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Wage-setting coordination in a small open economy*

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Abstract

This paper studies wage-setting coordination in a two-sector, open economy dynamic stochastic general equilibrium model. Two large sectoral unions anticipate the effects of their wage demands on aggregate variables. In an open economy, there are externalities that the unions can take into account to increase aggregate welfare, but the strategic interaction between the sectoral unions tends to erode this gain. When wage coordination takes place through a wage norm set by either of the sectors, this minimizes the strategic interaction. However, wage norms create welfare losses as sector-specific wage adjustment is required to make an efficient adjustment to shocks.

Keywords: Labour unions; open economy; wage-setting coordination

JEL classification: *E*02; *F*41; *J*51

1. Introduction

Wage bargaining in many European countries occurs at a sectoral or higher level (Visser, 2019). Wages are bargained by unions that are large enough to influence the aggregate economy. In an open economy context, the conventional wisdom has been that the export sector unions should have a leading role in wage formation (Calmfors and Seim, 2013). In practice, this form of coordination has been most notably established in Norway, Sweden, and Germany. The argument is that export sector unions have a better understanding of the desired cost level compared with the rest of the world, and it is, therefore, beneficial for macroeconomic performance if wage formation in the rest of the economy is tied to wage formation in the

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export sector. Even recently, international institutions have recommended export sector-led wage formation.[1]

The study's results raise the question of whether the tradeable sector should act as the opening sector in wage-bargaining rounds. In the model, being a wage leader benefits the tradeable sector at the expense of the non-tradeable sector. The question also raised is whether non-tradeable sector wages should closely follow tradeable sector wages. Because external and domestic shocks affect the tradeable and non-tradeable sectors differently, the elimination of sector-specific adjustment can lead to welfare losses.

Wage-setting coordination is studied using a small open economy, dynamic stochastic general equilibrium (DSGE) model. The economy comprises non-tradeable and tradeable goods producing sectors. In each sector, there is one labour union that sets the wages. The setting is similar to that in the study by Calmfors and Seim (2013), which examines pattern bargaining in a static framework. The economy in this model is a member of a monetary union, and, as in Galí and Monacelli (2008), it is assumed that a monetary union consists of a continuum of small economies for which the union-wide aggregate variables are exogenous.

The unions in both sectors are non-atomistic and hence anticipate the effects of their wage demands on the aggregate variables. The consumption of domestic households consists of imported traded goods and domestic non-traded goods. Because in a monetary union, there is no stabilizing effect of the nominal exchange rate for a single member economy, nominal wages in the tradeable sector translate directly to export prices. Export prices determine the demand for domestic exports, and export revenues matter for the demand for domestic non-tradeable goods. In addition, non-tradeable goods are used as intermediate inputs for exports, linking non-tradeable sector wages and non-tradeable sector production to export prices and export demand.

I study how the coordination of wage-setting alters steady-state allocations and the adjustment to shocks. Similarly to Calmfors and Seim (2013), I examine pattern wage-setting as a Stackelberg game and uncoordinated wage-setting as a Nash game. In addition, I study coordination with a wage norm, where the wage set by the leader is imposed on the follower. This is because, in many economies where export-oriented sector unions are wage leaders, near-equal wage growth across sectors appears to be the outcome of pattern bargaining.

[1] OECD (2016) and European Commission (2017) recommendations to Finland were, respectively: "[n]egotiations should be sequenced such that trade-exposed industries settle before the others" and "[w]hile respecting the role of social partners, ensure that the wage setting system enhances local wage bargaining and removes rigidities, contributing to competitiveness and a more export industry-led approach".

The steady-state analysis in this study corresponds to the analysis in the study by Calmfors and Seim (2013). However, I allow for a richer model and study dynamic adjustments to shocks. With this richer model, I can analyse how specific factors in the economic environment influence the wage-setting by unions. Calmfors and Seim (2013) question the conventional wisdom that tradeable sector wage leadership leads to best economic performance. They find that non-tradeable sector wage leadership leads to greater wage restraint and higher employment than uncoordinated bargaining in a monetary union environment. By contrast, the results in this study do not support wage leadership by either sector.

As a result of strategic interaction between unions, wage leadership leads to steady-state solutions, in which the leader gains at the expense of the follower. If the tradeable sector acts as a leader, it sets a higher wage than with uncoordinated wage-setting. This lowers the employment in the tradeable sector but leads to an employment–consumption combination, which gives greater utility for tradeable sector workers than an uncoordinated wage-setting structure.

As the income of tradeable sector workers decreases, there is less demand for non-tradeable goods. The non-tradeable sector union reacts to lower demand by setting a lower wage. A portion of non-tradeable goods is used as intermediate inputs for exports. When the tradeable sector wage is increased, this lowers export demand and demand for non-tradeable goods as inputs for exports. This also leads the non-tradeable sector union to set a lower wage.

When a non-tradeable sector union acts as the wage leader, it also sets a higher wage than occurs in an uncoordinated wage-setting, but it is more constrained than a tradeable sector union. Most of the demand for non-tradeable goods comes from domestic demand, and, with wage-setting, the non-tradeable sector union must consider the possibility of substituting non-tradeable goods for imports in domestic consumption. A smaller share of non-tradeable sector production is used as intermediate inputs for exports, and only from this part can the non-tradeable sector act strategically against a tradeable sector union.

A wage norm where the leader's wage is imposed on the follower mitigates the strategic interaction between unions. However, in most dynamic simulations, this wage norm leads to outcomes that are detrimental to aggregate welfare. If productivity shock processes differ across sectors, it creates heterogeneity between sectors and makes differential wage growth rates between sectors desirable. Furthermore, the aggregate shocks affect each sector differently, so sector-specific adjustment is required. When the tradeable sector sets the wage norm, the non-tradeable sector over-adjusts to export demand shocks and under-adjusts to domestic demand shocks.

The analysis in this study is welfare-based. The objective of a union is to maximize the expected utility of a representative worker household in the union's sector, subject to model constraints and taking into account the wage-setting of the other union. Unions in the model can be viewed as Ramsey social planners that implement optimal policies using their instruments, which are sectoral nominal wage rates. The approach is analogous to optimal monetary or fiscal policy analysis (see, e.g., Schmitt-Grohé and Uribe, 2007), but the model includes two Ramsey planners. A methodological contribution of this study is that a DSGE model with two Ramsey planners is solved.

The comparison of different wage-setting schemes is based on the lifetime utility of households, which corresponds to the analysis of optimal monetary or fiscal policy. In Calmfors and Seim (2013), wage-setting regimes are compared in terms of employment and wage levels. This approach can be useful for policy discussion because results in terms of employment and wage levels are easier to communicate. However, there can be a large discrepancy between the objective of a union and an evaluation in terms of employment and wage levels. If social optimality is achieved with low wages and resulting high employment, why do the unions in the model not maximize these directly instead of maximizing expected lifetime utility, which consists of consumption and lost leisure? One could argue that low wages and the resulting high employment are relevant comparison criteria given the high social cost that excess unemployment creates and the positive effects of high employment for public finances, but these features do not exist in the model. Hence, considering those factors when analysing the implications of the model can easily lead to an inconsistency between the model and the interpretation of its results.

The study of Calmfors and Seim (2013) is the one that is closest to the analysis in this paper. Also, Vartiainen (2002, 2010) and Holden (2003) study wage-setting in a static, open economy model. Gnocchi (2009) studies the wage-setting of non-atomistic unions in a closed economy, New Keynesian model.

The paper is organized as follows. In Section 2, I introduce the model. The model is parametrized in Section 3. In Section 4, I present the results. I conclude in Section 5.

2. Model

The model is based on the New Keynesian, small open economy models by Galí and Monacelli (2005, 2008), albeit with several extensions. These models are the prototype open economy models in the New Keynesian literature and were hence chosen as a starting point. As in Galí and Monacelli (2008), the economy in this study belongs to a monetary union and takes the union-wide aggregate variables as a given. For simplicity, trade in goods is restricted to taking place within the monetary union, and I abstract from the modelling the rest of the monetary union.

There are two sectors: a non-tradeable goods-producing sector (N) and a tradeable goods-producing sector (T). In both sectors, there are firms producing intermediate goods. They have monopoly power and set their own prices, but they are small and take the aggregate price level as a given. Labour is the only input in the production process. Intermediate goods are aggregated into sectoral final goods. Non-tradeable goods are used for domestic private consumption and as intermediate inputs for exports. Tradeable goods are used for exports only. Firms are owned by capitalists who do not supply labour but earn profits, which they use for consumption.

Worker households supply labour and use their wage incomes for consumption and to invest in bond holdings. Worker households are represented by sectoral labour unions, which set the wages. To make the wage-setting problem of sectoral unions meaningful, I deviate from the standard single representative agent framework and assume that, in each sector, there is a representative household that supplies labour to that sector alone. Without the assumption of two sectoral representative households, both unions would be maximizing the utility of the same household and there would be no room for a game between unions. To fully utilize the modelling of two representative households, incomplete financial markets are assumed. Without that assumption, households would be able to insure themselves perfectly, and households in both sectors would consume the same amounts in all states of the world.

2.1. Consumption and production

2.1.1. Worker households. The economy consists of two types of worker households. A portion of s_T supplies labour to the tradeable goods sector and a portion of s_N supplies labour to the non-tradeable goods sector. Jobs in both sectors require sector-specific skills. It is assumed that acquiring new skills is so costly that there is no sectoral reallocation. Both types of households maximize their expected lifetime utility,

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C^w_{k,t}, L_{k,t}), \qquad k = T, N, \tag{1}$$

where T refers to a tradeable sector household and N to a non-tradeable sector household. The period utility function is given by

$$U(C^w_{k,t}, L_{k,t}; Z_t) \equiv Z_t \left(\frac{{C^w_{k,t}}^{1-\sigma}}{1-\sigma} - \frac{{L_{k,t}}^{1+\phi}}{1+\phi} \right). \tag{2}$$

Worker households obtain utility from consumption, C_t, and disutility from supplying labour, L_t. Z_t is an exogenous demand shifter – a discount rate shock – which follows a first-order autoregressive process in logs, $\log(Z_t) = \rho_z Z_{t-1} + e_t^z$.

Maximization is subject to a sequence of periodic budget constraints given by

$$P_t C_{k,t}^w + \frac{B_{k,t+1}}{R_{k,t}} \leq W_{k,t} L_{k,t} + B_{k,t}, \tag{3}$$

where P_t is the aggregate price level, W_t is the nominal wage rate, and B_t denotes the holdings of bonds that are traded within the monetary union. The return on bonds, R_t, is assumed to be debt elastic as in Schmitt-Grohé and Uribe (2003):[2]

$$R_{k,t} = R_t^* \exp(-\nu_a B_{t+1} - \nu_o B_{k,t+1}). \tag{4}$$

The return on the bond holding of a household consists of R_t^* (the union-wide interest rate) and the risk premium. The risk premium has both country-specific and household-specific components. The country-specific risk premium depends on the aggregate level of bond holdings, B_t, while the household-specific premium depends on the bond holdings of the household, $B_{k,t}$. ν_a measures debt elasticity with respect to aggregate bond holdings, while ν_o measures debt elasticity with respect to the bond holdings of the household. It is assumed that a household internalizes the effect of its bond holdings to the risk premium only through the household-specific risk premium component.

A debt elastic interest rate is needed to ensure a stationary steady state. Debt elasticity with respect to both the aggregate bond holdings and the bond holdings of the household is required to ensure that the Blanchard–Kahn condition, the stability condition for the rational expectations solution, is satisfied in all wage-setting regimes.

In each period, a household allocates its income to the consumption and bond holdings. This leads to an inter-temporal optimality condition, which is given by

$$\beta E_t \left[\frac{Z_{t+1}}{Z_t} \left(\frac{C_{k,t+1}^w}{C_{k,t}^w} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \right] = \frac{1 + \nu_o B_{k,t+1}}{R_{k,t}}. \tag{5}$$

Equation (5) differs from the standard Euler equation by the numerator on the right-hand side, which comes from households internalizing the impact of their bond holdings on the interest rate they face.

[2] Schmitt-Grohé and Uribe (2003) have only aggregate bond holdings in the function for the risk premium, and the functional form is slightly different. The reason for the chosen functional form was to ease the derivations.

Households do not decide on labour supply. Sectoral unions set the wages and households supply the amount of labour that satisfies firms' labour demand. The assumption is similar as in the model of Erceg et al. (2000), where wages are set by atomistic household-specific unions.

2.1.2. Capitalists. In both sectors, capitalists own the firms and obtain the profits, which is their only source of income. For simplicity, it is assumed, as in Broer et al. (2020), that capitalists use all their income for consumption in each period. A capitalist obtains utility from consumption by

$$U(C^c_{k,t}; Z_t) \equiv Z_t \left(\frac{C^{c\ 1-\sigma}_{k,t}}{1-\sigma} \right), \tag{6}$$

and the consumption is determined by the budget constraint

$$P_t C^c_{k,t} = D_{k,t}, \tag{7}$$

where $D_{k,t}$ is the profits generated by the firms in sector k.

2.1.3. Intermediate goods-producing firms. Non-tradeable and tradeable sector firms produce intermediate goods for wholesale firms, which aggregate the sectoral final goods. The firms are indexed by j and distributed on the unit interval. The firms producing intermediate goods use sector-specific labour as their input, and the productivity of the labour depends on an exogenous productivity process. Firms operate in the two sectors with production functions of the form,

$$Y_{k,t}(j) = A_{k,t} L_{k,t}(j) \qquad k = N, T, \tag{8}$$

and the sector-specific productivities $A_{k,t}$ follow $\log(A_{k,t}) = \rho_a \log(A_{k,t-1}) + e^A_{k,t}$.

Intermediate-goods producing firms produce differentiated goods and hence have monopoly power over setting the price. The non-tradeable and tradeable final goods are aggregated from intermediate goods using the following aggregation technology:

$$Y_{k,t} \equiv \left(\int_0^1 Y_{k,t}(j)^{(\epsilon-1)/\epsilon} dj \right)^{\epsilon/(\epsilon-1)}. \tag{9}$$

The firms in both sectors set prices in order to maximize profits with respect to a sequence of demand constraints. Prices are assumed to be sticky, following the Calvo (1983) model, and only a fraction $1-\theta$ of firms is allowed to reset prices in the current period. The maximization problem of a firm is written as

$$\max_{\bar{P}_{k,t}(j)} \sum_{p=0}^{\infty} \theta^p E_t \left[Q^k_{t,t+p} [Y_{k,t+p}(j)(\bar{P}_{k,t}(j) - MC^n_{k,t+p})] \right], \tag{10}$$

subject to

$$Y_{k,t+p}(j) \leq \left(\frac{\bar{P}_{k,t}(j)}{P_{k,t+p}} \right)^{-\epsilon} Y_{k,t+p}. \tag{11}$$

The price that a firm j in sector k sets is $\bar{P}_{k,t}(j)$, $MC^n_{k,t}$ is the nominal marginal cost, and $Q^k_{t,t+p}$ is a stochastic discount factor given by

$$Q^k_{t,t+p} = \beta^p \frac{Z_{t+p}}{Z_t} \left(\frac{C^c_{k,t+p}}{C^c_{k,t}} \right)^{-\sigma} \frac{P_t}{P_{t+p}}. \tag{12}$$

The resulting first-order condition for a firm's price setting is given by

$$\sum_{p=0}^{\infty} \theta^p E_t \left\{ Q^k_{t,t+p} \left[(1-\epsilon) \left(\frac{\bar{P}_{k,t}(j)}{P_{k,t+p}} \right)^{-\epsilon} Y_{k,t}(j) + \epsilon \frac{\bar{P}_{k,t}(j)^{-(\epsilon+1)}}{P^{-\epsilon}_{k,t+p}} Y_t MC^n_{k,t+p} \right] \right\} = 0. \tag{13}$$

Equation (13) contains a summation towards infinity, but it can be presented recursively as a two-period problem using the auxiliary variables $F_{k,t}$ and $K_{k,t}$ and defining the sectoral gross inflation rate $\Pi_{k,t} = P_{k,t-1}/P_{k,t}$.

$$K_{k,t} = F_{k,t} \frac{\epsilon - 1}{\epsilon} \left(\frac{1 - \theta \Pi^{\epsilon-1}_{k,t}}{1-\theta} \right)^{1/(1-\epsilon)}, \tag{14}$$

$$\begin{aligned} F_{k,t} = & \left(\frac{\bar{P}_{k,t}}{P_{k,t}} \right)^{1-\epsilon} Y_{k,t} \\ & + \theta \beta E_t \frac{Z_{t+1}}{Z_t} \left\{ \left(\frac{C^c_{k,t+1}}{C^c_{k,t}} \right)^{-\sigma} \frac{1}{\Pi_{t+1}} \left(\frac{\bar{P}_{k,t}}{P_{k,t}} \frac{P_{k,t+1}}{\bar{P}_{k,t+1}} \right)^{1-\epsilon} \Pi^{\epsilon}_{k,t+1} F_{k,t+1} \right\}, \end{aligned} \tag{15}$$

and

$$\begin{aligned} K_{k,t} = & \left(\frac{\bar{P}_{k,t}}{P_{k,t}} \right)^{-\epsilon} Y_{k,t} MC_{k,t} \\ & + \theta \beta E_t \frac{Z_{t+1}}{Z_t} \left\{ \left(\frac{C^c_{k,t+1}}{C^c_{k,t}} \right)^{-\sigma} \frac{1}{\Pi_{t+1}} \left(\frac{\bar{P}_{k,t}}{P_{k,t}} \frac{P_{k,t+1}}{\bar{P}_{k,t+1}} \right)^{-\epsilon} \Pi^{1+\epsilon}_{k,t+1} K_{k,t+1} \right\}. \end{aligned} \tag{16}$$

The evolution of prices over time is given by the relation

$$1 = (1-\theta)\left(\frac{\bar{P}_{k,t}}{P_{k,t}}\right)^{1-\epsilon} + \theta\Pi_{k,t}^{\epsilon-1}. \tag{17}$$

The relation for sectoral final output and production is obtained by integrating equation (8) over j.

$$\int_0^1 Y_{k,t}(j)dj = \int_0^1 A_{k,t}L_{k,t}(j)dj. \tag{18}$$

The right-hand side reduces to $A_{k,t}L_{k,t}$ because the level of technology is assumed to be equal across firms, and labour is assumed to be homogeneous within the two sectors. Substituting equation (11) for the left-hand side yields

$$Y_{k,t}\int_0^1 \left(\frac{P_{k,t}(j)}{P_{k,t}}\right)^{-\epsilon} dj = A_{k,t}L_{k,t}. \tag{19}$$

$\Delta_{k,t} = \int_0^1 (P_{k,t}(j)/P_{k,t})^{-\epsilon} dj$ measures price dispersion and its evolution is given by

$$\Delta_{k,t} = (1-\theta)\left(\frac{\bar{P}_{k,t}}{P_{k,t}}\right)^{-\epsilon} + \theta\Pi_{k,t}^{\epsilon}\Delta_{k,t-1}. \tag{20}$$

The price dispersion creates a wedge between the aggregate production and the aggregate final output and is the real cost of price level variability in the New Keynesian models with Calvo-type price rigidity.

2.1.4. Final goods. Households consume final consumption goods that consist of domestic non-tradeable goods and imports $C_{F,t}$:

$$C_t \equiv \left[(1-\alpha)^{1/\eta}C_{N,t}^{(\eta-1)/\eta} + \alpha^{1/\eta}C_{F,t}^{(\eta-1)/\eta}\right]^{\eta/(\eta-1)}. \tag{21}$$

Demands for non-tradeable and imported goods by domestic households are given by

$$C_{N,t} = (1-\alpha)\left(\frac{P_{N,t}}{P_t}\right)^{-\eta} C_t, \qquad C_{F,t} = \alpha\left(\frac{P_{F,t}^*}{P_t}\right)^{-\eta} C_t. \tag{22}$$

Import prices are determined exogenously to the domestic economy. Imported goods are aggregated from exports of all monetary union member countries according to

$$C_{F,t} \equiv \left(\int_0^1 C_{E,t}(i)^{(\gamma-1)/\gamma} di\right)^{\gamma/(\gamma-1)}, \tag{23}$$

where the countries are distributed on the unit interval. The elasticity of substitution parameter γ gives the price elasticity that a country faces for its aggregate exports.

The bundle of exported goods that the domestic economy produces consists of non-tradeable and tradeable goods:

$$C_{E,t} \equiv \left[(1-\delta)^{1/\eta^*} C_{N,t}^{E\;\;(\eta^*-1)/\eta^*} + \delta^{1/\eta^*} C_{T,t}^{(\eta^*-1)/\eta^*}\right]^{\eta^*/(\eta^*-1)}. \tag{24}$$

Equation (24) takes into account that the production of exports requires inputs that are usually thought of as part of the non-tradeable sector. These include, for example, transportation, construction, and financial services. This increases the strategic interaction between the sectoral unions. Because non-tradable goods are used as inputs in the production of exports, the non-tradeable sector wages have a direct effect on the price competitiveness of the domestic exports.

Cost-minimizing input demands of the exporters for non-tradeable and tradeable goods are given by

$$C_{N,t}^{E} = (1-\delta)\left(\frac{P_{N,t}}{P_{E,t}}\right)^{-\eta^*} C_{E,t}, \qquad C_{T,t} = \delta\left(\frac{P_{T,t}}{P_{E,t}}\right)^{-\eta^*} C_{E,t}. \tag{25}$$

It is assumed that the rest of the member economies in the monetary union are identical to the home economy. Hence, the total demand for exports from the domestic economy can be derived from the demand functions for the final goods above, and the total demand for exports is given by

$$C_{E,t} = \alpha\left(\frac{P_{E,t}}{S_t P_{F,t}^*}\right)^{-\gamma}\left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\eta} C_t^*. \tag{26}$$

Variables with an asterisk denote monetary union-wide aggregates. S_t is an exogenous demand shifter for the exports of the domestic economy and captures the role of an export demand shock. It follows $\log(S_t) = \rho_s \log(S_{t-1}) + e_t^s$.

Total demand for tradeable goods is given by $Y_{T,t} = C_{T,t}$ and total demand for the non-tradeable goods is $Y_{N,t} = C_{N,t}^E + C_{N,t}$. Aggregate consumption is the sum of sectoral consumptions $C_t = s_N(C_{N,t}^w + C_{N,t}^c) + s_T(C_{T,t}^w + C_{T,t}^c)$.

2.2. Wage-setting

In both sectors, there is a labour union that sets the wage rate for its respective sector. The labour union maximizes the utility of the representative household in its sector, subject to model constraints. Given the wage level, households supply the amount of labour required to meet the labour demands of the firms. The chosen wage formation structure corresponds to right-to-manage bargaining, in which labour unions have all the bargaining power.

This wage-setting structure was chosen for its simplicity and because it is comparable to how the labour market is typically modelled in DSGE models when the labour supply or wage-setting takes place at the household level. If, in a DSGE model, it is assumed that the labour market is competitive, households maximize utility by choosing a labour supply with subject to budget constraint. If, alternatively, as in Erceg et al. (2000), it is assumed that small household-specific unions set wages, then the maximization is subject to the household's budget constraint and firms' labour demand. The essential difference between wage-setting by a large union and a household-specific union is that in the large union case, maximization is subject to all constraints of the model.

The objective of the union in this study is different from a traditional labour union objective function, which typically includes wage income and home production or unemployment benefits. However, the difference is merely about interpretation and functional form. The traditional labour union objective function is linearly increasing in consumption and linearly decreasing in employment. The objective of the union in this study, the utility function of the representative household, is non-linearly increasing in consumption and non-linearly decreasing in employment.

The sectoral union maximizes the utility of the representative household of its sector, subject to the constraints of the model: equations (3)–(26) and the definitions of final demands. This approach to wage-setting by unions is similar to the planner's problem in the Ramsey optimal policy formulation, which is typically used in the context of optimal fiscal and monetary policy, as in the study by Schmitt-Grohé and Uribe (2007). In optimal fiscal and monetary policy studies, the instruments available to the planner are tax rates, fiscal spending, and interest rates. In this study, the instrument is the sectoral nominal wage. In addition, instead of only one planner, this model has two planners: the two sectoral unions. In the planning problem, the actions of the other planner need to be taken into account.

Several wage-setting regimes are considered. Unions can set wages with or without coordination. Similarly to Calmfors and Seim (2013), uncoordinated wage-setting is modelled as a Nash game and wage leadership as a Stackelberg game. Because in the real world there is always some sequence of wage agreements reached by different sectors, uncoordinated wage-setting, where wages are set simultaneously, has no precise empirical counterpart. However, it serves as a useful benchmark for other types of wage-setting regimes. Stackelberg-type wage leadership is modelled in order to proxy pattern bargaining, which is common in many countries where bargaining occurs predominantly at the sectoral level. Furthermore, I consider the wage norm where the wage set by the leader is imposed on the follower.

2.2.1. Uncoordinated wage-setting. Let y_t denote all the other variables in the model except wage rates. Equations (3)–(26) and the definitions of final demands can be written in the form

$$G(y_t, y_{t-1}, W_{N,t}, W_{T,t}) - E_t F(y_{t+1}) = 0, \tag{27}$$

where $G(:)$ consists of terms comprising only variables that are known on period t and $F(:)$ comprises terms that include only variables with an expectations operator.

In uncoordinated wage-setting, a Nash game, the union's problem in sector k can be defined as

$$\max_{y_t, W_{k,t}} \sum_{p=0}^{\infty} E_t \beta^p \Big\{ U(C^w_{k,t+p}, L_{k,t+p}) - \lambda^k_{t+p} \times \big[G(y_{t+p}, W_{N,t+p}, W_{T,t+p}) - F(y_{t+1+p}) \big] \Big\}, \tag{28}$$

where λ^k_t is a vector of Lagrange multipliers. However, the maximization of the system in equation (28) leads to a time-inconsistent policy. The variables of period t enter the system only in the $G(:)$ part, whereas variables of all later periods enter both $G(:)$ and $F(:)$. For example, in period t, y_t enters $F(:)$ in expectations and, in period $t+1$, it enters $G(:)$ as known. Following Marcet and Marimon (2011), the system is augmented with lagged multipliers to give[3]

$$\max_{y_t, W_{k,t}} \sum_{p=0}^{\infty} E_t \beta^p \Big\{ U(C^w_{k,t+p}, L_{k,t+p}) - \lambda^k_{t+p} G(y_{t+p}, y_{t-1+p}, W_{N,t+p}, W_{T,t+p}) + \frac{1}{\beta} \lambda^k_{t-1+p} F(y_{t+p}) \Big\}. \tag{29}$$

In the Nash game, the wage of the other sector is taken as given. Let $x_{k,t} = [y_t \;\; W_{k,t}]$. The first-order conditions for the unions' wage-setting are given as

$$\frac{\partial U(C^w_{k,t}, L_{k,t})}{\partial x_{k,t}} - \lambda^k_t \frac{\partial G(y_t, y_{t-1}, W_{N,t}, W_{T,t})}{\partial x_{k,t}} - \beta E_t \lambda^k_{t+1} \frac{\partial G(y_{t+1}, y_t, W_{N,t+1}, W_{T,t+1})}{\partial x_{k,t}} + \frac{1}{\beta} \lambda^k_{t-1} \frac{\partial F(y_t)}{\partial x_{k,t}} = 0. \tag{30}$$

Equation (30) determines the evolution of the wages and the Lagrangian multipliers. Given the wages, the system of equations in (27) determines the evolution of the rest of the model's variables.

[3]It is assumed that there exist a period −1, and the unions respect the commitments made in the past.

2.2.2. Wage leadership. The wage leadership is modelled similarly to Calmfors and Seim (2013) as a Stackelberg game. The follower's problem corresponds to that in a Nash game, because the follower takes the wage of the leader as a given. The leader takes into account the reaction of the follower, and the first-order conditions of the follower are included as constraints in the leader's maximization problem.

Let variables with F in the index correspond to the follower and L to the leader. The maximization problem of the leader is given as

$$\max_{y_t, W_{F,t}, W_{L,t}} \sum_{p=0}^{\infty} E_t \beta^p \Big\{ U(C^w_{L,t+p}, L_{L,t+p}) - \lambda^L_{1,t+p} G(y_{t+p}, y_{t-1+p}, W_{N,t+p}, W_{T,t+p}) + \frac{1}{\beta}\lambda^L_{1,t-1+p} F(y_{t+p}) - \lambda^L_{2,t+p} \times \left[\frac{\partial U(C^w_{F,t}, L_{F,t})}{\partial x_{F,t}} - \lambda^F_t \frac{\partial G(y_t, y_{t-1}, W_{N,t}, W_{T,t})}{\partial x_{F,t}} + \frac{1}{\beta}\lambda^F_{t-1} \frac{\partial F(y_t)}{\partial x_{F,t}} \right] + \lambda^L_{2,t-1+p} \lambda^F_t \frac{\partial G(y_t, y_{t-1}, W_{N,t}, W_{T,t})}{\partial x_{F,t-1}} \Big\}. \tag{31}$$

The first-order conditions for equation (31) determine the evolution of the wage rate and the Lagrangian multipliers of the leader. Conditionally on the wage rate of the leader, equation (30) determines the evolution of the wage rate and the Lagrangian multipliers of the follower. Given the wages, the system of equations in equation (27) determines the evolution of the rest of the model variables.

2.2.3. Wage norm. An alternative interpretation of pattern bargaining is that the wage set by the leader becomes a normative reference point for the followers (Calmfors and Seim, 2013). To model this, I assume a wage-setting regime where one of the unions sets the wage, and the wage rate in the other sector is pegged to that. In this wage-setting regime, the maximization problem for the leader is similar to that with uncoordinated wage-setting, but an additional equation is added as a constraint

$$W_{F,t} = W_{L,t}. \tag{32}$$

The follower has no maximization problem, as the follower's wage is determined by equation (32). First-order conditions in the leader's problem determine the evolution of wages and the Lagrangian multipliers. Given the wages, the evolutions of the rest of the model variables is determined by equation (27).

2.2.4. Competitive labour market. The wage-setting regimes described above are compared with a competitive labour market. There, the wages are outcomes of a standard intra-temporal utility maximization of households. Real wages are equal to the marginal rate of substitution between leisure and consumption:

$$-\frac{U_{L_{k,t}}}{U_{C^w_{k,t}}} = \frac{W_{k,t}}{P_t}. \tag{33}$$

In the next sections, this regime is referred to as the competitive labour market.

2.3. Equilibrium

Given the optimality conditions for the wages, they are determined simultaneously in the equilibrium together with other model variables. The equilibrium in the model is a sequence of prices $\{P_t\}$, wages, $\{W_t^N, W_t^T\}$, and allocations $\{C^w_{N,t}, C^w_{T,t}, C^c_{N,t}, C^c_{T,t}, D_{N,t}, D_{T,t}, Y_{N,t}, Y_{T,t}, C_t, C_{N,t}, C_{F,t}, C_{T,t}, C_{E,t}, C^E_{N,t}\}$ that satisfy equilibrium conditions (3)–(5), (7), (14)–(17), (19)–(22), (24)–(26), the sectoral resource constraints, the definition of aggregate consumption (at the end of Section 2.1), and the first-order conditions for wages in Section 2.2, given the exogenous processes for productivity, domestic demand and export demand shocks.

The next section introduces the parametrization of the model.

3. Parametrization

The parameter values are shown in Table 1. β, σ, ϕ, θ, and the autocorrelation coefficients are parametrized using conventional values in the literature. The value-added share of non-tradeable goods in exports, $1-\delta$, is set to 0.37, which corresponds to the average value-added share of non-tradeable sector in the production of manufacturing goods in the countries Austria, Denmark, Finland, Germany, and Sweden in 2011.[4] Given δ, α is set to 0.25 to yield the same value-added share of tradeable sector as is the average of the value-added share of manufacturing sectors for the same data.

The average value-added share of manufacturing sectors in the data is 0.16, and in the model, it is given by $s_T = \alpha\delta = 0.16$. The value-added share of the non-tradeable sector is given by $s_N = (1-\alpha)+\alpha(1-\delta) = 0.84$. Unitary steady-state labour productivity is assumed for both sectors, and

[4]Source: OECD Input–Output tables and calculations by the author.

Table 1. Parameter values

Discount factor	β	0.99
Risk aversion	σ	1
Inverse of Frisch elasticity	ϕ	1
Calvo parameter for price stickiness	θ	0.4
Substitutability of intermediate goods	ϵ	6
Share of imports in consumption	α	0.25
Share of non-tradeable goods in exports	$1-\delta$	0.37
Elasticity of substitution between imports and non-tradeables in consumption	η	1
Elasticity of substitution between tradeables and non-tradeables in exports	η^*	1
Price elasticity of exports	γ	6
Debt elasticity with respect to aggregate bonds	ν_a	0.001
Debt elasticity with respect to household bonds	ν_o	0.001
Autocorrelation of TFP shock	ρ_a	0.9
Autocorrelation of external demand shock	ρ_s	0.9
Autocorrelation of discount rate shock	ρ_z	0.7

hence the value-added shares equal population shares. The price elasticity of exports, γ, is set to 6 as in Cacciatore et al. (2016), who use the estimates by Imbs and Mejean (2015). The debt elasticity parameters, ν_a and ν_o, are assumed to be equal and are set to the lowest possible value that yields a rational expectations solution for the model.

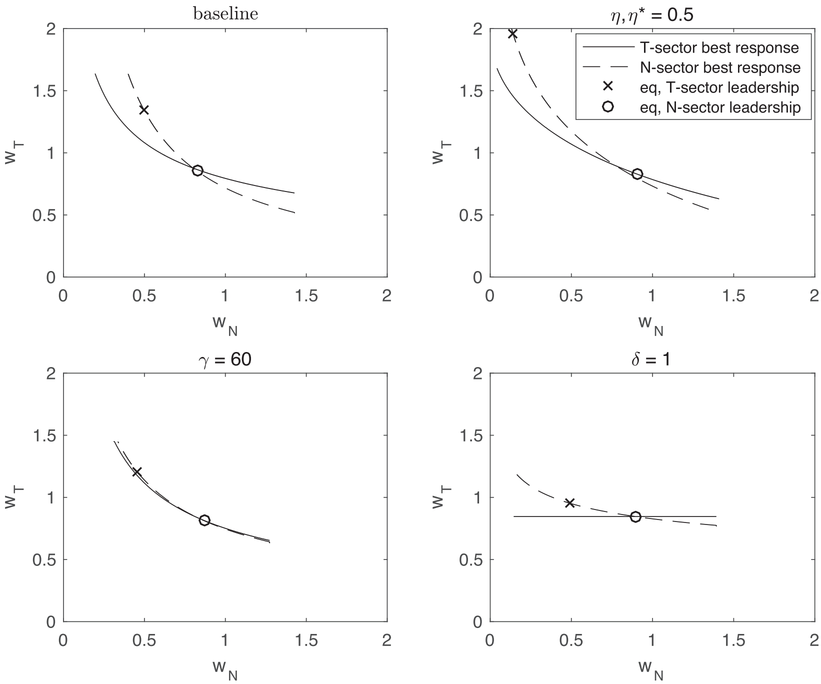
4. Results

This section presents the result from the parametrized model. At first, analysis is conducted on steady-state allocations and then the dynamic simulations are presented. By changing parameter parameter values, we can study how different features of the model influence unions' wage-setting.

4.1. Steady-state allocations

Figure 1 shows the best responses of both unions and the equilibria under the wage leadership of each union. The Nash equilibrium lies at the intersection of the best-response curves. The wage-setting of the wage follower is functionally identical to that in the Nash equilibrium because the wage follower takes the wage of the leader as given. Hence, the equilibria of the Stackelberg games lie on the best-response curves of the follower. Both best-response curves are non-increasing, and consequently wage-setting actions are strategic substitutes. The follower in a Stackelberg game is worse off than in the Nash equilibrium when the actions of the players are strategic substitutes (see, e.g., Rasmusen, 2007, p. 94).

Figure 1. Best-response functions



Notes: The Nash equilibrium lies in the intersection of lines. The equilibria under Stackelberg games are denoted by × and ∘.

In both sectors, the union's wage-setting is constrained by the demand for non-tradeable and tradeable goods. In the steady-state of this model, wages translate into sectoral prices with a constant mark-up. The demand for exports is determined by the relative price of exports to world price level. Both non-tradeable and tradeable goods are used in the aggregation of exports, and hence both non-tradeable and tradeable sector wages matter for export demand. The share of non-tradeable goods in domestic consumption is influenced by the relative price of non-tradeable goods to imported goods, which is only affected by non-tradeable sector wages. Total domestic consumption in turn is determined by the income of domestic households, and this is influenced by the wages of both sectors through export demand.

The wage-setting of a union has negative spill-over effects on the utility of the workers in the other sector. A wage increase in one sector raises the export price, which also decreases the total exports and inputs from the other sector. In the parametrization, it is assumed that the price elasticity of exports (γ) is always higher than the substitution elasticity between sectoral final goods in the aggregation of exported final goods (η^*). Although a wage increase in one sector shifts input demand to the other sector, the negative effect on total export demand dominates.

Another negative spill-over effect originates in the wage-setting of the tradeable sector union. Export demand affects the consumption demand of domestic households because a portion of the income of domestic households originates from exports. As long as the price elasticity of exports is greater than one, an increase in export price decreases the total revenues from exports. For this reason, an increase in the tradeable sector wage has a negative impact on domestic consumption demand for non-tradeable goods.

Non-tradeable sector wage-setting has one additional negative spill-over effect on the utility of the workers of the tradeable sector. An increase in the non-tradeable sector wage increases domestic price level and decreases the real wage and purchasing power of the tradeable sector workers. However, in the baseline parametrization, the utility function is logarithmic in consumption, and hence this spill-over effect does not influence the wage-setting of the tradeable sector union because the income and substitution effects of a real wage increase cancel each other out.

The best-response curves of unions are downward-sloping in this model. A higher wage in one sector reduces the labour demand in the other sector. Then the optimal response of the union on the other sector is to decrease the wage rate to obtain again the optimal ratio for marginal utilities of consumption and leisure. The best-response curve of a non-tradeable sector union is steeper than that of a tradeable sector union because tradeable sector wage affects non-tradeable sector wage via two channels but non-tradeable sector wage affects tradeable sector wage via only one channel. When tradeable sector wage is increased, this reduces the demand for non-tradeable goods by decreasing the export input demand and domestic consumption demand.

When the non-tradeable sector wage is increased, this decreases demand for tradeable goods only through decreased input demand for exports. As discussed below, this channel is shut down when δ is set to unity and exports consist only of tradeable goods. Then the best-response line of the tradeable sector becomes horizontal and the tradeable sector wage does not respond to changes in the non-tradeable sector wage.

Unions in both sectors have an incentive to set wages higher than the competitive labour market wage by exploiting the terms-of-trade externality, which is established in the literature on optimal monetary policy in an open economy (see, e.g., Benigno and Benigno, 2003). By increasing the price level of exports, a social planner (be it a labour union or a central bank) can make domestic households better off, as households' consumption will be greater for a given labour input. The consumption level itself will be lower than in the competitive labour market equilibrium, but the consumption–employment ratio gives a higher utility level. The possibility of exploiting the terms-of-trade externality is determined by the price elasticity of exports, which is parametrized by γ.

Table 2 presents the steady allocations. In the baseline parametrization, uncoordinated wage-setting leads to the Nash equilibrium, in which tradeable sector union sets a higher-than-competitive labour market wage and takes advantage of the terms-of-trade externality. The non-tradeable sector union sets a wage level that is lower than the competitive labour market wage. The non-tradeable sector union is more constrained in the wage-setting because it has to take into consideration both export demand and its influence on domestic demand and substitutability between imports and non-tradeable goods in domestic consumption.

Because of the increased export price level, both non-tradeable and tradeable sector households work less than in a competitive labour market economy. However, the reduction in consumption is smaller than the reduction in employment because of terms-of-trade improvement. As a result of the higher wage rate, tradeable sector households consume the same amount as non-tradeable households despite the lower employment in the tradeable sector. This leads to the utility of the non-tradeable sector being lower and the utility of the tradeable sector being higher compared with competitive labour market equilibrium.

When the wages are set as Stackelberg games, this leads to very asymmetric outcomes. When the non-tradeable sector is the Stackelberg leader, it can make more than it would have with an uncoordinated wage-setting. However, welfare is still lower than in the competitive labour market and sectoral nominal wages are close to those in an uncoordinated wage-setting. When the tradeable sector acts as the Stackelberg leader, it can improve its position considerably more than it could with an uncoordinated wage-setting, and at the expense of the non-tradeable sector. The tradeable sector wage is much higher and the non-tradeable sector wage is much lower than with an uncoordinated wage-setting. Employment in the tradeable sector decreases considerably. However, because of a lower domestic price level and increased wage level, the reduction in the tradeable sector households' consumption is much smaller.

The best-response curve of the non-tradeable sector is steeper than the best-response curve of the tradeable sector union (Figure 1). This is behind the asymmetric outcomes of Stackelberg wage-setting. When the tradeable sector sets a wage first, it anticipates that the non-tradeable sector has to accommodate by lowering the wage rate in response to decreased export and domestic demand. When the non-tradeable sector sets the wage, it anticipates that the tradeable sector union will set a lower wage if the non-tradeable sector union sets a higher wage than would occur in an uncoordinated wage-setting. Still, this matters only for export demand. The

Table 2. Steady-state allocations and welfare gains

Regime	W_N	W_T	P	P_E	L_N	L_T	C_N	C_T	Welfare gain		
									N	T	Total
Baseline parametrization											
Competitive	0.833	0.833	1.00	1.00	1.00	1.00	0.83	0.83			
Nash	0.800	0.877	0.97	1.02	0.96	0.87	0.79	0.79	−1.23	6.24	−0.05
N lead	0.828	0.864	0.99	1.02	0.91	0.87	0.76	0.76	−1.02	2.36	−0.49
T lead	0.505	1.331	0.69	1.12	0.96	0.36	0.70	0.70	−13.58	23.14	−7.80
N norm	0.836	0.836	1.00	1.00	0.98	0.98	0.82	0.82	0.04	0.04	0.04
T norm	0.836	0.836	1.00	1.00	0.98	0.98	0.82	0.82	0.04	0.04	0.04
$\eta, \eta^* = 0.5$											
Competitive	0.833	0.833	1.00	1.00	1.00	1.00	0.83	0.83			
Nash	0.774	0.896	0.95	1.02	0.94	0.87	0.77	0.82	−2.25	10.36	−0.27
N lead	0.911	0.826	1.07	1.03	0.83	0.86	0.71	0.67	−0.84	−10.10	−2.30
T lead	0.142	1.955	0.31	1.25	0.79	0.19	0.36	1.20	−93.08	57.22	−69.40
N norm	0.837	0.837	1.00	1.00	0.98	0.98	0.82	0.81	0.05	0.04	0.05
T norm	0.836	0.836	1.00	1.00	0.98	0.98	0.82	0.82	0.05	0.04	0.05
$\gamma = 60$											
Competitive	0.833	0.833	1.00	1.00	1.00	1.00	0.83	0.83			
Nash	0.829	0.836	1.00	1.00	0.99	0.99	0.83	0.83	−0.12	0.64	0.00
N lead	0.873	0.812	1.04	1.00	0.92	0.99	0.77	0.77	0.46	−6.37	−0.61
T lead	0.469	1.186	0.65	1.01	0.99	0.39	0.72	0.72	−15.44	23.93	−9.24
N norm	0.833	0.833	1.00	1.00	1.00	1.00	0.83	0.83	0.00	0.00	0.00
T norm	0.833	0.833	1.00	1.00	1.00	1.00	0.83	0.83	0.00	0.00	0.00

Table 2. Continued

Regime	W_N	W_T	P	P_E	L_N	L_T	C_N	C_T	Welfare gain		
									N	T	Total
$\delta = 1$											
Competitive	0.833	0.833	1.00	1.00	1.00	1.00	0.83	0.83			
Nash	0.892	0.846	1.05	1.02	0.87	0.91	0.73	0.73	−0.19	−4.45	−1.25
N lead	0.892	0.846	1.05	1.02	0.87	0.91	0.73	0.73	−0.19	−4.45	−1.25
T lead	0.501	0.950	0.68	1.14	0.87	0.46	0.64	0.64	−15.75	11.71	−8.89
N norm	0.836	0.836	1.00	1.00	0.98	0.98	0.82	0.82	0.04	0.04	0.04
T norm	0.836	0.836	1.00	1.00	0.98	0.98	0.82	0.82	0.04	0.04	0.04
$\delta = 1, \sigma = 0.1$											
Competitive	0.833	0.833	1.00	1.00	0.86	0.86	0.72	0.72			
Nash	0.907	0.860	1.07	1.03	0.67	0.71	0.57	0.57	−0.89	−4.29	−1.74
N lead	0.859	0.856	1.02	1.03	0.73	0.73	0.61	0.61	−0.63	−0.88	−0.69
T lead	0.612	0.946	0.79	1.13	0.62	0.40	0.48	0.48	−9.78	5.36	−5.99
N norm	0.839	0.839	1.00	1.01	0.83	0.83	0.69	0.69	0.08	0.08	0.08
T norm	0.839	0.839	1.00	1.01	0.83	0.83	0.69	0.69	0.08	0.08	0.08

Notes: Welfare gain defined as percentage points of steady-state consumption decrease to provide the equivalent level of welfare as that in competitive labour market economy. Thus, a positive figure means that welfare is higher in the alternative wage-setting regime than in the competitive labour market economy. Total welfare gains are weighted averages of sectorial welfare gains and weights are the sectorial population shares.

larger share of non-tradeable goods is absorbed by domestic consumption. If the non-tradeable sector wage is increased, this shifts consumption demand towards imports. Import prices are external and the non-tradeable sector union has no means to affect import prices with its wage-setting.

Going against conventional wisdom, the results suggest that it is the tradeable sector that has a bigger incentive to drive the economy to a low competitiveness equilibrium when acting as a wage leader. This is similar to the findings by Calmfors and Seim (2013). The non-tradeable sector is more constrained in its wage-setting because, in addition to taking export demand into account, it also has to consider domestic demand, where it cannot play against the tradeable sector. Still, non-tradeable sector leadership yields lower aggregate employment than uncoordinated wage-setting yields. This questions the result of Calmfors and Seim (2013) that in a monetary union environment, non-tradeable sector leadership leads to lower wages and higher employment than uncoordinated wage-setting.

One might argue that the modelling of the tradeable sector wage leadership in this study is not realistic because, in many economies, a wage agreement in the tradeable sector is a normative ceiling for other sectors. To model this, an inequality constraint should be added to the model to take into account the fact that the non-tradeable sector wage cannot exceed the tradeable sector wage. This constraint was not added because it would complicate the computation. However, this does not create a problem for the analysis because when the non-tradeable sector is a follower, it does not set higher wages than the leader, as can be seen from Table 2. Even if this inequality constraint were added to the model, it would not be binding.

When the wage of the leader is imposed as a binding norm, both sectors can benefit, compared with the competitive labour market, by exploiting the terms-of-trade externality. When wages are set under a wage norm, there is no strategic interaction among unions. However, the benefits from the terms-of-trade improvement are rather small. Thus, it can be concluded that in the steady-state analysis of this model, there are fewer externalities that wage formation can exploit to benefit the overall economy than there are possibilities for strategically acting unions to benefit at the expense of the other sector.

The features in the economic environment that influence the unions' wage-setting are substitution elasticities and the share of non-tradeable goods in the aggregation of exports. Export price elasticity determines the strength of the terms-of-trade externality. Strategic interaction between unions is determined by the substitution elasticity between imports and non-tradeable goods, and substitution elasticity and the share between non-tradeable and tradeable goods in the aggregation of export final goods. We can change the values for these parameters and analyse the impact on wage-setting.

4.1.1. Subsitution elasticities, η, η^*. Unitary elasticities are often used for the substitutability between non-tradeable and tradeable goods, or between domestic goods and imported goods. Galí and Monacelli (2005, 2008) use unitary elasticity for domestic and imported goods. Calmfors and Seim (2013) assume unitary elasticity for tradeable and non-tradeable goods in consumption. Cacciatore et al. (2016) use 0.85 as the value for the elasticity between tradeable and non-tradeable goods based on estimates by Mendoza (1991), but they assume unitary elasticity for non-tradeable and tradeable goods in the aggregation of exports. However, because of the very different nature of tradeable goods (which are mostly manufactured goods) and domestic non-tradeable goods (which are mostly services), one could consider the substitution elasticity to be very low.

The second panel in Table 2 shows that when substitution elasticities between non-tradeable and tradeable goods are changed to 0.5, the Nash and Stackelberg equilibrium wages move further away from the competitive labour market wages. When the substitution elasticity between non-tradeable and tradeable inputs in exports is lower, it allows the tradeable sector to take more advantage of the terms-of-trade externality because an increase in the tradeable sector wage causes less substitution to non-tradeable goods. For this reason, the Nash equilibrium moves further away from the competitive labour market equilibrium. Because of lower elasticity, the follower has to implement a larger wage decrease than under the baseline parametrization to induce the same change in demand. The Stackelberg leader can exploit this and obtain an equilibrium where the leader can set a higher wage and the follower a lower wage than under unitary substitution elasticities.

Interestingly, under this parametrization, the non-tradeable sector union as a leader can set the wage level above the competitive labour market wage, to which the tradeable sector has to respond with a lower-than-competitive labour market wage level. The non-tradeable sector union can improve its position as a leader compared with the Nash equilibrium more than under the baseline parametrization. An improvement in the non-tradeable sector welfare comes at the expense of tradeable sector welfare and with higher export prices and lower aggregate employment than under the baseline parametrization.

4.1.2. Demand elasticity of exports, γ. The price elasticity parameter of exports, γ, was set to 6 in the baseline parametrization, which is in line with recent estimates provided by Imbs and Mejean (2015) and used in the parametrization of an open economy DSGE model in Cacciatore et al. (2016). However, it is usually thought that it is the stiff international competition faced by firms in the tradeable sector that makes the tradeable sector's wage leadership beneficial to the aggregate economy. In line with this, in Calmfors and Seim (2013), demand elasticity is assumed to be infinite. It could be also that γ around 6 is suitable value for cyclical analysis, whereas, in the longer run, firms have less market power in the international markets, and higher values of export price elasticity are more suitable for the steady-state analysis.

To study the robustness of results in relation to export demand elasticity, the steady state of the model was solved using $\gamma = 60$. Consequently, wage norms yield the same equilibrium as the competitive labour market. This reveals that there is now no externality for wage setters that they can take advantage of and a sector can only benefit at the expense of the other sector.

As shown in Figure 1, the tradeable sector best-response curve is now steeper than under the baseline parametrization and tradeable sector wages respond more to non-tradeable sector wages. When the price elasticity of exports is high, an increase in non-tradeable sector wages and export prices results in a larger drop in export demand, to which the tradeable sector union has to respond.

Welfare levels are similar to those under the baseline parametrization, but the position of the non-tradeable sector union is slightly improved as it can obtain higher welfare than the competitive labour market equilibrium yields. When the non-tradeable sector union acts as a leader, the employment level drops more than under the baseline parametrization.

As there is no terms-of-trade externality, the unions cannot increase aggregate utility over the competitive labour market outcome. Wage norms still prevent the unions from taking advantage of the other sector. Hence, wage norms are favourable also in this parametrization because they yield the same aggregate utility as the competitive labour market outcome but without harming either of the sectors.

4.1.3. Share of non-tradeable goods in the production of exports, δ.

When δ is increased to 1, non-tradeable sector intermediate goods are not used in the aggregation of exports. As shown in Figure 1, the best-response curve of the tradeable sector is now horizontal. This is because the substitutability channel in the aggregation of exports is now shut down. The only way that the non-tradeable sector wage is related to the tradeable sector wage-setting is through the real wage. The domestic price level is determined by the non-tradeable sector union because import prices are assumed to be constant. With logarithmic utility in terms of consumption ($\sigma = 1$), income and substitution effects cancel each other out for optimal labour supply. Consequently, the real wage level is not important for the tradeable sector union in its wage-setting. The tradeable sector wage level is therefore unresponsive to the non-tradeable sector wage level and non-tradeable sector leadership coincides with the Nash equilibrium.

When the tradeable sector union acts as a leader, it still has the possibility of setting a higher wage, which will reduce export demand and hence domestic demand. The non-tradeable sector union has to respond to this with a lower wage compared with the Nash equilibrium and the competitive labour market outcome. Still, the tradeable sector wage is considerably lower than in the baseline parametrization, where the non-tradeable goods are used as inputs to exports and the tradeable sector union is able improve its position much less compared with the Nash equilibrium. Having non-tradeable goods as inputs to exports increases the strategic behaviour of the tradeable sector union.

The non-tradeable sector position is improved compared with the baseline parametrization, and the non-tradeable sector union can set the wage higher than the competitive labour market wage in uncoordinated wage-setting and when it is the wage leader. This suggests that when non-tradeable goods are used as inputs to export goods, it constrains the non-tradeable sector union's wage-setting. The use of non-tradeable goods as inputs for exports both constrains the non-tradeable sector union's wage-setting and increases the strategic behaviour of the tradeable sector union. Hence, it seems the use of non-tradeable goods as inputs for exports is an important channel for the strategic interaction between the unions.

4.1.4. Comparison with Calmfors and Seim (2013). The results in this paper differ from those in Calmfors and Seim (2013) regarding the non-tradeable sector leadership. Calmfors and Seim (2013) obtain a result that in a monetary union member economy, non-tradeable sector leadership leads to wage restraint and higher employment than uncoordinated wage-setting and tradeable sector leadership. I find that the non-tradeable sector wage is higher under non-tradeable sector leadership and that aggregate employment is lower than under uncoordinated wage-setting. This result was also obtained in the previous sections when parameter changes were analysed.

Calmfors and Seim (2013) display results in terms of real wages but an inspection of their results suggests that the non-tradeable sector union has a downward-sloping best-response curve, and the tradeable sector union has an upward-sloping best-response curve, in terms of nominal wages.[5] To understand the factors behind the different results in this study and in

[5]Calmfors and Seim (2013) find that the follower sector sets the same real wage as in uncoordinated wage-setting. When the non-tradeable sector is the leader, it sets a lower real wage than in an coordinated wage-setting, whereas the tradeable sector sets a higher real wage rate in uncoordinated wage-setting when it acts as a leader. I calculated the equilibrium *nominal* wages. When non-tradeable sector is the leader, both sectors set lower nominal wages than in uncoordinated wage-setting. When the tradeable sector is the leader, the tradeable sector

Calmfors and Seim (2013), it is useful to see whether certain parameter changes lead to an upward-sloping best-response curve for the tradeable sector in this study's model.

In the previous section, it was shown that when δ is set to 1 and non-tradeable goods are not used in the production of exports, the tradeable sector's response curve becomes horizontal. Also Calmfors and Seim (2013) assume that non-tradeable goods are not used as inputs for exports. One difference between the models is in the functional form of the utility function. In the model of Calmfors and Seim (2013), the utility function is linear in terms of consumption. When σ is changed to 0.1, the utility function is nearly linear in terms of consumption. With these changes, the tradeable sector best-response curve becomes upward-sloping. As displayed in the lowest panel in Table 2, similar results to Calmfors and Seim (2013) are obtained. Non-tradeable sector leadership leads now to lower wages and higher employment than uncoordinated wage-setting whereas tradeable sector leadership leads to lower employment.

Given that δ is set to 1, non-tradeable sector wage-setting influences tradeable sector wage-setting only through the domestic price level, which matters for the tradeable sector real wage. Intuition for the upward-sloping best-response curve is that when σ is below unity, the substitution effect dominates the income effect. A nominal wage increase in the non-tradeable sector decreases the tradeable sector real wage to which the tradeable sector union responds by increasing nominal wage, thereby reducing demand for tradeable sector labour.

4.1.5. Summary of the steady-state analysis. The primary insight from the steady-state analysis can be summarized as follows. In an open economy, there are externalities that large wage-setters can take account of in order to increase the aggregate welfare above the competitive labour market allocation. However, adverse consequences arising from strategic interaction can consume this surplus and bring the economy to an inferior equilibrium. Tradeable sector leadership does not seem to be beneficial in terms of aggregate household welfare. Tradeable sector leadership does lead to a lower wage rate in the non-tradeable sector, but this does not follow from the tradeable sector's commitment to a lower wage. Instead, when the tradeable sector is the wage leader, it sets the wage considerably higher

sets a higher wage and the non-tradeable sector sets a lower wage than in uncoordinated wage-setting. Given that the best-response curves cross in the Nash equilibrium and the follower is on its best-response curve, the calculated equilibrium nominal wages suggest that the non-tradeable sector's best-response curve is downward-sloping and the tradeable sector's best-response curve is upward-sloping.

than the competitive labour market wage and pushes the economy to an equilibrium where the non-tradeable sector needs to respond with a lower wage level.

Wage norms yielded the most favourable outcomes because, under those wage-setting regimes, unions cannot act strategically, but they can exploit the terms-of-trade externality. However, it could be that for a steady-state analysis, high export price elasticity is more appropriate and the terms-of-trade externality vanishes. In this case, wage norms do not bring better equilibrium than the competitive labour market outcome.

Tradeable sector leadership was not found to be beneficial for the aggregate economy. Non-tradeable sector leadership was not found to increase aggregate utility over uncoordinated wage-setting, and, as opposed to results in Calmfors and Seim (2013), it was found to yield lower employment compared with an uncoordinated wage-setting. These results were found to be robust, when tested using different parametrizations.

4.2. Dynamics

This section examines the welfare consequences of different wage-setting regimes when the economy is subject to shocks. While the previous section focused on steady-state comparisons in a static framework, this section looks at how wage-setting regimes influence the ability of the model economy to adjust to shocks. The shocks considered are productivity, export demand, and domestic demand shocks.

The dynamics are obtained by linearizing the equations and solving the linearized system using the algorithm of Klein (2000). Welfare comparisons are obtained by taking the second-order approximation using the algorithm of Gomme and Klein (2011). A second-order approximation is needed because the lifetime welfare costs of deviations from the deterministic steady state are zero up to the first-order approximation; in addition, not all the effects, most notably the welfare cost of relative price distortions, are taken into account in first-order approximations. The analysis here is similar to that of Schmitt-Grohé and Uribe (2007), who study optimal fiscal and monetary policy in a medium-scale DSGE model.

The welfare comparisons are made with respect to a competitive labour market economy. To make welfare comparisons meaningful, the deterministic steady states across comparison regimes must be equal. This is implemented by assuming that in a competitive labour market economy, there are sectoral mark-ups. The sectoral mark-ups are calibrated to bring the same sectoral steady-state wages as in the comparison regime. As the steady-state values for all other variables are determined by the sectoral wages and the exogenous variables, the steady states are the same for the comparison regimes.

4.2.1. Productivity shock. Table 3 shows the standard deviations and welfare gains when the economy is subject to productivity shocks. The first panel in Table 3 shows the outcomes when the productivity shock process is common to both sectors. Wage-setting by unions is welfare-improving for both sectors compared with competitive labour market outcomes. Prices are assumed to be sticky, and this creates friction in the economy. Consequently, adjustment to shocks in the competitive labour market economy is not optimal. In an uncoordinated wage-setting, and under the leaderships of both sectors, the standard deviation of tradeable sector wages is close to that of the competitive labour market economy. However, the non-tradeable sector wages have higher standard deviations than in the competitive labour market economy, and welfare improvement is an outcome of the more responsive non-tradeable sector wages. When nominal wages are more responsive, they speed up the adjustment to the shock and product market mark-ups vary less, which decreases inefficiencies in the economy.

In the competitive labour market economy, and under uncoordinated and Stackelberg wage-settings, the standard deviations of sectoral wages vary considerably between sectors. This suggests that sector-specific wage adjustment is required. When wages are set under wage norms, only the sector that sets the wage norm gains, compared with the competitive labour market economy. When the non-tradeable sector union sets the common wage, tradeable sector wages responds too little and, conversely, the non-tradeable sector wage level is too responsive when the tradeable sector sets the common wage.

The second panel in Table 3 shows the standard deviations and welfare gains when the prices are flexible. In this case, there is no friction in the economy, and the responses of the competitive labour market economy are optimal. Uncoordinated and Stackelberg wage-setting yield outcomes that are close to the competitive labour market, and the wage-setting by the unions cannot increase aggregate welfare over the welfare in the competitive labour market economy.

The third panel in Table 3 shows the results for a scenario with productivity shock taking place in the tradeable sector and constant productivity present in the non-tradeable sector. This increases the negative effects of wage norms for aggregate welfare.

4.2.2. Export demand shock. The effects of a negative export demand shock on the economy can be accommodated by lowering wages, which decreases the export prices to counteract the drop in export demand.

Conventional wisdom has been that in an export-oriented economy, non-tradeable sector wages should closely follow tradeable sector wages. Figure 2 shows the impulse responses to a negative export demand shock

Table 3. Standard deviations and welfare gains

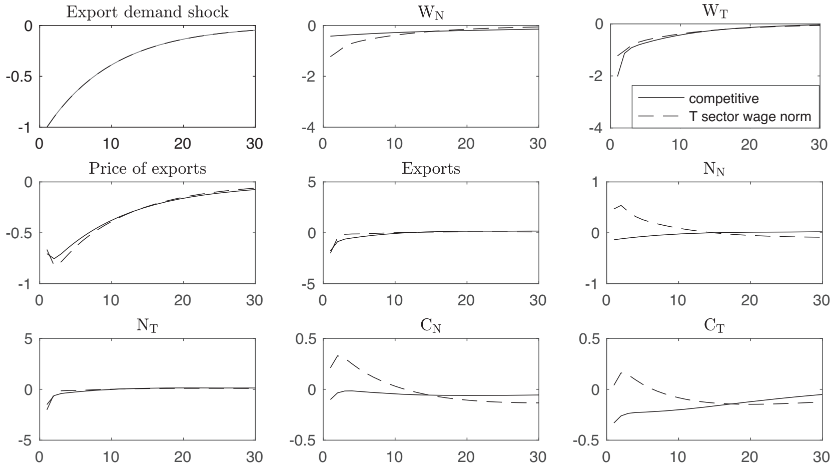
Regime	Standard deviations							Welfare gain		
	W_N	W_T	P	N_N	N_T	C_N	C_T	N	T	Total
Productivity shock, baseline parametrization										
Competitive	0.116	0.201	0.09	0.02	0.10	0.17	0.22			
Nash	0.134	0.202	0.08	0.05	0.09	0.16	0.20	0.25	0.63	0.31
N lead	0.137	0.200	0.08	0.04	0.09	0.16	0.20	0.25	0.65	0.32
T lead	0.157	0.201	0.10	0.05	0.12	0.16	0.20	0.24	0.70	0.31
N norm	0.150	0.150	0.06	0.04	0.33	0.16	0.23	0.30	−1.01	0.09
T norm	0.179	0.179	0.03	0.09	0.06	0.13	0.16	−0.13	1.39	0.11
Productivity shock, $\theta = 0$										
Competitive	0.124	0.211	0.10	0.02	0.11	0.18	0.23			
Nash	0.125	0.211	0.10	0.02	0.11	0.18	0.22	0.00	0.02	0.00
N lead	0.128	0.209	0.10	0.01	0.10	0.18	0.22	0.00	0.03	0.00
T lead	0.113	0.231	0.12	0.02	0.09	0.18	0.21	−0.04	0.03	−0.03
N norm	0.147	0.147	0.08	0.04	0.43	0.18	0.25	0.11	−3.69	−0.49
T norm	0.183	0.183	0.04	0.09	0.07	0.14	0.16	−0.50	0.40	−0.36
Productivity shock, A_N constant										
Competitive	0.081	0.121	0.06	0.02	0.06	0.02	0.04			
Nash	0.075	0.136	0.05	0.02	0.06	0.02	0.04	0.00	0.40	0.07
N lead	0.075	0.135	0.06	0.02	0.06	0.02	0.03	0.00	0.39	0.07
T lead	0.051	0.170	0.04	0.01	0.09	0.01	0.02	−0.08	0.50	0.02
N norm	0.089	0.089	0.06	0.03	0.22	0.02	0.05	−0.08	−0.52	−0.15
T norm	0.108	0.108	0.08	0.05	0.04	0.05	0.03	−0.27	0.53	−0.14
Export demand shock, baseline										
Competitive	0.154	0.309	0.11	0.03	0.19	0.04	0.10			
Nash	0.158	0.274	0.12	0.06	0.30	0.04	0.10	−0.12	2.03	0.22
N lead	0.160	0.270	0.12	0.05	0.30	0.05	0.09	−0.11	2.00	0.22
T lead	0.125	0.284	0.09	0.06	0.41	0.04	0.07	−0.39	2.23	0.02
N norm	0.180	0.180	0.13	0.09	0.67	0.05	0.12	0.17	−7.10	−0.98
T norm	0.245	0.245	0.16	0.12	0.21	0.11	0.08	−2.09	1.77	−1.48

Table 3. Continued

Regime	Standard deviations							Welfare gain		
	W_N	W_T	P	N_N	N_T	C_N	C_T	N	T	Total
Export demand shock, $\eta, \eta^* = 0.5$										
Competitive	0.226	0.300	0.16	0.03	0.19	0.06	0.11			
Nash	0.225	0.264	0.16	0.06	0.31	0.07	0.11	−0.24	2.63	0.21
N lead	0.220	0.254	0.16	0.04	0.30	0.08	0.08	−0.19	1.73	0.11
T lead	0.066	0.263	0.04	0.08	0.49	0.02	0.04	0.35	1.88	0.59
N norm	0.192	0.192	0.14	0.10	0.67	0.05	0.10	0.52	−8.25	−0.87
T norm	0.244	0.244	0.16	0.11	0.21	0.14	0.08	−1.59	0.46	−1.27
Domestic demand shock, baseline										
Competitive	0.110	0.015	0.06	0.02	0.11	0.07	0.06			
Nash	0.065	0.010	0.04	0.05	0.08	0.09	0.08	0.44	0.66	0.48
N lead	0.062	0.009	0.04	0.05	0.08	0.09	0.08	0.45	0.60	0.47
T lead	0.076	0.028	0.05	0.05	0.10	0.09	0.09	0.45	0.69	0.48
N norm	0.057	0.057	0.03	0.04	0.27	0.09	0.08	0.48	−0.32	0.35
T norm	0.013	0.013	0.01	0.09	0.06	0.12	0.11	0.17	1.32	0.35
Domestic demand shock, $\eta, \eta^* = 0.5$										
Competitive	0.121	0.020	0.06	0.01	0.12	0.07	0.06			
Nash	0.071	0.013	0.05	0.05	0.08	0.09	0.08	0.34	1.61	0.54
N lead	0.073	0.014	0.05	0.05	0.09	0.09	0.08	0.36	1.73	0.57
T lead	0.111	0.024	0.06	0.06	0.10	0.11	0.09	−0.13	0.96	0.04
N norm	0.059	0.059	0.04	0.04	0.29	0.09	0.08	0.28	1.14	0.42
T norm	0.013	0.013	0.01	0.09	0.06	0.12	0.11	−0.03	2.99	0.45

Notes: Conditional on a 0.1 standard deviation for each shock. Welfare gains defined as percentage points of steady-state consumption decrease to provide the equivalent level of welfare as in the competitive labour market economy. Thus, a positive figure means that welfare is higher in an alternative wage-setting regime than in the competitive labour market economy. Total welfare gains are weighted averages of sectorial welfare gains, and weights are the sectorial population shares.

Figure 2. Impulse responses to export demand shock



for the competitive labour market economy and when the tradeable sector sets the wage under the wage norm. The competitive labour market outcome is that both sectors adjust to export demand shock, but the wage adjustment is considerably larger in the tradeable sector. The fourth panel in Table 3 shows that pegging the non-tradeable sector's wage to the tradeable sector wage generates welfare costs for the non-tradeable sector. The impulse responses in Figure 2 illustrate that as the wage norm holds strictly, the non-tradeable sector is forced to over-adjust. Non-tradeable sector wages and prices decrease to the extent that production of non-tradeable goods increases. Hence, there is a boom in the non-tradeable sector, which results from an exogenous *decrease* in export demand.

The simulation with the export demand shock illustrates that when the tradeable sector union sets wages under the wage norm, it does lead to a closer alignment of non-tradeable sector wages and prices with external conditions. However, this increases macroeconomic volatility in the economy and alters the behaviour of the non-tradeable sector compared with a competitive labour market economy with sector-specific adjustment.

The fourth panel in Table 3 shows that under uncoordinated and Stackelberg wage-setting, the tradeable sector can set wages so that welfare in the tradeable sector is higher compared with a competitive labour market. The welfare in the non-tradeable sector is lower under these wage-setting regimes compared with a competitive labour market. As a robustness analysis, the substitution elasticities between non-tradeable and tradeable goods were lowered from the baseline unitary elasticity to 0.5. This changed the results only regarding tradeable sector leadership (see the fifth panel in Table 3). Under this parametrization, the welfare is higher also in the non-tradeable sector compared with a competitive labour market outcome. However, the increase in the welfare does not come from more responsive non-tradeable sector wages but from less responsive wages.

4.2.3. Domestic demand shock. A domestic demand shock affects a household's effective discount rate, and consequently a household's consumption-savings decisions, which determines domestic consumption demand. Because the shock is a purely domestic shock, the demand conditions for exports are not affected. To stabilize the shock, a change in the real interest rate would be needed. Because the model economy is a member of the monetary union, monetary policy does not respond to domestic demand shocks. When a demand shock depresses demand, a decrease in the real interest rate is needed. In a competitive labour market economy, households increase their labour supply due to depressed demand, which lowers nominal wages and prices, and the economy goes into a deflationary spiral.

When sectoral unions set wages, they understand that overly responsive wages reduce welfare when adjusting to domestic demand shocks. Consequently, unions' wage-setting leads to lower standard deviations of wages, and to improvements in aggregate welfare compared with the competitive labour market economy. The last two panels in Table 3 show that the effects of wage norms on welfare depend on the substitutability between non-tradeable goods and tradeable goods.

4.2.4. Summary of the dynamic analysis. Contrary to the steady-state analysis, the differences between the Nash and Stackelberg wage-settings are not so large in terms of dynamics. This suggests that the strategic incentives of the unions are smaller in terms of dynamics than in terms of steady-state allocations. When prices are sticky, unions can improve the adjustment to shocks. Uncoordinated and Stackelberg wage-setting improve the welfare of households in both sectors in most of the cases studied in this section. This improved adjustment can sometimes lead to more wage adjustment, sometimes less, depending on the shock.

Improvements in the welfare of both sectors were obtained only when sector-specific wage adjustment was allowed. Besides the effects of domestic demand shock under the baseline parametrization, wage norms benefit only the sector that sets the common wage. In an open economy, the two sectors face very different economic environments, and, consequently, aggregate shocks affect the sectors differently.

5. Conclusions

This paper develops a novel way to model wage-setting coordination between non-tradeable and tradeable sector unions in an open economy. The analysis is based on studying the steady-state allocations and on dynamic simulations. The comparisons of different wage-setting regimes are made with reference to household welfare, as is common in studies on optimal monetary and fiscal policy.

It should not be taken as a given that wage formation led by the tradeable sector is necessarily beneficial for the aggregate economy. The steady-state analysis shows that when making the realistic assumption that a sectoral union maximizes the welfare of the households that it represents, and when it acts as a wage leader in terms of timing, this often leads to welfare gains for households in the leader's sector at the expense of households in the other sector.

In the real world, pattern bargaining leads to near-equal wage growth across sectors and wage growth is determined by an export-oriented industry. In terms of steady-state analysis, I find that a wage norm where the leader's wage is imposed on the follower eliminates the aggregate welfare-reducing strategic interaction between unions, but in dynamic simulations, it leads to results that reduce aggregate welfare. Aggregate shocks affect the non-tradeable and tradeable sectors differently and sector-specific adjustment is needed. If the tradeable sector sets the wage norm, the non-tradeable sector wage over-adjusts to export sector shocks and under-adjusts to domestic demand shocks. This result questions the importance of export sector-led pattern bargaining as its outcome – equal wage growth across sectors – was not found to be efficient in the dynamic simulations.

In the analysis, one union encompasses the whole non-tradeable or tradeable sector. In the real world, there are several unions in both sectors. In this case, internalization effects might be much weaker. Foreign competition could constrain a small union in the tradeable sector more than the concern that the transmission of wages to the domestic aggregate price level would constrain a small union in the non-tradeable sector. However, idiosyncratic shocks to the industry that starts the wage-setting round and sets the wage norm can lead to further volatility in the aggregate economy. An extension with several unions operating on non-tradeable and tradeable sectors could be explored in further research.

The analysis shows that it is difficult to construct a wage formation mechanism that would be robustly beneficial for members of both tradeable and non-tradeable sector unions. Binding the non-tradeable sector wage to the tradeable sector wage yielded an inefficient adjustment to shocks. Therefore, the possible benefits that wage coordination led by the tradeable sector is assumed to bring should be carefully weighted with the possible inefficiencies it can create.

Supporting information

Additional supporting information can be found online in the supporting information section at the end of the article.

Replication files

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