it-1} = 0$) is conducive to upwards price revisions only when the firm is competitive (price below the average market price). In this case the firm can raise the price in order to widen its profit margins. Conversely, positive inventories lead to a downward revision of price only if this is above the market price. At any rate, price P_{it} will never be set below the firm's average costs.

Desired production is determined as follows:

$$
Y_{it}^* = \left\{ \begin{array}{ll} Y_{it-1}(1 + \rho_{it}) & \text{if } I_{it-1} = 0 \text{ and } P_{it-1} \geq P_{t-1} \\ Y_{it-1}(1 - \rho_{it}) & \text{if } I_{it-1} > 0 \text{ and } P_{it-1} < P_{t-1} \end{array} \right. \tag{11}
$$

where ρ_{it} is an idiosyncratic shock uniformly distributed on the support $(0, h_\rho)$. The rationale behind this rule is that positive inventories (excess supply) trigger downwards quantity revisions only when the price is already low enough (below the average market price). In this case the firm does not want to further decrease the price to avoid a deterioration of its profit margins.

Goods demand

Before the consumption goods market opens, households receive their wage from the firms (if employed) and the interests $i_t D_{jt}$ from the bank. Hence, individual income (labor income plus capital income) at time t is defined as:

$$
I_{jt} = \left\{ \begin{array}{ll} i_t D_{jt} + w_{jt} & \text{if } j \text{ is an employed worker} \\ \\ i_t D_{jt} & \text{if } j \text{ is an unemployed worker} \end{array} \right. \tag{12}
$$

where D_{jt} are household j's deposits at the beginning of period t. Given available financial resources $D_{jt} + I_{jt}$, the consumer allocates a share $c \leq 1$ to consumption and the remaining part to savings. The consumption budget is therefore defined as

$$
C_{jt} = c(D_{jt} + I_{jt}). \tag{13}
$$

For simplicity we suppose the share c (i.e. the marginal propensity to consume out of wealth) to be the same for all households.

Consumers randomly enter the goods market and, because of search costs, can visit only a fixed number Z of firms, one of them being the largest (in terms of production) firm visited in the previous period. Consumers are assumed to adopt this "preferential attachment" mechanism in order to minimize the probability to be rationed.

Each consumer attempts to spend his/her consumption budget starting to buy from the firm charging the lowest price among the selected firms. If goods available at the first firm are not enough, the consumer will turn to the second cheapest firm, and so on. Because of uncertainty, therefore, households may not be able to purchase all the desired quantity of goods.

2.5 Accounting, bankruptcy and replacement

Upon the closure of the consumption goods market agents update their balance sheets.

Firms

At the end of period t firm i has sold quantity $Q_{it} \leq Y_{it}$ at price P_{it}, collecting revenues $R_{it} = Q_{it} P_{it}$. Firm's profits π_{it} are equal to revenues minus costs, which are the sum of wage bill and loan interests:

$$\pi_{it} = R_{it} - W_{it} - r_{it} L_{it}. \tag{14}$$

Hence, net worth A_{it} will evolve according to the law

$$A_{it+1} = A_{it} + \pi_{it}. \tag{15}$$

At the end of each period, the firm has also to pay back a fraction τ of its outstanding debt, which therefore evolves in the following way:

$$L_{it+1} = (1 - \tau) L_{it} + B_{it}. \tag{16}$$

In principle, above proportional repayment scheme imposes a higher burden on the first time steps after a firm has borrowed money. However, this bias is mitigated by the fact that firms generally ask for loans several times to finance production. Hence, not necessarily the average per-period repayment decreases monotonically over time.

The total cash flow generated by all the transactions occurred during period t is

$$CF_{it} = R_{it} + B_{it} - W_{it} - (r_{it} + \tau) L_{it}, \tag{17}$$

whereby we get the law of motion of the firm's liquid resources, i.e. bank deposits:

$$D_{it+1} = D_{it} + CF_{it}. \tag{18}$$

We assume that the firm is declared insolvent only if it is not able to serve its debt to the bank, in which case it exits the market. This implies that the firm may

remain active even if it is "technically" in default, that is if $A_{it+1} < 0$, provided that deposits D_{it+1} are positive. When the firm defaults, its employed workers get fired.

The bankrupt firm is replaced by a new one, whose initial capital is financed by the Government through a flat tax ψ levied on households' wealth. This mechanism, although not very realistic, assures stock-flow consistency without affecting wealth inequality and, at the same time, determines a negative impact on the economy by reducing households' spending capacity, as real bankruptcies actually do.

Price P_{it+1} and wage w_{it+1} of the new firm are set to the level of their corresponding average market values P_t and w_t. Moreover, the new firm inherits from the defaulted one a share κ of its outstanding debts L_{it}, whereas the remaining part $(1 - \kappa)$ is absorbed by the bank's capital as bad debt.

This perfect replacement of bankrupt firms, used to keep constant the number of firms, can be motivated on the basis of two widely accepted stylized facts: first, in established industries the number of firms tend to settle down around a roughly constant level (Sutton, 1997); second, the inflows and outflows of firms show strong positive correlation (Geroski, 1991, reports a correlation coefficient of 0.796 for a sample of 95 industries in United Kingdom in 1987). So, in the model we are implicitly assuming a correlation equal to 1. We can therefore imagine that our model describes the behavior of a "mature" and stable economy characterized by little innovation. Moreover, a constant population may also be interpreted as a statistical equilibrium, where at the micro level firms continuously enter and exit the market but at the macro level the population remains rather stable.

We point out that the replacement can be interpreted not only as a true substitution of an old firm with a new one, but also as a mere financial restructuring of the same defaulting firm.

Households

At the end of time t household j's wealth is totally held in bank deposits, which evolve according to to the following:

$$D_{jt+1} = D_{jt} + I_{jt} - C_{jt} - \Psi_j, \tag{19}$$

where I_{jt} is given by Eq. (12), C_{jt} is the expenditure on consumption and Ψ_j is the household's total contribution to help the Government to refinance defaulted firms (see above section 2.5).

The bank

At the end of the period the bank calculates its profits:

$$\pi_t^b = \sum_{i \in \Omega} r_{it} L_{it+1} - \sum_{j=1}^{H} Int_{jt} - BD_t, \tag{20}$$

where Ω is the bank's loan portfolio, $Int_{jt} = i_t D_{jt}$ are the interests paid on household j's deposits at the beginning of period t and BD_t is the bank's bad debt (non-performing loans) recorded at the end of the period. As explained in Section 2.5, bad debt is defined as a fraction $(1 - \kappa)$ of bankrupt firms' outstanding debts.

Total bank credit evolves according to the following law of motion:

$$L_{t+1} = (1 - \tau)L_t + \sum_{i \in \Theta} B_{it} - BD_t, \tag{21}$$

where Θ is the set of firms that borrowed in period t.

Finally, the law of motion for the bank's equity can be defined as

$$E_{t+1} = E_t + \pi_t^b \equiv L_{t+1} - D_{t+1}. \tag{22}$$

2.6 Results

In this Section we present a brief overview of some general properties of the model.[1] Fig. 1 shows four time series relative to a typical simulation, obtained using the parameter values reported in Table 3. These baseline parameters will be changed in Section 3 when performing sensitivity analysis.

Panel 1(a) shows real GDP, while the closely related unemployment rate is reported in Panel 1(b). We can see that the economic activity is characterized by a rather regular alternation of expansions and recessions without a tendency to converge to some steady-state. This cyclical behavior cannot be explained in terms of microeconomic frictions such as search costs (which are fixed) or exogenous aggregate shocks (which are not), but is caused by a combination of idiosyncratic random shocks and non-linear relationships. A major driving force behind fluctuations is firms' cash flow. During expansions, in fact, unemployment drops, wages rise and firms build up debts to finance increasing production. As long as revenues are sufficient for firms to pay interests on their bank loans, production can continue to expand. However, debt accumulation and rising labor and financial costs reduce firms' cash flow and, eventually, may lead to bankruptcy. If the number of bankrupted firms is large enough, or if big firms default, aggregate production shrinks and unemployment increases. The loss of jobs determines a reduction in households' income and consumption, which in turn negatively affects

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[1] The model was implemented in MATLAB, and the code is available upon request.

Table 3: Parameters.

Parameter	Description	Value
T	Number of periods	500
F	Number of firms	100
H	Number of workers	600
Z	Number of firms visited by a consumer	4
M	Number of labor applications	4
D	Job contract length	8
c	Marginal propensity to consume	0.8
h_η	Maximum growth rate of prices	0.1
h_ρ	Maximum growth rate of quantities	0.1
h_ξ	Maximum growth rate of wages	0.05
h_χ	Maximum % decrease of reservation wages	0.05
ψ	Recapitalization coefficient	0.01
i_t	Policy rate	0.01
θ	Credit rating threshold	0.2
τ	Debt repayment rate	0.05
Φ	Defaulting window	10
$1 - \kappa$	Share of bad debt	0.05

firms' sales and profits. Moreover, a second-order 'financial accelerator' mechanism adds to the ongoing recession, because bankruptcies, by lowering firms' credit worthiness, lead to credit rationing by the bank (Eq. 7). However, recessions have also the important function of wiping less efficient and more indebted firms out of the market. This natural selection mechanism in the long run helps to make the economy financially sounder and, eventually, leads to a new expansion phase.
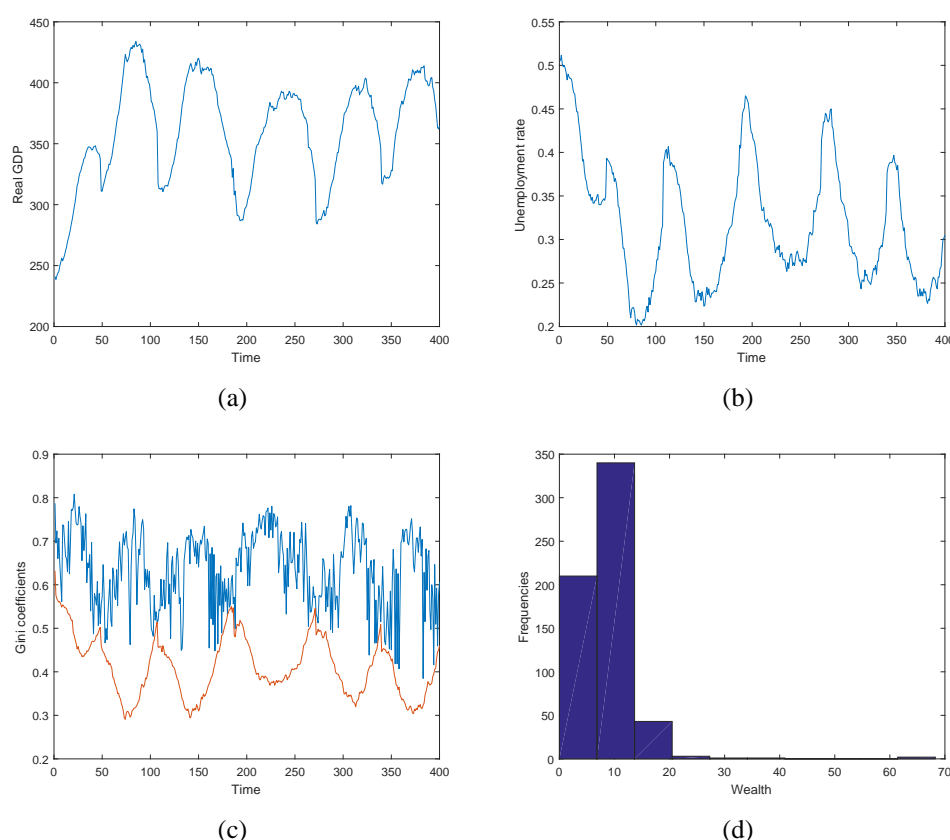
Figure 1: (a): Real output; (b): Unemployment rate; (c): Gini coefficients for wealth (blue line) and income (red line); (d): Wealth distribution at $t = 500$.

Strictly speaking, the levels of unemployment displayed by the model in the baseline simulation (between 20% and 45%) are difficult to see in modern, developed Countries. Nonetheless, we should take into consideration that the model does not feature a public sector. Government expenditure, in facts, is the main stabilizer of modern economies together with active monetary policy, and in our model we have neither of the two. In addition, the model is not calibrated, that is

the baseline parameter configuration was not chosen to make the simulated data close to the real ones. As a consequence, absolute values (i.e. first moments) should not be given too much importance whereas, on the contrary, relative values such as co-movements should be considered. A co-movement analysis, in fact, reveals that the model is rather realistic at business-cycle frequencies, as the cyclical components of GDP, unemployment, consumption and inflation display cross-correlations that are very similar to the empirical counterparts of U.S. economy at quarterly frequencies (for more details we refer to Chen and Desiderio, 2018).

At a lower level of aggregation the model reproduces qualitatively several empirical regularities concerning job flows. We find in fact that unemployment is positively correlated to long-term unemployment (defined as the workforce that has been unemployed for more than three periods), that layoffs and hirings are strongly correlated both in levels and in differences, and that layoffs show higher volatility and are more correlated to unemployment than hirings (Blanchard and Diamond, 1990; Davis *et al.*, 1996). Moreover, the model also replicates three well-known statistical regularities describing the interplay between labor market and aggregate activity at business cycles frequencies, namely the Phillips curve, the Beveridge curve and the Okun law.

As all in all our model displays quite realistic features, we deem it as a valid tool to perform computational experiments. Thus, in the next section we will use it to study the relationship between job contract duration and inequality.

3   Computational experiments

In this Section we will assess the effect of job contract duration on income and wealth inequality, measured by the Gini index. We start by a local sensitivity analysis exercise (Section 3.1) involving parameter D, then in Section 3.2 we will check the robustness of our result by a global sensitivity analysis, that is by controlling for other relevant model parameters. Finally, in Section 3.3 we will examine possible non-linearities and interactions with other parameters through a pairwise sensitivity analysis.

3.1   Local sensitivity analysis

In this Section we analyze the behavior of inequality for increasing values of the job contract length D, going from 1 to 16. For each value of contract duration we run 100 independent simulations of 500 periods; for each simulation i we compute the average Gini coefficient g_i relative to the variables of interest and then we take the Monte Carlo average $\bar{g} = 100^{-1} \sum_i g_i$ across simulations.

Figure 2 shows the results.[2] In Panel (a) we can see the average Gini index for wealth decreasing monotonically. As for income, from Panel (b) we can see that the relationship is less clear, with the Gini index first increasing and then decreasing monotonically for $D > 2$. We also fit the two curves using different regression models of contract duration, involving levels, quadratics and logarithms. These models are then ranked according to their coefficients of determination. With an R^2 of about 99% we rank as the best fit for wealth a model with both the logarithm and the squared logarithm of parameter D (implying a theoretical turning point at about $D = 35$), while for income the best model includes the level D and the quadratic term D^2 (R^2 of about 86% and estimated turning point between 12 and 13). In both cases the estimated models prompt that the relationship between Gini index and job contract duration is decreasing over the considered parameter space, but also that it might be non-monotonic for larger values of D.

(a)   (b)
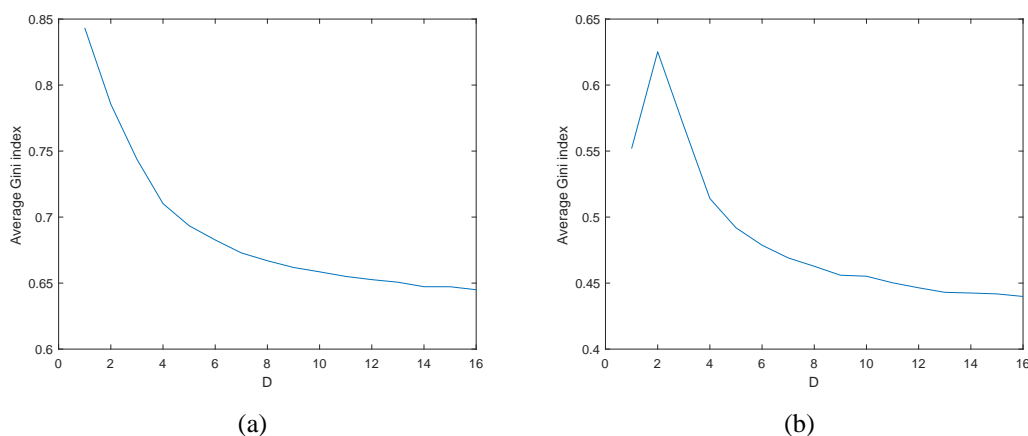
Figure 2: Monte Carlo Gini index as function of job contract duration for (a): wealth; (b): income.

Different mechanisms link inequality to job contracts. The principal channel through which contracts affect inequality is probably unemployment, because when more workers are employed income distribution becomes less unequal among the poorer classes of the population, that is those who suffer more from the loss of jobs. This is confirmed by Panel (a) of Figure 3, where the Monte Carlo unemployment rate is reported. A glance at this variable, in fact, reveals that its response to parameter D closely follows that of the income Gini index: as D increases, unemployment first increases and then decreases monotonically for

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[2] The Gini coefficients are pretty high, but Piketty (2014, pg. 248-249) reports a wealth Gini of 0.67 for a medium-high inequality, of 0.73 for a high inequality and 0.85 for a very high inequality, and an income Gini of 0.49 for high inequality and 0.58 for very high inequality.

D > 2. The reason why this happens is straightforward: when contracts are longer, in fact, firms can fire workers less frequently and therefore they are forced to pay wages even when this is not economically efficient from the individual point of view. On the other hand, however, this microeconomic inefficiency has the un-intended consequence of sustaining aggregate demand for the consumption good. In other words, longer contracts increase the likelihood of having macroeconomic coordination between aggregate demand and supply, thus reducing the probability to experience recessions and long periods of high unemployment. However, we will see that this mechanism works specially when monetary policy and the commercial bank's credit policy are loose.

Another channel through which contracts affect inequality is wage dispersion. Longer contracts, in fact, reduce wage dispersion just as they reduce income inequality. This can be seen in Panel (b) of Figure 3, which shows that the Monte Carlo coefficient of variation of nominal wages behaves very similarly to income inequality. There are basically two reasons for this to happen. First reason: if jobs terminate less often, then firms need to open less vacancies and, according to Eq. (4), to raise less frequently their wage offer in order to attract workers. Thus, longer contracts reduce wage competition among firms and, as a consequence, also the dispersion of *offered* wages. There is also a second reason: if contracts are longer, reallocation of workers among firms occurs less frequently and there-fore workers have less chances of finding jobs paying higher salaries. This, on average, will reduce the dispersion of *actually paid* wages. Taken together, these two mechanisms cause longer contracts to reduce wage dispersion and income inequality.

Income inequality is also tightly connected to wealth inequality. Not only does the former affect the latter through Eq. (19), but the latter positively feeds back into the former as well. Besides wages, in fact, income is also determined by fi-nancial revenues (see Eq. (12)), which depend on accumulated wealth. Hence, income inequality is exacerbated by wealth inequality through capital income. Moreover, wealth inequality feeds positively back into itself. Combining Eqs. (12), (13) and (19), in fact, we get the following reduced-form law of motion for wealth:

$$D_{t+1} = (1-c)w_t + (1-c)(1+i_t)D_t,$$

proving that inequality is partly cause of itself.

3.2   Global sensitivity analysis

The results emerging in Section 3.1 are obtained by changing only the job contract duration *D*, while all the other parameters are fixed at their baseline values. The obvious objection is that the relationship between inequality and contract length

(a)   (b)
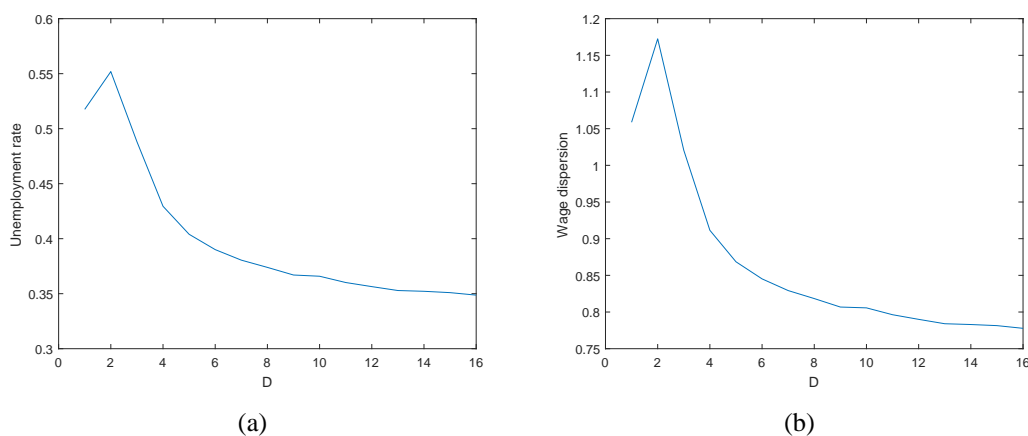
Figure 3: (a): Monte Carlo unemployment rate; (b): Monte Carlo coefficient of variation of nominal wages.

may change if the other parameters change. The aim of this Section is therefore to investigate this possibility through a global sensitivity analysis exercise, consisting in changing several parameters simultaneously. To this scope we will use the technique already introduced in Chen and Desiderio (2018), which we briefly illustrate in Section 3.2 for the reader's sake. Subsequently, we will report our findings in Section 3.2.

The GSA procedure

The method is an instance of indirect inference based on the estimation of an auxiliary regression model (Richiardi, 2018). Suppose that we want to assess how the model parameters γ, belonging to the parameter space Γ, affect a statistic s computed on the output of the agent-based model, which in general will also be a function of initial conditions A_0 and random numbers r:

$$s = s(A_0, \gamma, r). \tag{23}$$

To do this we resort to the estimation of an auxiliary regression meta-model

$$s = \beta\gamma + u(A_0, \gamma, r), \tag{24}$$

where the meta-parameters β measure the partial effect of the model parameters γ on s.[3] In principle, the regression error u may depend on the initial conditions, on the stream of random numbers and on the model parameters. For simplicity,

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[3] This is a simple implementation of the Kriging meta-modeling approach.

we will assume that the error does not depend on the initial conditions, which is true if the data generating process of the model is ergodic, and on γ. Assuming that error term u does not depend on γ amounts to assume that the relationship between s and the model parameters be indeed linear. If this is not true, model (24) can always be augmented with non-linear functions of γ. Hence, from now on we will suppose that the error depends only on the stream of random numbers r.

In order to estimate the meta-model we have to generate n vectors γ_i randomly sampled from the parameter space Γ and n streams of numbers r_i. Then, for each vector γ_i and stream r_i we simulate the agent-based model n times, obtaining n values s_i for the statistic of interest.[4] Consequently, using the samples for s and for the parameters we can estimate by OLS the relationship

$$s_i = \beta \gamma_i + u(r_i), \ \forall i = 1...n, \tag{25}$$

obtaining estimated meta-parameters $\hat{\beta}$. Clearly, these estimates depend on the unobserved sequences of random numbers. However, the central point of our approach is that we treat the numbers r_i in Eq. (25) simply as omitted explanatory variables influencing s_i through the error term. And as the stream r_i was randomly selected, necessarily it is uncorrelated with the regressors γ_i, which therefore are not correlated even with the error u_i. Hence, under the assumption that the regression model (25) is correctly specified, the OLS estimators $\hat{\beta}$ applied to it are consistent for β when $n \to +\infty$.

The strength of our approach, therefore, is both its simplicity of implementation and its parsimony in terms of required computational effort.

Results

As already explained, we perform GSA to make sure that the results obtained in Sec. 3.1 are robust to changes to other parameters. In this Section we are going to apply the approach explained above to equation (25) controlling for a set of parameters that we deem relevant for inequality. Besides the job contract duration D, these are the number of job applications M, the policy rate i_t (which is actually held fixed within a given simulation), the bank's lending attitude θ, the maximum wage growth rate h_ξ (see Eq. (4)) and the marginal propensity to consume c. Hence, $\gamma = (D, M, i_t, \theta, h_\xi, c)'$ and s will be both the income and wealth Gini coefficient.

For each parameter we restrict the corresponding parameter space Γ to a suitable range of values, as summarized by Table 4. From the parameter space we randomly draw 500 parameter vectors γ_i and run the model 500 times (so, $i = 1...500$),

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[4] In practice, when for a given γ_i we run a simulation of the agent-based model to generate the corresponding s_i, we randomly choose the seed of the random number generator.

choosing randomly also the seed of the random number generator. Then, for each simulation we take the average Gini coefficients after discarding the first 100 periods.

Table 4: Parameter space.

Parameter	N. of values	Range
D	15	[2-16]
M	9	[2-10]
i_t	100	[0.001-0.05]
θ	100	[0.1-0.9]
h_ξ	100	[0.005-0.2]
c	100	[0.1-0.99]

Table 5 reports the results. Overall, the meta-model explains about the 73% of the variability of wealth Gini coefficient and about the 70% of the variability of the income Gini. As we can see, our previous result is confirmed by GSA: longer contract duration decreases inequality, *even* when other parameters change. Inequality is reduced also when labor market frictions decrease (higher *M*), probably because a more efficient matching between demand and supply of labor reduce unemployment (Table 6, column (1)). Conversely, all the other parameters increase inequality, with only slight differences between income and wealth.

Table 5: Global sensitivity analysis. Dependent variables: (1) wealth Gini index; (2) income Gini index. Observations = 500. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	−.0032487***	−.0040573***
M	−.0071622***	−.0088425***
i	2.578706***	3.737546***
θ	.5541099***	.6499673***
h_ξ	1.479424***	1.877328***
c	.4308005***	.1739708**
constant	.0775336***	.0788892***
R^2	0.7325	0.7027

Another important application of global sensitivity analysis is that of discovering possible interaction effects among parameters, and our approach is no exception. In order to assess how job contract duration interacts with other mechanisms, in fact, it would be sufficient to augment equation (25) with a series of interaction

Table 6: Global sensitivity analysis. Dependent variables: (1) unemployment rate; (2) coefficient of variation of nominal wages. Observations = 500. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	$-.0071242$***	$-.0394336$***
M	$-.0050102$**	$-.0164015$
i	3.643887***	11.57396***
θ	$.5434112$***	3.813831***
h_ξ	1.552907***	8.93351***
c	$.1597501$***	$.6994892$**
constant	$.1082692$***	-1.091638***
R^2	0.6888	0.7122

terms between D and the other parameters, along with non-linear terms. However, because of limited sample variation in the model parameters γ, in our case multicollinearity turns out to be an issue. So, we devote the next section to the partial solution to this problem.

3.3 Pairwise sensitivity analysis

In this Section we are going to assess the interaction effects between contract duration D and the other parameters $\gamma_{-D} = (M, i_t, \theta, h_\xi, c)'$. To this scope we will apply for five times the same approach to GSA illustrated in Sec. 3.2 but allowing only one parameter at time to vary along with D. In addition, besides an interaction term we include also the quadratics in order to control for non-linearities.

Tables 7, 8, 9, 10 and 11 show the results. In general, D appears to interact with other parameters, in particular with the policy rate i_t and the bank's lending attitude. In fact, the coefficient on the interaction terms ($D \cdot i_t$ and $D \cdot \theta$) are both positive and statistically significant. This means that the ability of longer job contracts to curb inequality is reduced in presence of a more restrictive monetary policy (higher i_t) or credit policy (higher θ). In principle, one can even figure out a level for i_t and θ such that longer contracts actually *increase* inequality. To corroborate our claims, in Figure 4 we report both Gini coefficients plotted against parameter D but conditional to different values of the policy rate i_t: what we can see is that the relationship is decreasing for $i_t < 0.02$ and increasing for $i_t \geq 0.02$ (the same happens if we condition on different values of parameter θ). The explanation is straightforward. As before argued, longer contracts help sustain aggregate demand but, at the same time, place a higher financial burden on firms. So, when monetary policy is loose and/or there is easy access to credit, firms

can continue to operate normally by getting more into debt, but in the opposite situation high cost of money and reduced availability of credit increase the firms' probability of bankruptcy and, thus, unemployment.

These findings suggest once more how economic mechanisms are closely intertwined. In particular, we can see that microeconomic policies aimed at affecting the rigidity of the labor market may interact with macro policies: more flexible labor markets may decrease inequality and/or foster growth in one macroeconomic framework, but may well have opposite effects in other macro contexts. Thus, neglecting the interconnections operating through different markets and different levels of the economic activity can lead to biased theoretical propositions and consequently to wrong policy-making. This could even explain why earlier and more recent empirical investigations on labor market rigidity have produced rather contrasting results: simply, they referred to very different macroeconomic contexts.

Table 7: Dependent variables: (1) wealth Gini index; (2) income Gini index. Observations $= 100$. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	$-.0212296$***	$-.0240443$***
D^2	$.0008061$***	$.0009428$***
M	$-.0408372$***	$-.0739105$
M^2	$.0025112$***	$.0048221$***
$D \cdot M$	$-.0002063$*	$-.0003974$
constant	$.8959761$***	$.7982146$***
R^2	0.9566	0.8709

Table 8: Dependent variables: (1) wealth Gini index; (2) income Gini index. Observations $= 100$. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	$-.0252143$***	$-.0242421$***
D^2	$.0005836$**	$.0000874$
i	-8.352666***	-10.4918***
i^2	128.7976***	143.2883***
$D \cdot i$	$.5299984$*	$.9531615$***
constant	$.8429809$***	$.6739915$***
R^2	0.6530	0.6585

Table 9: Dependent variables: (1) wealth Gini index; (2) income Gini index. Observations = 100. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	$-.0303895$***	$-.0511326$***
D^2	$.0009897$***	$.0019148$***
θ	$-.6169521$***	-1.010256***
θ^2	$.9640496$***	1.585148***
$D \cdot \theta$	$.0135256$***	$.0169756$**
constant	$.874455$***	$.8030813$***
R^2	0.9275	0.9158

Table 10: Dependent variables: (1) wealth Gini index; (2) income Gini index. Observations = 100. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	$-.0136754$***	$-.0169911$*
D^2	$.0005007$**	$.0007818$**
h_ξ	1.601388***	2.639591***
h_ξ^2	-2.854801*	-2.539246
$D \cdot h_\xi$	$-.027055$	$-.073807$**
constant	$.6470349$***	$.4035157$***
R^2	0.6523	0.6263

Table 11: Dependent variables: (1) wealth Gini index; (2) income Gini index. Observations = 100. Significant at 1%:***; at 5%:**; at 10%:*.

Regressors	(1)	(2)
D	$-.0253802$***	$-.04131$***
D^2	$.001139$***	$.0017461$***
c	$.0320147$	$.2068659$***
c^2	$.5478875$***	$-.1262083$**
$D \cdot c$	$-.0049221$	$-.0019306$
constant	$.4590701$***	$.5695174$***
R^2	0.9440	0.7854

(a) (b)

(c) (d)
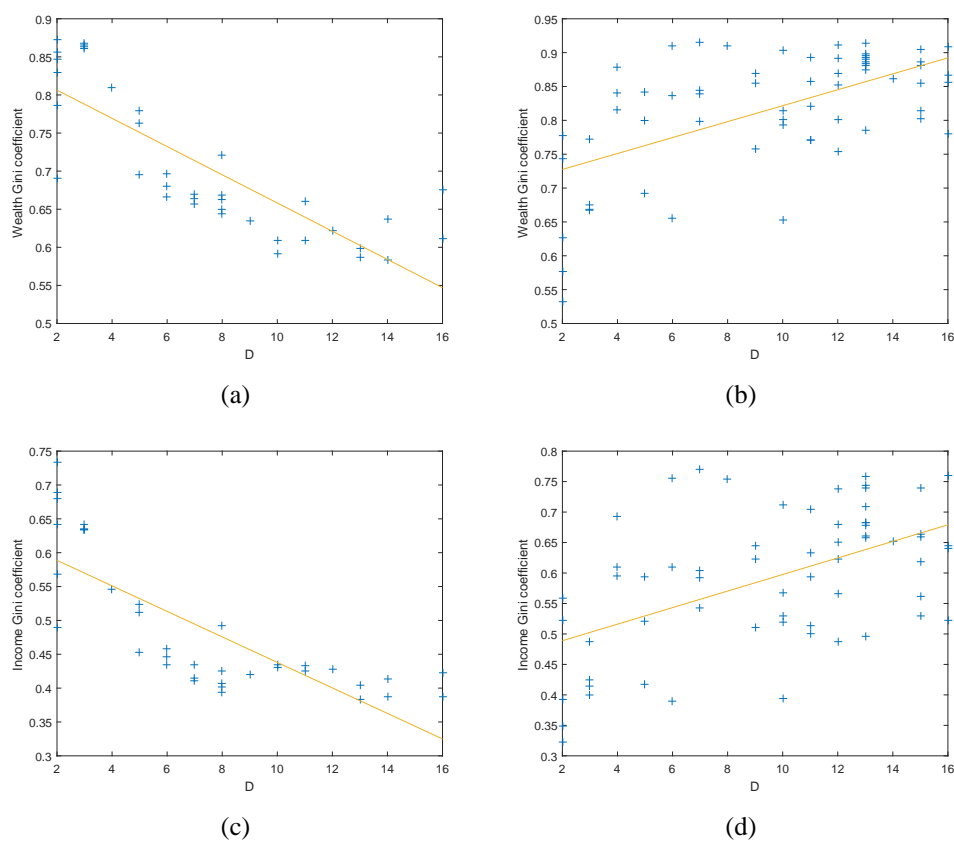
Figure 4: Scatter plot of D and wealth Gini conditional to: (a) $i_t < 0.02$; (b) $i_t \geq 0.02$. Scatter plot of D and income Gini conditional to: (c) $i_t < 0.02$; (d) $i_t \geq 0.02$.

4 Conclusive remarks

Structural labor market reforms have been on the political agenda of many OECD Countries for more than two decades. In particular, these have been aimed at increasing the degree of flexibility of the employer/employee relationship, in the presumption of fostering growth and decreasing unemployment. However, recent empirical evidence has shown that flexibility may have detrimental effects on unemployment and social welfare.

The main concern of this paper is how a major source of flexibility like temporary job contracts affects income and wealth inequality. To this scope we use an agent-based macroeconomic model already presented in Chen and Desiderio (2018), which is quite effective at replicating a number of stylized facts.

By using the model as a computational laboratory, we assess the impact of different job contract durations on inequality through three kinds of sensitivity analysis. The first experiment is a canonical local sensitivity analysis involving contract duration only. The second experiment, involving several parameters at the same time, is carried out as a robustness check. Finally, we propose a pairwise sensitivity analysis performed by changing two parameters at time. This experiment is aimed at discovering possible interaction effects between contract duration and other factors. We want to stress that the last two kinds of analysis are implemented through a methodology first introduced by Chen and Desiderio (2018) that reduces the computational burden of simulations.

In line with recent empirical evidence, the three experiments clearly indicate that longer contract length decreases inequality. There are mainly two reasons behind our result. One is that longer contracts reduce the ability of firms to fire workers and therefore force them to pay wages even when this is not economically convenient for the individual firm. This has the macroeconomic consequence of sustaining aggregate demand during downturns, thus reducing unemployment. The second reason is that longer contracts reduce wage competition among firms and, consequently, wage dispersion.

We also find that the positive effects of longer contracts on inequality are diminished by tighter monetary policy and credit policy. The last result might be of particular interest for policy makers, as it prompts that the final effect of institutional reforms may depend also on the macroeconomic context.

Admittedly, our findings could be biased in favor of longer contract duration because of the absence of international linkages. In fact, an economy with a rigid labor market is likely to suffer from the international competition exerted by another economy with more flexible working relationship. Hence, considering open economies as an additional robustness check will be the object of future research.

Acknowledgements

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