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The Role of (De-)Centralized Wage Setting for Industry Dynamics and Economic Growth: An Agent-Based Analysis with the Eurace@Unibi Model

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The Role of (De-)Centralized Wage Setting for Industry Dynamics and Economic Growth: An Agent-Based Analysis with the Eurace@Unibi Model*

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Abstract

In this paper, we employ the agent-based macroeconomic Eurace@Unibi model to study the economic implications of different degrees of de-centralization in the wage setting. Starting from a baseline scenario, corresponding to a high degree of unionization, in which wages are fully centralized and indexed on economy-wide productivity gains and inflation, we investigate how an increasing level of de-centralization affects the dynamics of output, employment, inequality, and market concentration. We think of decentralization as wages being a weighted average of an economy-wide 'union wage' and a firm-specific component depending on the firm's productivity and the experienced tightness of the labor market. Our findings suggest that stronger centralization of the wage setting process induces lower wage inequality and stronger concentration on the consumption good market. Furthermore, due to more physical investments, an economy with more centralized wage setting is characterized by higher productivity and faster economic growth.

Keywords: centralized wage bargaining, collective agreement, de-unionization, industry dynamics, inequality, growth
JEL Classification: C63, E24, J50, L16

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1 Introduction

One of the key challenges economic policy makers face is to foster economic growth while at the same time keeping the dynamics of (income) inequality in focus. Clearly, the evolution of income inequality is closely connected to the dynamics of wage distributions, and recent empirical work (e.g. Card et al., 2013; Barth et al., 2016) highlights that the increase in heterogeneity of wages across firms (respectively plants) is the most important factor driving increasing wage dispersion. Concurrently, the last decades have been characterized by a decline in the degree of unionization in many industrialized countries (see, e.g., Ebbinghaus and Visser, 1999; Visser, 2006; Firpo et al., 2018) and also institutional changes towards more decentralized wage setting on the firm-level in countries like Germany (Dustmann et al., 2014). The general narrative in this respect is that although these developments seem to contribute to an increase in wage inequality, they increase the firms' competitiveness and thereby foster (local) economic growth.

In this paper, we study the effect of a decentralization of the wage setting both on economic growth and on the evolution of wage inequality in a dynamic macroeconomic model. The model captures the competition between firms, both, on the labor and the consumption goods market as well as potential demand effects induced by different wage-setting regimes. Furthermore, productivity dynamics in our model are driven by endogenous technology choices of investing firms, such that we can study how the wage setting regime influences investment and the speed of adoption of new technologies, and how these processes interact with the endogenously emerging dynamics of industry concentration.

Existing models comparing the implications of centralized versus de-centralized wage setting have to a large extent relied on models with static oligopoly-type product market interaction (Haucap and Wey, 2004; Blomgren-Hansen, 2012) or have completely abstracted from product market competition between firms (Moene and Wallerstein, 1997; Vona and Zamparelli, 2014). In an influential early contribution Calmfors and Driffill (1988) provide an analysis of the effect of (de-)centralization of wage bargaining in a setting with several industries with perfect competition in each industry and output of the industries being partial substitutes on the product market. They assume that demand is fixed independent from the households wage income and establish that under certain conditions there is a hump-shaped (inverse hump-shaped) relationship between the degree of centralization of wage bargaining and the average wage level (employment).[1] With the exception of Moene and Wallerstein (1997) all the mentioned studies take a static perspective without considering how different wage setting regimes influence the firms' investment decisions and technology choices.[2] Moene and Wallerstein (1997), focusing

[1] See Driffill (2006) for a survey of the stream of literature building on this analysis.

[2] Several papers have studied from a theoretical perspective the implications of centralization

entirely on the competition between firms on the labor market, show that in the absence of product market competition more centralized wage setting yields higher firm productivity but lower employment compared to de-centralized bargaining of wages.

Our perspective in this paper is that the dynamics of output and wage distributions are crucially driven by the interplay between technological change, evolution of industry structure, and the dynamics on the labor market. Hence, we aim to gain a better understanding of how different wage setting regimes influence this interplay. In order to capture these effects, we carry out our analysis in the framework of the macroeconomic agent-based Eurace@Unibi model (see Dawid et al., 2019). This model, building on the original Eurace model (see Deissenberg et al., 2008), combines explicit representations of the dynamic competition between firms on the labor and product market in a closed macroeconomic setting with endogenous technology choices of firms and endogenous determination of demand. It has strong empirical micro-foundations for the agents' behavioral rules (Dawid et al., 2019), and has also been shown to be able to reproduce a large set of empirical stylized facts (e.g., Dawid et al., 2018b). The model has been used as a framework for policy analysis in different policy domains (see Dawid et al., 2018a; Deissenberg and van der Hoog, 2011), and has proved useful in understanding implications of different degrees of labor market flexibility (Dawid et al., 2014) and dynamic mechanisms determining wage inequality (Dawid and Gemkow, 2014; Dawid et al., 2018b). More generally, our analysis contributes to the growing literature on agent-based macroeconomics (see Dawid and Delli Gatti, 2018), in which recently several papers have considered macroeconomic effects of the institutional setup in the labor market (Dosi et al., 2017, 2018; Caiani et al., 2019), and the literature on the agent-based analysis of labor market dynamics (see Neugart and Richiardi, 2018).

The starting point of our analysis is an economy with a workforce with (ex-ante) uniform skills. There is a fully centralized wage setting, where workers have a uniform wage, labeled as union wage, which is updated over time taking into account inflation and average productivity growth in the economy. We then compare the dynamics emerging in such a setting with scenarios, in which at some given point in time the binding power of the centrally determined union wage is reduced and firms have the option to offer individual wages, which deviate from collectively agreed wage, to job candidates. More precisely, we assume that wage offers made to applicants are a weighted average of the centralized wage and a firm specific wage offer, which is determined according to a wage setting rule that

of wage bargaining on firms' innovation incentives (e.g. Haucap and Wey, 2004; Mukherjee and Pennings, 2011; Basak and Mukherjee, 2018), however this stream of literature focuses on hold-up issues firms face when bargaining with labor unions after investment and, therefore, is quite distinct from our agenda in this paper.

takes into account the expected productivity of the worker and the frequency with which the firm has been rationed on the labor market in the past.[3] The weight on the union wage then decreases during a transition phase till a certain long run degree of wage centralization is reached. We interpret this process as a reduced form representation of a de-unionization of the workforce or changes in the institutional setup of the labor market, which allows for firm specific agreements that deviate from outcomes of industry wide bargaining. The long run weight the union wage has in the workers' individual wages captures how strong the degree of de-unionization respectively the flexibility in local firm-level wage agreements are. In our experiments, we vary this long run weight from a value of one, which corresponds to the benchmark of fully centralized wage setting throughout to a value of zero, which implies that in the long run wages are fully decentralized and firm specific.

We find that in the considered setting a centralized determination of wages does not only reduce wage and income inequality, but also induces faster growth in output and productivity in the economy, compared to scenarios with more decentralized wage setting. The main driving force underlying these results is that under centralized wage setting firms that already perform well profit from a uniform wage in terms of lower unit labor costs. These translate into lower prices they can charge compared to their competitors which increases their market share and spurs further investments. Hence, average productivity and output in the economy grow faster than with a de-centralized wage setting where individual market shares of firms are more volatile and investment behavior is spread among a larger fraction of firms and overall lower.

Although these findings about the positive dynamic effects of wage centralization clearly should be seen in the context of the assumptions underlying our experiments, for example the homogeneity of workers with respect to their general skills, our analysis highlights several channels through which the degree of centralization affects economic dynamics, which so far have not been recognized in the literature.

The paper is organized as follows. In Section 2 we give a brief description of the structure of the Eurace@Unibi model with particular focus on the wage setting mechanism and the aspects that are different in this paper from the standard version of the model. The setup of our simulation experiment as well as the results of our analysis are discussed in Section 3. Concluding remarks are given in Section 4, and in the Appendix we provide the parameter setting underlying our analysis.

[3]The rule determining the firm specific wage component corresponds exactly to the wage setting rule used in the standard version of the Eurace@Unibi model as documented in Dawid et al. (2019).

2 The Model

2.1 Overall Structure

In a nutshell, the Eurace@Unibi model describes an economy with an investment and a consumption goods sector, and a labor, a financial, and a credit market in a regional context. Capital good firms provide investment goods of different vintages and productivities. Consumption good firms combine capital and labor of varying degrees of general and specific skills to produce a consumption good that households purchase. Households' saved income goes into the credit and financial markets through which it is channeled to firms financing the production of goods.

In this paper, we use a one-region setup of the Eurace@Unibi model to analyze the economic implications of different levels of wage centralization, where in the standard version of the model, the wage setting is fully decentralized. More precisely, the wages of workers are determined at the firm level, on the one hand, by the expectation at the time of hiring the employer has about the level of specific skills of the worker, and, on the other hand, by a base wage variable. The base wage is driven by the (past) tightness of the labor market and determines the overall level of wages paid by a particular employer.

In order to address aspects of wage centralization, we extend the Eurace@Unibi model by modifying the wage setting protocol of the labor market. In particular, we introduce a labor union that determines a collective wage proposal. This union wage is adjusted over time, on the one hand, in order to compensate for inflation and, on the other hand, to claim a share of the economy-wide productivity gains to the workers. The wage bargaining between firms and the union is modeled in reduced form by assuming that the actual wage that a firm has to pay is a linear combination of the centralized union wage and the firm-specific wage. The weight used in the linear combination is thereby an exogenous model parameter and reflects the power of the union in the wage negotiation. Since it also determines the degree of wage centralization, we will employ this parameter as the policy parameter in our analysis.

A complete description of the model is provided in Dawid et al. (2019). Due to space constraints here no full treatment of the model is given. Rather, we describe only the main aspects of the model, which are crucial for the understanding of the mechanisms driving the policy results discussed below.[4]

Capital goods of different quality are provided by capital goods producers with infinite supply. The technological frontier (i.e. the quality of the best currently available capital good) improves over time, where technological change is driven by a stochastic (innovation) process. Firms in the consumption goods sector use

[4]Note that the description of the model provided here is to a large extend identical to the ones given in Dawid et al. (2018c,b).

capital goods combined with labor input to produce consumption goods. The labor market is populated with workers that acquire specific skills on the job, which they need to fully exploit the technological advantages of the capital employed in the production process. Every time when consumption goods producers invest in new capital goods they decide which quality of capital goods to select, thereby determining the speed by which new technologies spread in the economy. Consumption goods are sold at a central market platform (called mall), where firms store and offer their products and consumers come to buy goods at posted prices.

Labor market interaction is described by a simple multi-round search-and-matching procedure where firms post vacancies, searching workers apply, firms make offers and workers accept/reject. Banks collect deposits from households and firms and give credits to firms. The interest that firms have to pay on the amount of their loan depends on the financial situation of the firm, and the amount of the loan might be restricted by the bank's liquidity and risk exposure. There is a financial market where shares of a single asset are traded, namely an index bond containing all firms in the economy. The allocation of dividends to households is, therefore, determined by the wealth of households in terms of their stock of index bonds. The dividend paid by each share at a certain point in time is given by the sum of the dividends currently paid by all firms. The central bank provides standing facilities for the banks at a given base rate, pays interest on banks' overnight deposits and might provide fiat money to the government. Finally, the government collects income and profit taxes at fixed rates and pays out social benefits to unemployed households.

Firms that are not able to pay the financial commitments declare illiquidity. Furthermore, if the firm has negative net worth at the end of the production cycle insolvency bankruptcy is declared. In both cases it goes out of business, stops all productive activities, and all employees loose their jobs. The firm writes off a fraction of its debt with all banks with which it has a loan and stays idle for a certain period before it becomes active again.

The choice of the decision rules in the Eurace@Unibi model is based on a systematic attempt to incorporate rules that resemble empirically observable behavior documented in the relevant literature. Concerning households, this means, for example, that empirically identified saving rules are used. Furthermore, purchasing choices are described using models from the Marketing literature with strong empirical support. In particular, in several parts of the model, decision makers are described by logit models. These models are well suited to capture decisions where individuals try to maximize some objective function which depends on some variables common to all decision makers and are explicitly represented in the model, as well as on aspects that are idiosyncratic to each decision maker and captured in the model by a stochastic term. With respect to firm behavior we follow the

'Management Science Approach', which aims at implementing relatively simple decision rules that match standard procedures of real world firms as described in the corresponding management literature. A more extensive discussion of the Management Science approach can be found in Dawid and Harting (2012).

Agent actions can be time-driven or event-based, where the former can follow either subjective or objective time schedules. Furthermore, the economic activities take place on a hierarchy of time-scales: yearly, monthly, weekly and daily activities all take place following calendar-time or subjective agent-time. Agents are activated asynchronously according to their subjective time schedules that is anchored on an individual activation day. These activation days are uniformly randomly distributed among the agents at the start of the simulation, but may change endogenously (e.g., when a household gets re-employed, its subjective month gets synchronized with the activation day of its employer due to wage payments). This modeling approach is supposed to capture the decentralized and typically asynchronous nature of decision making processes and activities of economic agents.

2.2 Agents, Markets, and Decisions

2.2.1 Output Decision and Production

Consumption goods producers need physical capital and labor for production. A firm i has a capital stock $K_{i,t}$ that is composed of different vintages v with $v = 1, ..., V_t$, where V_t denotes the number of available vintages a time t. The accumulation of physical capital by a consumption goods producer follows

$$K^v_{i,t+1} = (1 - \delta)K^v_{i,t} + I^v_{i,t} \tag{1}$$

where δ is the depreciation rate and $I^v_{i,t} \geq 0$ is the gross investment in vintage v.

The production technology in the consumption goods sector is represented by a Leontief type production function with complementarities between the qualities of the different vintages of the capital good and the specific skill level of employees for using these vintages. Vintages are deployed for production in descending order by using the best vintage first. For each vintage the effective productivity is determined by the minimum of its productivity and the average level of relevant specific skills of the workers. Accordingly, output for a consumption goods producer i at time t is given by

$$Q_{i,t} = \sum_{v=1}^{V_t} \min \left[K^v_{i,t}, \max \left[0, L_{i,t} - \sum_{k=v+1}^{V_t} K^k_{i,t} \right] \right] \cdot \min \left[A^v, B_{i,t} \right], \tag{2}$$

where $L_{i,t}$ is labor input, A^v is the productivity of vintage v and $B_{i,t}$ denotes the average specific skill level in firms as explained in more detail in Section 2.2.3.

The fact that the considered production function takes into account the vintage structure of the capital stock and that firms select among different available vintages enables us to capture the effect of workers' skills on the incentives of firms to invest into new technologies (see Section 2.2.4).

Once every month each firm determines the quantities to be produced and delivered to the mall. Actual demand for the product of a firm in a given month is stochastic (see below) and there are stock-out costs, because consumers intending to buy the product of a firm move on to buy from a different producer in case the firm's stock at the mall is empty. Therefore, the firm faces a production planning problem with stochastic demand and stock-out cost. The simplest standard heuristic used in the corresponding Operations Management literature prescribes to generate an estimation of the distribution of demand and then choose the planned stock level after delivery such that the (estimated) stock-out probability during the following month equals a given parameter value which is influenced by stock-out costs, inventory costs and risk attitude of the firm (see, e.g., Silver et al., 1998). Firms in the Eurace@Unibi model follow this simple heuristic, thereby generating a target production quantity for the considered month. Based on the target production quantity the firm determines the desired input quantities of physical capital and labor. Realizing this production plan might induce the need to buy new physical capital, hire new labor or to obtain additional credit. The firm might be rationed on the labor and credit market, in which case it adjusts its production quantity downwards.

2.2.2 Pricing Decision

Consumption goods producers set the price of their products once a year which is consistent with empirical observations (see, e.g., Fabiani et al., 2006). The pricing rule is inspired by the price setting described in Nagle et al. (2011, ch.6), a standard volume on strategic pricing in the Managerial literature. Firms seek for a profit-maximizing price taking into account the trade-off between price, sales and costs.

To obtain an indication of the effect of price changes on sales the consumption goods producers carry out *simulated purchase surveys* (see Nagle et al., 2011, pp. 304). A representative sample of households is asked to compare a firm's product with the set of the currently available rival products for a range of prices. Households' answers are based on the same decision rules they use for their real purchasing decisions. Based on the resulting demand estimations and cost considerations firms choose the price which maximizes their expected discounted profit stream over their planning horizons.

2.2.3 Adjustment of Specific Skills of Workers

The productivity of a worker h is determined by an endogenously increasing specific skill level $b_{h,t}$. It is assumed that during the hiring process the specific skills of job candidates cannot be observed by potential employers. They become observable during the production process. Workers increase the specific skills over time during production by a learning process. The speed of learning depends on the average quality of the technology $A_{i,t}$ used by employer i:

$$b_{h,t+1} = b_{h,t} + \chi^S \cdot \max[0, A_{i,t} - b_{h,t}]. \tag{3}$$

Here $b_{h,t}$ are the specific skills of worker h in period t and $0 < \chi < 1$ denotes the speed of adjustment of specific skills.[5]

2.2.4 Technological Change

The supply of the capital goods and the process of technological change is modeled in a very simplified way. We recur to a single capital good producer that offers different vintages of the capital good $v = 1, ..., V_t$ that have distinct productivities A^v. Alternatively, our representation of the supply of capital goods can be interpreted as a market with monopolistic competition structure, where each vintage is offered by a single firm, which uses the pricing rule described below.

New vintages become available over time following a stochastic process. To avoid spurious growth effects, due to stochastic differences in the dynamics of the technological frontier between runs, we use identical realizations of the stochastic process governing the emergence of new vintages in all runs.

To keep the description of this sector as simple as possible, no explicit representation of the production process and of the needed input factors is introduced. To account for the cost dynamics, it is assumed that the main factor of production costs is the wage bill and, since wages increase on average with the same rate as productivity grows (see Subsection 2.2.6), the growth rate of productivity is used as a proxy for the increase in production costs of the capital goods.

The pricing of the vintages $p_{v,t}$ is modeled as a combination of cost-based p_t^{cost} and value-based prices $p_{v,t}^{value}$ (see, e.g., Nagle et al., 2011):

$$p_{v,t} = (1 - \lambda)p_t^{cost} + \lambda p_{v,t}^{value}. \tag{4}$$

Due to our assumption above, p_t^{cost} increases with the average productivity of the economy. For the value-based price component the average general and specific

[5] In the general version of the model heterogeneity of the learning speed across individuals is captured and it is assumed that the speed of adjustment positively depends on the level of general skills (see Dawid et al., 2018d). In the context of the policy analysis in this paper we abstract from the explicit representation of the heterogeneity of general skills.

skills in the economy are determined first. In a next step the discounted productivities for each vintage are calculated for a firm that employs workers whose human capital is equal to the average of the economy. The value-based part $p_{v,t}^{value}$ is proportional to this estimated effective productivity of the vintage. The motivation for this rule is that the capital good producer tries to estimate the value of each vintage, in terms of effective productivity, for its average customer. Furthermore, it is assumed that the capital good producer is able to deliver any demanded quantity of any vintage.

The reason why we choose such a simplified representation of the capital goods sector is our focus on the interaction of labor market and consumption goods market dynamics. Therefore, we try to keep all other sectors as simple as possible. Not explicitly modelling the hiring and firing decisions of the capital goods producer has two main implications. First, there are no wage payments from the capital goods producer to households. However, in order to close the model, all revenues of the capital goods producer are channeled back to the households through dividends on the index bonds. Second, the capital goods producer is never rationed on its input markets, in particular on the labor market. The qualitative implication of explicitly capturing the capital goods producer's hiring process would be that in periods when labor market tightness is high there would be a relatively high probability that the capital goods producer is rationed on the labor market. Being rationed the firm would not be able to deliver the full amount of capital goods that is demanded by the consumption goods producers. This would slow down the expansion of these consumption good producers relative to their plans. Such a qualitative effect is already present in the model since consumption good producers need to hire labor themselves whenever they want to expand their production. Through this channel a tight labor market has already a hampering effect on firms' expansion and potential rationing of the capital goods producer would not add a qualitatively different effect.

2.2.5 Investment and Vintage Choice

If consumption good producers have a target output level which cannot be produced with their current capital stock, they acquire new capital. To this end, a consumption goods firm has to choose from the set of available vintages. For the decision in which vintage to invest the complementarity between specific skills and technology plays an important role: due to the inertia of the specific skill adaptation, the effective productivity of a vintage with $A^v > B_{i,t}$ is initially below its quality. It converges to A^v over time as the specific skills of workers at the firm catch up to the quality of the vintage. Therefore, the firm computes a discounted sum of estimated effective productivities over a fixed time horizon S. The specific skill evolution is estimated for each time step within $[t, t+S]$ using (3), where

the firm inserts its average specific skill values. A logit choice model based on the ratio of the estimated effective productivity and price for each available vintage determines which vintage is ordered.

Capital goods are produced on demand, and as consumption goods producers may find it more suitable for their production plans not to employ the latest vintages, the capital good producer keeps on delivering also older vintages as the technology frontier grows. Note, that the way we model the capital good producer it is a proxy for a more differentiated market with different firms supplying different vintages. In this sense, we capture vertical differentiation in the supply of capital goods. Having an elaborated vintage supply is crucial for our contribution given that the dynamics of the model unfold through the interaction of heterogeneous labor and capital as inputs to competing consumption goods producers. In particular, our approach allows to capture the effects of the skill endowment in a region on the vintage choice of firms and therefore on local technological change, which is an important mechanism in our analysis.

2.2.6 Labor Market Interaction

If the current workforce of a firm is not sufficient to produce its target output, the firm posts vacancies for production workers. The wage it offers is a combination of a firm-specific wage offer $\tilde{w}_{i,t}^{O}$ and a centrally determined wage component w_t^U.

The firm specific wage offer has two constituent parts. The first part is the market driven base wage $w_{i,t}^{base}$. The base wage is paid per unit of (expected) specific skills of the worker. If the firm cannot fill its vacancies and the number of unfilled vacancies exceeds some threshold $\overline{v} > 0$ the firm raises the base wage offer by a fraction φ to attract more workers, i.e.

$$w_{i,t+1}^{base} = (1+\varphi) w_{i,t}^{base}. \tag{5}$$

The second part of the firm-specific wage offer is related to an applicant's expected level of specific skills. Since the specific skills represent the (maximal) productivity of the employees, the wage $w_{i,t}$ is higher for higher (expected) specific skills. Because the specific skill level of a job applicants is not observable firms use the average specific skills of all their employees to estimate that skill level and would offer a wage of

$$\tilde{w}_{i,t}^{O} = w_{i,t}^{base} \times \min[A_{i,t} \bar{B}_{i,t-1}] \tag{6}$$

where $\bar{B}_{i,t-1}$ are the average specific skills of all employees in the firm. A firm can observe the specific skill levels of all its current employees, however, this information will not be transferred to a competitor in case a worker applies there.

The second wage component w_t^U is determined by a labor union and is, therefore, the same for all firms. The aim of the union is to equalize the wage inequality

that emerges from firms' heterogeneity with respect to productivity. Furthermore, the workers should benefit from the productivity gains in the economy and should be compensated for real income losses due to inflation. Altogether, we assume that the union wage is adjusted over time by

$$w_t^U = w_{t-1}^U \left(1 + \max\left[0, \bar{\pi}_t + \bar{g}_t\right]\right), \tag{7}$$

where $\bar{\pi}_t$ is the mean monthly inflation rate and $\bar{g}_t$ the average economy-wide productivity growth per month, both averaged over the last year. The actual wage offer of a firm is then

$$w_{i,t}^O = (1 - \lambda_t^C)\tilde{w}_{i,t}^O + \lambda^C w_t^U, \tag{8}$$

where $\lambda_t^C \in [0, 1]$ captures the level of centralization in the wage determination. Note that this wage setting is a reduced form representation of a bargaining process between firms and the labor union, where λ_t^C is a time variant policy parameter that represents the negotiation power of the labor union.

Similarly, we assume that the adjustment of wages of incumbent workers depends on the level of wage centralization. Formally, we have for the wage of a worker h that works for employer i in the two consecutive periods $t-1$ and t

$$w_{h,i,t} = w_{h,i,t-1}(1 + \max\left[0, \bar{g}_t + \lambda_t^C \bar{\pi}_t\right]). \tag{9}$$

Thus, if the wages are determined fully decentralized, then the wages of incumbent workers increase with the speed of productivity growth. If, however, the wages become more centralized, then wage adjustment of incumbent workers better accounts for inflation. In case of full centralization, all wages of incumbent workers correspond to the union wage w_t^U.

An unemployed worker considers the wage offers posted by a random sample of searching firms and compares them with her reservation wage $w_{h,t}^R$. A worker h only applies to firm i if it makes a wage offer $w_{i,t}^O > w_{h,t}^R$.

The level of the reservation wage is determined by the current wage if the worker is employed, and in case of an unemployed worker by her previous wage, where the reservation wage declines with the duration of unemployment. The reservation wage never falls below the level of unemployment benefits. If the unemployed worker receives one or more job offers she accepts the job offer with the highest wage offer. In case she does not receive any job offers she remains unemployed.

In case the workforce of a firm is too large relative to its target output level, the firm adjusts its number of workers. The set of dismissed workers is random. Additionally, there is a small probability for each worker-employee match to be separated in each period. This should capture job separations due to reasons not explicitly modeled.

2.2.7 Consumption Goods Market Interaction

The consumption goods market is represented by a mall at which the consumption goods producers can offer and sell their products to their customers. Households go shopping once a week and try to spend their entire weekly consumption budget for one good. The consumption budget is determined using a (piecewise) linear consumption rule according to the buffer-stock approach (see Carroll, 1997; Allen and Carroll, 2001). At the beginning of their shopping procedure they get information about the prices of all available goods at the mall, but they get no information about the available quantities. The decision which good to buy is described using a logit-choice model with strong empirical foundation in the Marketing literature (see, e.g., Malhotra, 1984). We assume the most important factor governing the consumers choice is the price sensitivity of consumers and therefore the intensity of competition between the consumption good producers.

The consumption requests for the different goods are collected by the mall and, if the total demand for one good exceeds its mall inventory level then the mall has to ration the demand. In this case the mall sets a rationing quota corresponding to the percentage of the total demand that can be satisfied with the available goods. Each household receives the indicated percentage of the requested consumption good.

After the shopping activity, rationed households may still have parts of their consumption budget available. Those households have the opportunity to spend the remaining budget for another good in a second shopping loop. In this case the shopping process is repeated as described above.

The production of the consumption goods firm follows a fixed time schedule with fixed production and delivery dates. Even if the mall stock is completely sold out it can only be refilled at the fixed delivery date. Consequently, all the demand that exceeds the expected value of the monthly sales plus the additional buffer cannot be satisfied.

2.3 Parametrization and Validation

In order to determine the values and ranges of parameters to be used in the policy experiments we follow an approach that combines direct estimation of parameters for which empirical observations are available with an indirect calibration approach. This is done in order to establish confidence in the ability of the model to capture economic mechanisms which are relevant for real world economic dynamics. Standard constellations have been identified, where values of parameters are chosen to reflect empirical evidence whenever possible and where a large set of stylized facts can be reproduced. Furthermore, the fact that the development of the Eurace@Unibi model follows as far as possible the Management Science

approach, briefly discussed above, provides empirical grounding to individual decision rules, thereby addressing the important point of empirical micro-foundations for modeled behavior.

The set of macroeconomic stylized facts that have been reproduced by the standard constellations of the Eurace@Unibi model includes persistent growth, low positive inflation and a number of important business cycle properties: persistent fluctuations of output; pro-cyclical movement of employment, consumption and investment, where relative sizes of amplitudes qualitatively match those reported e.g. in Stock and Watson (1999), counter-cyclical movement of wages and firm mark-ups. On the industry level the model generates persistent heterogeneity in firm-size, profit rates, productivity and prices in accordance with empirical observations reported e.g. in Dosi et al. (1997). Also labor market regularities, like the Beveridge curve, are reproduced by the model with benchmark parameter constellations. The reader is referred to Dawid et al. (2012) for a more detailed discussion of this issue. Tables with the list of parameter values used in the simulations underlying this paper are provided in the Appendix.

3 Policy Analysis

3.1 Experimental Setup

Our simulation experiment addresses the long-term economic implications of a decentralization of the wage formation process. The starting point of our analysis is a baseline scenario that describes an economy with a fully centralized wage setting. Full centralization means that there is a uniform union wage from which firms cannot deviate to pay wages that would take firm specific characteristics into account. This baseline scenario is contrasted with policy scenarios in which at a specific point in time $t = T^D$ a decentralization process is initiated that leads to more flexibility in the wage setting thereby facilitating firms to deviate from the centrally set wage.

The narrative of this experimental setup is that the economy is initially characterized by a centralized collective wage setting, and then undergoes substantial changes in the institutional setup of the labor market and/or a de-unionization of the labor force that leads to less centralization in the wage formation process. The policy scenarios we analyze differ from each other in terms of the extent to which reductions in the centralization are realized. In the context of our model, the reductions can be achieved by decreasing the parameter λ_t^C governing the degree of centralization of the wage bargaining process.

In our experiments, we distinguish three time phases. In the pre-policy phase $0 < t < T^D$, we assume that the wage formation is fully centralized with $\lambda_0^C = 1.0$,

which corresponds to the situation observed in the baseline scenario. At period $t = T^D$, the decentralization process starts through which λ_t^C declines from its initial level λ_0^C to a scenario specific level $\bar{\lambda}^C < 1.0$. In order to capture that it takes some time before the reforms are fully effective, we assume a policy phase in which λ_t^C decreases gradually until it reaches the target level $\bar{\lambda}^C$. We assume that the adjustment is on a yearly base with step size Δ_{λ^C}. Thus, the policy phase covers the period from $t = T^D$ to $t = \bar{T}^D$, where

$$\bar{T}^D = T^D + 12 \cdot \left\lceil \frac{\lambda_0^C - \bar{\lambda}^C}{\Delta_{\lambda^C}} \right\rceil . \tag{10}$$

All following periods $t > \bar{T}^D$ constitute the post-policy phase. Put formally, the evolution of λ_t^C can be described by

$$\lambda_t^C = \begin{cases} \lambda_0^C & t < T^D, \\ \lambda_{t-1}^C & T^D \leq t < \bar{T}^D \text{ and } t \mod 12 \neq 0, \\ \lambda_{t-1}^C - \Delta_{\lambda^C} & T^D \leq t < \bar{T}^D \text{ and } t \mod 12 = 0, \\ \bar{\lambda}^C & t \geq \bar{T}^D. \end{cases} \tag{11}$$

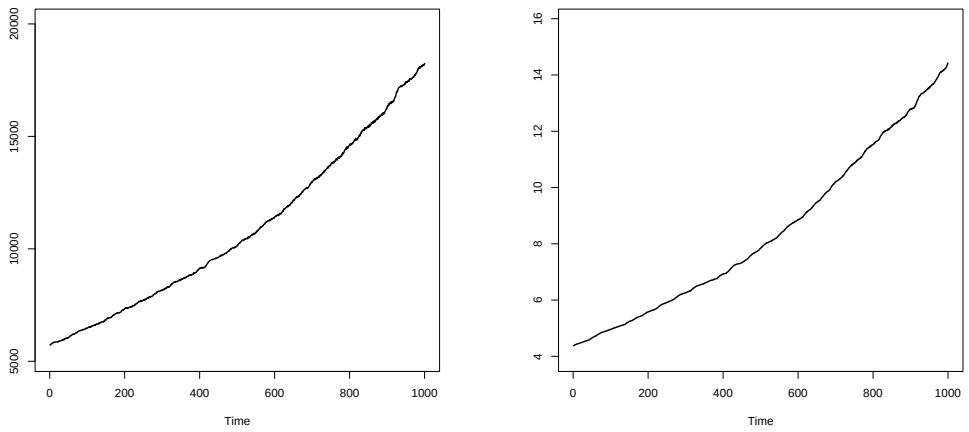
Since we focus on a long-term perspective, we consider the effects of a decentralization of the wage formation emerging after a relatively long time horizon of 1000 months. Moreover, we apply the policy treatment after a pre-policy phase of 1000 iterations (i.e. $T^D = 1000$) in order to ensure that no transient effects distort our policy analysis. Overall, we consider a time horizon of 2000 iterations where the pre-policy phase is used as transient period and will not be considered in the following analysis.

Besides the baseline scenario in which the wage setting is kept fully centralized over the full time horizon, we explore 10 policy scenarios with different target levels $\bar{\lambda}^C$. The analyzed values range from $\bar{\lambda}^C = 0$ corresponding to a scenario with full decentralization to $\bar{\lambda}^C = 0.9$ representing a high level of centralization, with a step size of 0.1 in between. We run for each of the 11 scenarios 100 Montecarlo simulations.

3.2 Results

3.2.1 The baseline scenario

We start the discussion of our results with a brief description of some key characteristics of our baseline scenario where the wage setting is kept fully centralized over the full time horizon. Once the behavior of the baseline model is described, we will go into the policy analysis applying the decentralization policies to our model.



(a) (b)

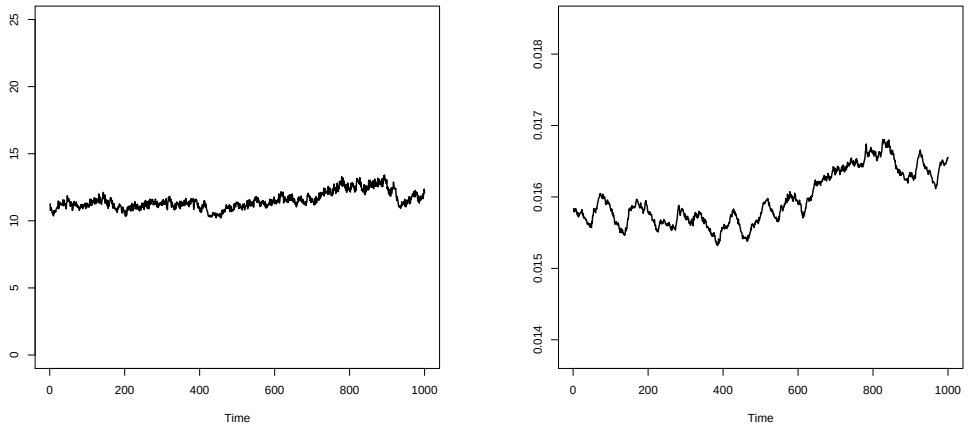
Figure 1: Time series of total output (a), and productivity (b) of the baseline scenario.

Figure 1 shows time series for aggregate output (panel a) and productivity (panel b). The economy features an increase in total output driven by a constant increase in productivity. The average annual growth rate is around 1.4% for total output and 1.44% for productivity. Figure 2 shows the time series for the unemployment rate (panel a) and the Herfindahl index (panel b) – a measure for industry concentration. Panel (a) indicates a stationary unemployment rate that fluctuates around a level of 11%. The Herfindahl index stays in a corridor between 0.0155 and 0.017. Given that the model has been set up with 80 firms, the simulated values for the Herfindahl index suggest a competitive industry with only a moderate tendency towards market concentration.[6] Altogether, the baseline scenario with a fully centralized wage formation describes an economy with a competitive industry characterized by technology-driven economic growth and persistent unemployment.

3.2.2 The long-term effects of a decentralized wage setting

Let us first consider the effects of a less centralized wage setting on growth and employment. In order to illustrate the simulation outcomes we use boxplots where each boxplot represents the distribution of a variable over the 100 batch runs for the considered levels of de-centralization from from 0% (baseline scenario) to 100% (full de-centralization). Figure 3 shows boxplots for the average annual growth

[6] In fact, the smallest possible Herfindahl index in an industry with 80 is 0.0125, describing a situation in which all 80 firms have the same market share.



(a) (b)

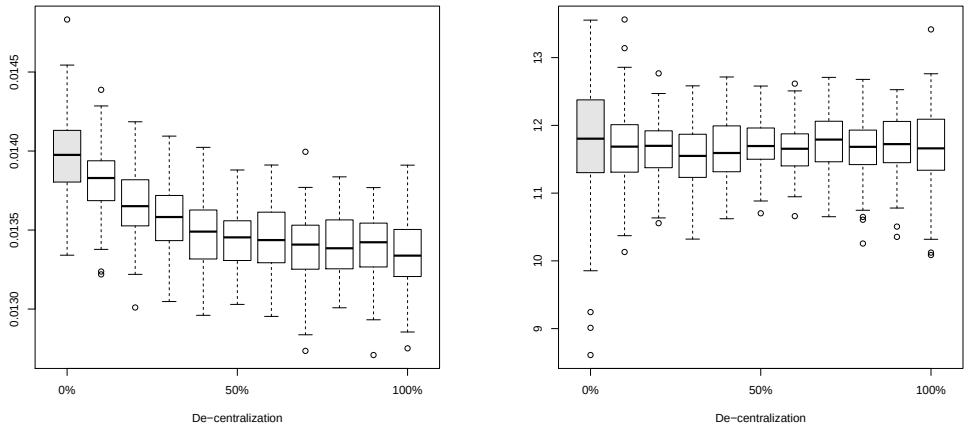
Figure 2: Time series of unemployment rate (a), and Herfindahl index (b) for the baseline scenario.

rate of total output (left panel) and the unemployment rate. The growth rate is computed for the entire time horizon and the unemployment rate is the average over the last 20 months.[7]

From Figure 3 (a) one can see that a decentralization of the wage setting results in a negative growth effect. The size of the effect is declining in the degree of flexibility meaning that a small to medium change in de-centralization causes stronger growth reductions whereas any further flexibility in the wage setting leads only to minor additional losses in output growth. Panel (b) demonstrates that the lower growth is not driven by negative employment effects. The reduction in the centralization of the wage setting does not change the unemployment rate in the long run.

Figure 4 illustrates the effects of an increasing de-centralization on inequality, where panel (a) depicts the effect on wage inequality, and panel (b) the effect on income inequality. Since wage inequality considers only labor income of employed households and, at the same time, we do not distinguish different types of workers, the inequality of wages is zero when wages are collectively negotiated. In fact, every worker receives the same labor income regardless of the characteristics of the employer or the tenure of the job. With an increasing decentralization of the wage setting process, however, firms have more scope to offer wages that reflect specific properties of the firm such as the firm-specific productivity profile and the

[7]Note that for expositional convenience the scale used for the boxplots describes a variation from $(1 - \bar{\lambda}^C) \times 100$.



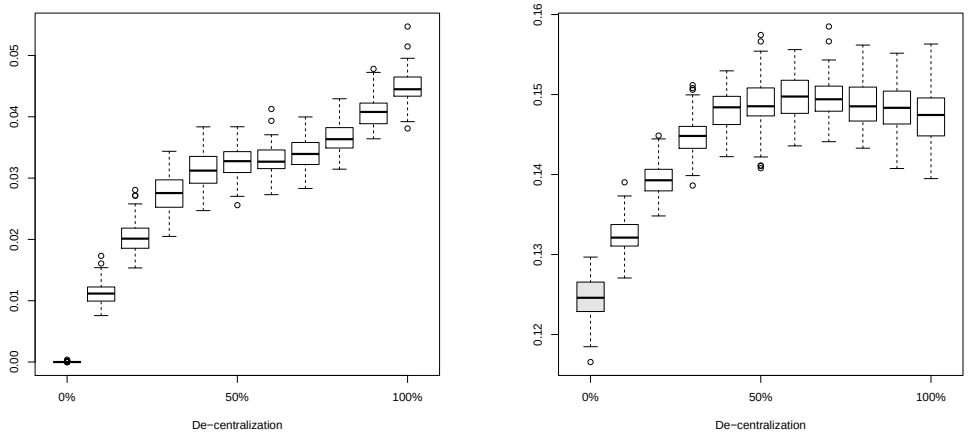
(a) (b)

Figure 3: Effect of a de-centralization on average output growth (a), and the unemployment rate at the end of the simulations (b).

perceived tightness the firm faces on the labor market. Consequently, the more decentralized the wage setting becomes, the more individualized are the wages resulting in an increasing wage inequality. Qualitatively, there is a similar picture for income inequality, which, besides wages, also includes unemployment benefits and capital income. Income inequality, which is already present in case of fully centralized wages, tends to increase with a larger decentralization, however only up to a degree of decentralization of 60%. After that income inequality slightly decreases as the wage setting becomes more decentralized.

Now, we turn to the implications of a de-centralized wage setting process for industry dynamics. Panel (a) of Figure 5 shows how the industry concentration is affected by a change in the wage centralization. One can see that the Herfindahl index is the highest in the baseline scenario and decreases as the wage setting becomes less concentrated. Thus, de-centralization is associated with less industry concentration in the long run. Panel (b) of that figure depicts the average number of ranks a firm moves up or down along the order by firm size in each period, which we use as an indicator for the dynamics of market shares. The figure suggests that the firm order shows the highest persistence in the baseline scenario and otherwise follows an inverse U-shaped relation, i.e. the volatility of market shares is the highest at medium levels of wage centralization.

In Figure 6 (a) we show the average size of the capital stock of firms at the end of the simulation. Apparently, the average capital stock of firms is the largest in the baseline scenario in which we have observed the highest output growth.



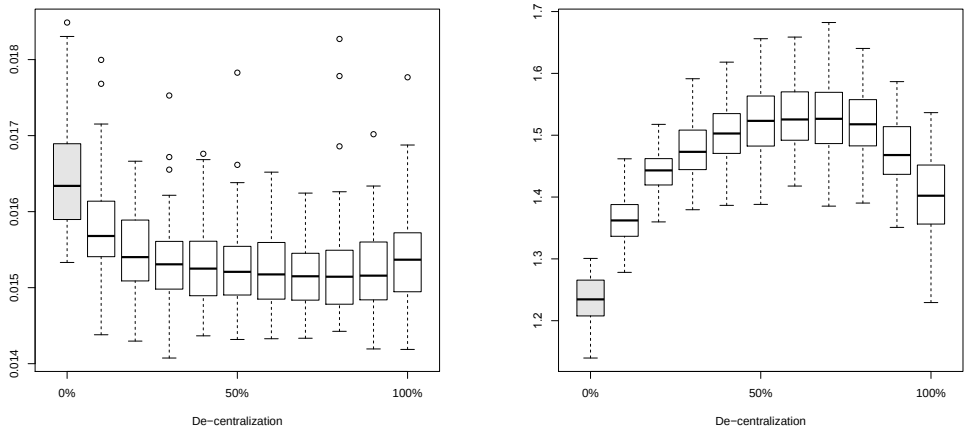
(a) (b)

Figure 4: Effect of a de-centralization on inequality of wages (a), and income (b) at the end of the simulation (measured as percentage standard deviation).

This gives a clear indication that the higher long-term growth under a centralized wage setting emerges through heavier overall investments by firms giving rise to larger capital stocks and faster replacement of old vintages. As a result, there is a higher productivity growth in the economy, which is indeed evidenced in panel (b) plotting the annual growth rate of the productivity of firms employed capital stock. This suggests that the negative effect of a de-centralization on output growth is driven by a slower pace of technical change, which in turn is the consequence of less capital investments of firms.

What stands behind these observations? First of all, it should be noted that firms compete on two markets, the goods market and the labor market. On the goods market, firms compete on prices to generate demand, where the cost structure of a firm eventually determines whether it is profitable to set a higher or a lower price compared to the competitors. On the labor market, firms bid for workers and the main distinguishing feature between firms is the wage that they offer to potential applicants.

A fully centralized wage has two implications. First, the competition on the labor market is turned off as firms can only offer the uniform union wage in the hiring process. In fact, if there are no differences in the wage offer, then job seekers are indifferent between any potential employer and choose the firm to apply randomly. The second implication is that uniform wages give firms with a high productivity a strong competitive advantage in the goods market. If wages are fully equal, the unit labor costs of a firm are entirely determined by its productivity,



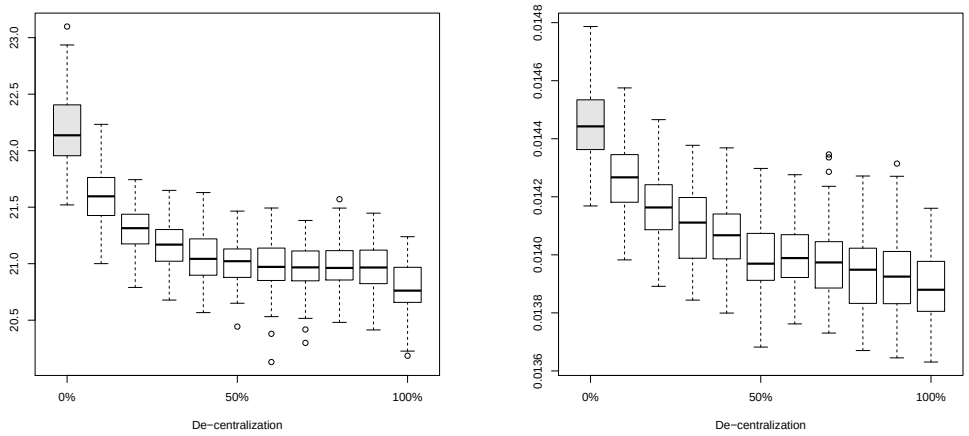
(a) (b)

Figure 5: Effect of a de-centralization on the Herfindahl index at the end of the simulation (a), and the firm size dynamics measured by firms' average change per period of ranks in the firm order determined by output size (b).

which enables high-tech firms to set prices more aggressively.

If, in contrast, the wage setting becomes more de-centralized, then wages become increasingly correlated with the productivity level of firms. This, however, weakens the cost advantage of high-tech firms as the higher wages counteract the cost-reducing effects of a higher productivity. At the same time, more flexibility in the wage setting strengthens the importance of base wage offers for the level of unit labor costs. As described in Section 2.2.6, the base wage offer reflects the wage a firm is willing to pay per expected unit of productivity and has therefore a positive impact on labor unit costs. It is driven by the competition on the labor market and tends to be higher for those firms that have historically faced more problems to fill open vacancies.

Hence, a change in the degree of wage centralization changes the relative importance of two channels driving the unit costs of firms. But how does a shift in the cost mechanisms affect the cost and price advantage of high-tech firms? In order to make a systematic comparison of high- and low-tech firms, we show in the following boxplots for different variables the ratios between high- and low-tech firms. We characterize a firm as high-tech firm if the productivity of its employed capital stock is above the median productivity in the firm population. A ratio above 1.0 implies that the considered variable is on average higher for high-tech firms than for low-tech firms. Figure 7 (a) depicts the price ratio between the two types of firms. One can see that high-tech firms set their prices more aggressively



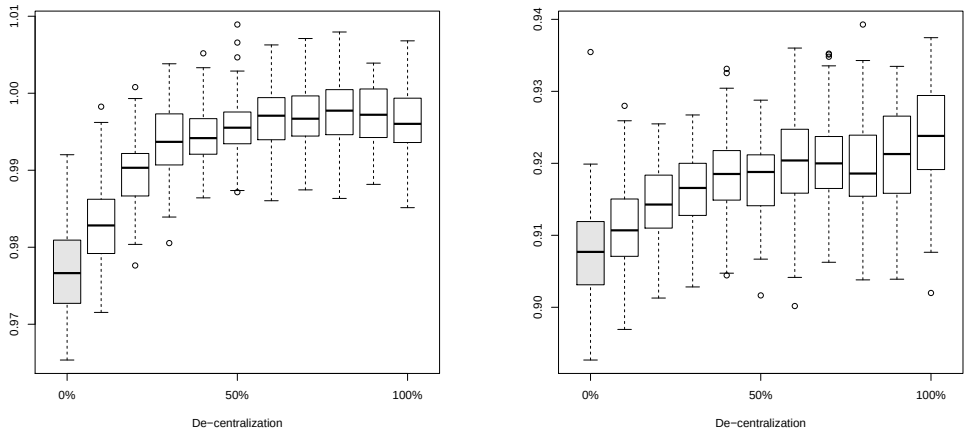
(a) (b)

Figure 6: Effect of a de-centralization on the average size of firms' capital stock (a), and the average productivity growth in the economy (b).

in comparison to low-tech firms. The price gap is the largest under a fully centralized wage regime. A qualitatively similar picture can be observed for the relative unit labor costs (panel b). The cost advantage of high-tech firms is also decreasing in the degree of de-centralization. Apparently, high-tech firms forfeit parts of their competitive advantage when the wage setting is shifted from full centralization to more flexible wage regimes.

In Figure 8 (a) and (b), we show the main determinants of the unit labor costs. Panel (a) plots the effect of a de-centralization on the relative productivity, where we consider the effective productivity defined as the minimum of the productivity of a firm's capital stock and the mean specific skills of workers of that firm. Again, the most pronounced differences between the two types of firms can be found under full centralization, where already a small flexibilization of the wage setting leads to substantial reductions in the productivity gap. In panel (b), we demonstrate the relative base wage offers.[8] Here, one can see that as long as the wages are sufficiently centralized, high-tech firms have on average larger base wage offers than low-tech firms. This can be explained by the productivity-driven cost advantage translating into more labor market activities of those firms which drive up their base wage offers over time. With an increasing de-centralization, however, wages become more heterogeneous among firms introducing the positive correlation between productivity and wages. In this situation, low-tech firms face an inherent

[8]Note that the base wage offer is not depicted for the baseline scenario as this variable is not determined under full wage centralization.



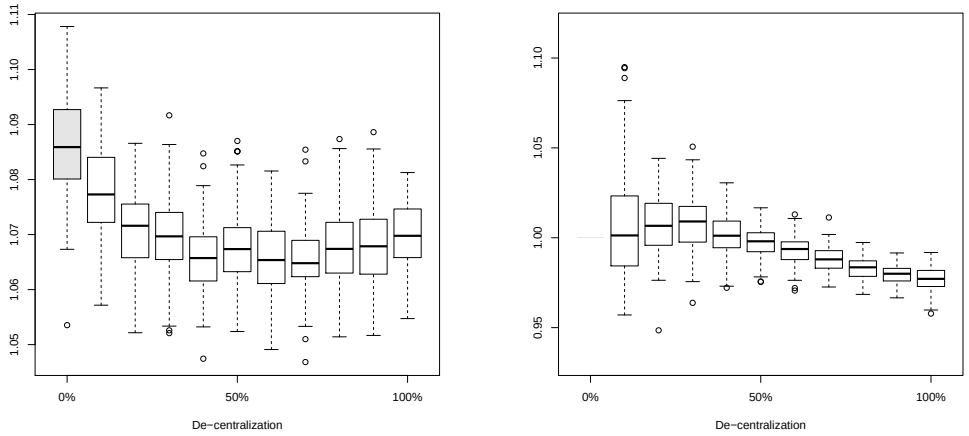
(a) (b)

Figure 7: Effect of a de-centralization on the ratio of high- and low-tech firms for prices (a), and unit labor costs (b).

disadvantage on the labor market and have to set higher base wage offers in order to still be able to successfully bid for workers. As a result, for higher levels of de-centralization, we observe that the base wage offers are higher for low-tech firms, which in turn contributes to larger unit labor costs in these scenarios.

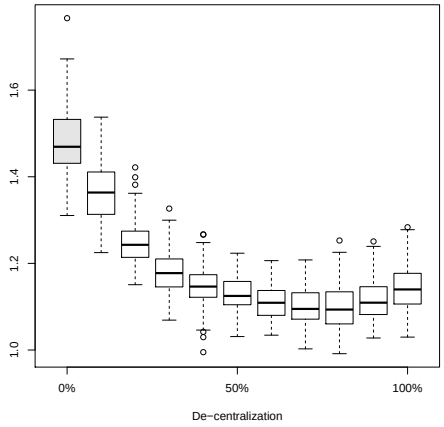
Overall, one can conclude that in case of a more centralized wage formation the cost and price advantages of high-tech firms are directly driven by their productivity advantage, whereas for a more de-centralized wage setting the competitive advantage of high-tech firms arises through the competition on the labor market in which high-tech firms can offer relatively high wages without substantially impairing their unit costs.

Finally, in Figure 8 (c) and (d), we demonstrate the relative size of the capital stock of high- and low-tech firms as well as their relative outputs. Again, in both figures, the largest difference between high- and low-tech firms can be observed in case of full wage centralization. A notable observation is, however, that under full wage centralization output and capital of high-tech firms are about 50% higher than output and capital of low-tech firms, whereas the productivity of high-tech firms exceeds the one of low-tech firms only by around 8%. This clearly indicates that the higher aggregate growth and the higher market concentration under wage centralization is driven by a relative growth of high-tech firms induced by their productivity-driven cost advantage. This cost advantage enables them to set prices more aggressively compared to their low-tech competitors, which in turn leads to more capital investments and larger output growth of these firms in the long run.

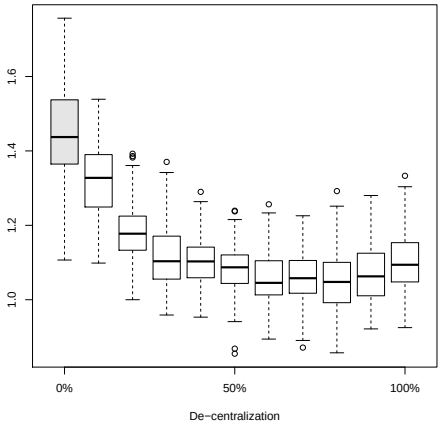


(a)

(b)



(c)



(d)

Figure 8: Effect of a de-centralization on the ratio between high- and low-tech firms for effective productivity (a), base wage offers (b), size of capital stocks (c), and output (d).

If wages are determined in a decentralized manner, then high-tech firms have still a cost advantage but it is weaker than the one under full wage centralization. As a result, there is less relative output growth of high-tech firms such that more of the productive resources of the economy are employed by low-tech firms which eventually gives rise to lower long-term growth of aggregate output.

4 Discussions and Conclusions

There has been a secular decline in the unionization of labor markets and coverage of workers with collective agreements. Moreover, collective agreements have become more flexible in the sense that opening clauses allow firms to deviate from regional or sectoral agreements to a larger extent than previously. It has been argued that while theses changes in the wage setting process of economies has been contributing to larger wage inequality, it should also have increased firms' competitiveness fostering economic growth.

In our contribution, we scrutinize this narrative. To this end, we analyze the effect of centralized versus de-centralized wage setting arrangements in a closed agent-based macro-economic model. In contrast to previous analyses, we incorporate not only the effect that de-centralized wage setting has on firms' competitiveness on the labor market, but also look into the effect it has on firms' competitiveness in the product market. We show that more wage flexibility indeed increases wage and income inequality. It has, however, a negative effect on output growth. De-centralized wages curb the cost advantage that high-tech firms have. Under centralized wages, high-tech firms can charge lower prices than their competitors which enables them to capture a larger market share spurring investments in their capital stock. The large and more up-to date capital stocks of the well performing high-tech firms in a market with centralized wages lead to higher growth rates than one gets in a market with de-centralized wages in which capital investments are spread among more firms but are overall lower.

We are aware that our analysis rests on a range of modeling assumptions and calibration choices that we had to make. Nevertheless, it suggests that one should be careful with overhasty policy conclusions on the benefits of de-unionized labor markets. More decentralized wage setting systems do appear to increase income inequality but they may not necessarily increase growth.

A Appendix

Table 1 gives an overview over the most important model parameters. Table 2 shows the set-up of the model with respect to different agent types.

Table 1: Values of selected parameters.

Parameter	Description	Value
u	Wage replacement rate	0.55
Φ	Target wealth/income ratio	16.67
κ	Adjustment wealth/income ratio	0.01
δ	Capital depreciation rate	0.01
χ	Service level for the expected demand	0.8
γ^C	Intensity of consumer choice	16.0
ρ	Discount rate	0.02
S	Firm time horizon in months	24
Δq^{inv}	Technological progress	0.05
λ	Bargaining power of the capital goods producer	0.5
γ^v	Logit parameter for vintage choice	30.0
φ	Wage update	0.005
$\overline{v}$	Number of unfilled vacancies triggering wage update	2
ψ	Reservation wage update	0.1
α_D	Number applications per day	1
α_T	Total number applications per month	6
χ^S	Specific skills adaptation speed for low skilled workers	0.03703
τ^I	Income tax rate	0.065

Table 2: Number of agents.

Agent type	Number
Households	1600
Consumption good firms	80
Capital good firm	1
Banks	2
Government	1
Central bank	1

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