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Damiaan Persyn

Katholieke Universiteit Leuven

LICOS Centre for Institutions and Economic Performance
Huis De Dorlodot
Deberiotstraat 34 – mailbox 3511
B-3000 Leuven
BELGIUM

TEL:+32-(0)16 32 65 98
FAX:+32-(0)16 32 65 99
http://www.econ.kuleuven.be/licos

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Damiaan Persyn[1]

VIVES and LICOS
Faculty of Business and Economics, Catholic University of Leuven
Naamsestraat 61, B-3000 Leuven, Belgium tel: +3216324230

Abstract

This paper considers the wage-setting behaviour of a monopoly union facing foreign competition. Contrary to intuition, trade integration is predicted to make union wages less sensitive to foreign wage changes if union preferences are sufficiently biased towards wages relative to employment. This is confirmed empirically using sector-level time-series on EU member states, using the existence of a statutory minimum wage as a proxy for union strength and wage-bias. The fact that there exist configurations in which wages become less correlated between countries after trade liberalisation does not imply that wages diverge internationally. The results do indicate, however, that some empirical results on the effects of economic integration on labour markets may need to be reinterpreted.

Key words: Unions, globalisation, economic geography, factor price equalisation JEL: J50, J31, F16

1. Introduction

The European Union has become increasingly economically integrated over the last decades. Vast improvements in transport infrastructure, streamlining of legislation and reforms such as the creation of a single market and currency have greatly facilitated trading with other member states. Firms have become more footloose and many firms have set up or relocated some production and sales plants abroad. The integration process has manifested itself in a significant increase in intra-EU trade and FDI relative to GDP.

Email addresses: damiaan.persyn@econ.kuleuven.be (Damiaan Persyn)

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The process of trade liberalisation has been welcomed by many, but has equally been perceived as increasing the exposure of workers to foreign competition. As such, economic integration would pose a threat to the labour market position of workers, both in terms of wages and employment opportunities. The economic literature has analysed the possible effects of trade liberalisation on employment and wages in a variety of settings. It is not our aim to summarise this literature here as excellent surveys can be found in, for example, Hoekman and Winters (2005) and Feenstra and Hanson (2004). The aim of this paper is to determine how trade integration affects the dependency of wages on local and foreign conditions. In this respect our contribution is related to two strands of literature which we want to single out.

Firstly, a question which has drawn considerable attention in the empirical literature is how trade liberalisation affects wages in different countries and the link between them. Many studies test for factor price equalisation or convergence, one of the key predictions of the classic Heckscher-Ohlin model of international trade (see Leamer, 1995, for a discussion). There exist markedly different approaches to test for wage convergence. For the EU, early studies of wage convergence such as Tovias (1982), Gremmen (1985) and Ben-David (1993) considered the evolution of income and wage disparity measures. Other studies following Burgman and Geppert (1993) tested whether wage differences between EU member states are stable in that wages in the different countries are cointegrated. For the US Robertson (2000, 2005) recently developed a model explaining the interdependency of wages in different countries and used it to test whether NAFTA has equalised wages between the US and Mexico. Moreover, Robertson tests whether trade liberalisation increased the responsiveness of Mexican wages to US wage shocks and has led to faster convergence towards a long-run equilibrium or towards wage equality.

The dependency of wages on the foreign wage level does not have to be solely driven by market forces, however. In Belgium, for example, the government responded to increasing international competition and the deteriorating relative cost competitiveness of the country by setting a maximum yearly wage increase for sectoral wage negotiations as an explicit function of the wage evolution in neighbouring countries. In a similar vein, the monopoly union in the small theoretical model we set up rationally adjusts its wage demands in function of the foreign wage level in order to preserve employment. Lower wages abroad then lead to more local wage discipline, and, *at least intuitively, trade liberalisation is expected to strengthen the international interdependency of wages*.

A second strand of literature which we build upon is the analysis of the effects of trade on unionised labour markets. Trade liberalisation is expected to limit the scope for union wage demands and, *at least intuitively, trade openness is expected to bring union wages more in line with non-union wages* by increasing the cost of raising union wages in terms of lost employment.[2] Empirical studies indeed mostly find proof of such a disciplining effect of international trade. Macpherson and Stewart (1990), for example, estimated the effect of import penetration on the difference between union and non-union wages. Abowd and Lemieux (1990) consider employment and wage effects of imports and exports on unionised labour markets. Fontagné and Mirza (2007) consider export market shares.

In section 2 two simple models are introduced to analyse the two expected disciplinary effects of trade integration described in the previous paragraphs in a single framework, by investigating the wage setting behaviour of a monopoly union adjusting its wage demands in face of foreign competition. We are far from the first to build a theory on the effect of trade liberalisation on unionised labour markets. For example Mezzetti and Dinopoulos (1991); Huizinga (1993); Driffill and van der Ploeg (1995); Naylor (1998, 1999) and Andersen and Sørensen (2000) set up models of international trade in an oligopolistic competition framework with unionised labour markets, and consider the effect of trade liberalisation on union wage demands. The effect of foreign wage changes on the local union wage demand is analysed in these models and some authors even derive an international Nash equilibrium in wages. In most models, however, the effect of a foreign wage change is constant (for example in Huizinga (1993) and Andersen and Sørensen (2000)), or a rather complicated function of model parameters including trade costs (for example in Driffill and van der Ploeg (1995)), but then a further analysis of the dependency on foreign wages is not undertaken. In general, these contributions tend to be more concerned with what happens to the level of union wages in response to trade liberalisation, with the derivation of an international Nash equilibrium in wages, or with the analysis of shifts in the optimal level of bargaining centralisation. All of these are very interesting questions, but lie outside the scope of this paper.

Section 2 starts with showing that the introduction of iceberg transport costs in the Andersen and Sørensen (2000) model causes the sensitivity of union wages with respect to foreign wages to unambiguously decrease after trade integration, in contrast to the original model. A second model considers a monopoly union facing internationally mobile firms. Here, the effect of trade liberalisation depends on union preferences. We show that if unions are relatively wage (employment) oriented, then (1) close to autarky wages are unit (in)elastic with respect to foreign wages and (unit) inelastic with respect to local alternative wage offers; (2) if trade is liberalised the sensitivity of wages with respect to alternative wage offers increases (decreases)

[2] Naylor (1998, 1999) shows that the opposite may actually occur in theory.

and the sensitivity to foreign wages decreases (increases).

Although some of these predictions are rather counter-intuitive, they are shown to hold to a large degree empirically, in section 3, using the extensive EUKLEMS and CEPII Trade and Production datasets. We proceed in three steps. First, country-sector specific intra-EU trade costs are calculated using bilateral sector-level trade data. The results confirm that the last two decades of the previous century were characterised by a significant decline in intra-EU trade costs. Second, it is shown that the employment cost of increasing wages has been increased by trade liberalisation. Third, using the existence of a statutory minimum wage in a country as a crude measure of union strength and wage-bias it is shown that, on average, in countries and sectors with more wage-oriented unions, trade liberalisation makes wages more sensitive to labour productivity, and does not strengthen the link with foreign wages. In countries with employment oriented unions the reverse holds.

Many studies (such as typical cointegration tests for convergence) consider wage regressions with foreign wages as a sole explanatory variable. When wages in two countries are driven by a common (stochastic) trend in labour productivity and sufficiently long time series are used, the relation between wages will be dominated by the presence of the common trend and one will find a one-to-one relationship between wages in different countries. In regressions with foreign wages as a sole explanatory variable, the change in the sensitivity to foreign wages predicted by our model will be only relevant and measurable for relatively short time series. We present empirical evidence in section 4, however, which strongly suggests that commonly used time-series may not be sufficiently long compared to the volatility in labour productivity for the dependency of wages to be solely determined by a common trend. In finite samples, the direct dependency of wages on foreign wages (caused, for example, by the behaviour of trade unions, as suggested in our model), apart from the link through labour productivity still matters and will be picked up by a simple regression of wages on foreign wages.

Overall our results call to reconsider some of the claims made in the empirical literature on the labour market effects of trade liberalisation. They also offer an explanation for some mixed results of tests for factor price equalisation or factor price convergence which are based on directly investigating the relationship between wages in different countries (as in, for example, Andersen, Haldrup, and Sørensen, 2000; Berger and Westermann, 2001; Robertson, 2000, 2005) and suggest that some of the claims made in these studies are not supported by their estimation approach. In finite samples trade integration may imply that wages converge internationally but simultaneously become less correlated with foreign wages, converge slower towards a long-run equilibrium, and appear 'less cointegrated' in the sense that statistical tests may confirm cointegration between wages in different countries before trade integration but fail to do so afterwards.

2. The effect of trade integration on union wage demands

This section introduces two monopoly union models in which the effect of trade liberalisation on union wage demands is analysed. We will focus on how trade liberalisation affects the dependency of union wages on foreign wages and its other determinants. Both models are characterised by a sector-level monopoly union in a small country unilaterally setting wages w to maximise a sufficiently differentiable concave utility function U.

Let us first consider the optimal union wage demand and some of its properties in general. Assume for now that union utility U depends only on union wages w in the sector, the extend of trade liberalisation in the sector ϕ, foreign wages w^f, and the wage offer in some other sector w^a which is considered as an alternative employment opportunity by the union. Excluding corner solutions, the first order condition defines the optimal union wage demand $w^*(\phi, w^f, w^a)$ as a function of ϕ, w^f and w^a

$$\frac{\partial\, U(w, \phi, w^f, w^a)}{\partial\, w} = F(w^*(\phi, w^f, w^a), \phi, w^f, w^a) = 0.$$

To derive the effect of a foreign wage change on the optimal union wage demand w^*, take the derivative of both sides of the equation $F = 0$ with respect to w^f

$$\frac{\partial\, F}{\partial\, w^*}\frac{\partial\, w^*}{\partial\, w^f} + \frac{\partial\, F}{\partial\, w^f} = 0.$$

The effect of foreign wages on the union wage demand can therefore be expressed as

$$\mathfrak{d}^{w^f}(w^*(\phi, w^f, w^a), \phi, w^f, w^a) \equiv \frac{\partial\, w^*(\phi, w^f, w^a)}{\partial\, w^f} \;=\; -\frac{\partial\, F}{\partial\, w^f}\Bigg/\frac{\partial\, F}{\partial\, w^*} \tag{1a}$$

or

$$\mathfrak{e}^{w^f}(w^*(\phi, w^f, w^a), \phi, w^f, w^a) \equiv \frac{\partial\, w^*(\phi, w^f, w^a)}{\partial\, w^f}\frac{w^f}{w^*(\phi, w^f, w^a)} = \frac{\mathfrak{d}^{w^f} w^f}{w^*}.$$

The symbols $\mathfrak{d}^{w^f}$ and $\mathfrak{e}^{w^f}$ serve as mnemonics for 'derivative' and 'elasticity'. The map $\mathfrak{d}^{w^f}$ expresses by how much the optimal union wage demand changes in response to a unit change in foreign wages, while the map $\mathfrak{e}^{w^f}$ expresses the percentage change in the union wage demand in response to a percentage change in foreign wages. Both measures might be relevant depending on the context. Following the same steps shows $\frac{\partial\, w^*}{\partial\, \phi} = -\frac{\partial\, F}{\partial\, \phi}\Big/\frac{\partial\, F}{\partial\, w^*}$.

Writing $\mathfrak{d}_i^{w^f}$ for the partial derivative of $\mathfrak{d}^{w^f}$ with respect to it's ith argument, the effect of trade liberalisation on the dependency of union wages on foreign wages is given by

$$\frac{\partial\, \mathfrak{d}^{w^f}}{\partial\, \phi} = \frac{\partial\, \mathfrak{d}^{w^f}(w^*(\phi, w^f, w^a), \phi, w^f, w^a)}{\partial\, \phi} = \mathfrak{d}_1^{w^f} \frac{\partial\, w^*}{\partial\, \phi} + \mathfrak{d}_2^{w^f} \tag{2a}$$

and

$$\begin{aligned} \frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \phi} &= \frac{\partial\, \mathfrak{e}^{w^f}(w^*(\phi, w^f, w^a), \phi, w^f, w^a)}{\partial\, \phi} = \frac{\partial}{\partial\, \phi}\left(\frac{\partial\, w^*}{\partial\, w^f}\frac{w^f}{w^*}\right) \\ &= \frac{\partial}{\partial\, \phi}\left(\frac{\partial\, w^*}{\partial\, w^f}\right)\frac{w^f}{w^*} + \frac{\partial\, w^*}{\partial\, w^f}\frac{\partial}{\partial\, \phi}\left(\frac{w^f}{w^*}\right) \\ &= \frac{\partial\, \mathfrak{d}^{w^f}}{\partial\, \phi}\frac{w^f}{w^*} - \frac{\mathfrak{d}^{w^f} w^f}{w^{*2}}\frac{\partial\, w^*}{\partial\, \phi}. \end{aligned} \tag{2b}$$

Following the same steps, we can define $\mathfrak{d}^{w^a}$ and $\mathfrak{e}^{w^a}$ and derive the effects of ϕ thereon:

$$\mathfrak{d}^{w^a} \equiv \frac{\partial\, w^*(\phi, w^f, w^a)}{\partial\, w^a} = -\frac{\partial\, F}{\partial\, w^a}\Big/\frac{\partial\, F}{\partial\, w^*} \qquad \mathfrak{e}^{w^a} \equiv \frac{\mathfrak{d}^{w^a} w^f}{w^*}$$

$$\frac{\partial\, \mathfrak{d}^{w^a}}{\partial\, \phi} = \mathfrak{d}_1^{w^a}\frac{\partial\, w^*}{\partial\, \phi} + \mathfrak{d}_2^{w^a} \qquad \frac{\partial\, \mathfrak{e}^{w^a}}{\partial\, \phi} = \frac{\partial\, \mathfrak{d}^{w^a}}{\partial\, \phi}\frac{w^f}{w^*} - \frac{\mathfrak{d}^{w^a} w^f}{w^{*2}}\frac{\partial\, w^*}{\partial\, \phi}.$$

As these expressions are hard to sign in general, two specific examples will be considered in the remainder of this section. In both cases the optimal union wage demand can be written as an explicit function of ϕ, w^f and w^a. The quantities $\mathfrak{d}^{w^f}$, $\mathfrak{d}^{w^a}$ and the effect of ϕ thereon then can be derived directly. Nevertheless, the more general expressions given above will be useful to determine the origin of some of the properties of the models.

A first model we consider is the Andersen and Sørensen (2000) monopoly-union model of international Cournot competition. In this model, the partial derivative of the optimal union wage demand with respect to foreign wages is positive ($\mathfrak{d}^{w^f} > 0$), but does not depend on transport costs (and therefore (2a) reduces to $\partial\, \mathfrak{d}^{w^f}/\partial\, \phi = 0$). However, because union wage demands (counter-intuitively) increase as trade opens up ($\partial\, w^*/\partial\, \phi > 0$), trade liberalisation lowers the sensitivity with respect to foreign wages when this sensitivity is expressed as an elasticity ($\partial\, \mathfrak{e}^{w^f}/\partial\, \phi < 0$). A unit increase in foreign wages causes the same unit increase in union wage demands before and after trade liberalisation, but the elasticity $\mathfrak{e}^{w^f}$ decreases after trade liberalisation because this union wage change is expressed relative to a higher union wage.

In section 2.1, it is shown that by introducing iceberg transport costs in the Andersen and Sørensen (2000) model, trade liberalisation decreases the sensitivity of union wages with respect to foreign wages *both* when the sensitivity is expressed as a partial derivative ($\partial\, \mathfrak{d}^{w^f} / \partial\, \phi < 0$) and as an elasticity ($\partial\, \mathfrak{e}^{w^f} / \partial\, \phi < 0$): With iceberg transport costs, the decrease in the sensitivity of union wages with respect to foreign wages after trade liberalisation is not solely caused by increasing union wage demands.

In section 2.2, a rather different model is introduced where a monopoly union faces internationally mobile firms, and the optimal union wage demand decreases after trade liberalisation. In spite of the decrease in union wages, trade liberalisation may still lower the sensitivity of union wages with respect to foreign wages when it is expressed as an elasticity. Whether trade liberalisation increases or decreases the sensitivity of union wages with respect to foreign wages depends on union preferences in this model, both when this sensitivity is expressed as a derivative and as an elasticity.

2.1. A monopoly union model with international Cournot competition

This section considers the effect of trade liberalisation on the sensitivity of union wage demands with respect to foreign wages in the Andersen and Sørensen (2000) model with iceberg transport costs.

Say there are two countries, Home and Foreign, each of which contain M firms indexed by i. Firms produce differentiated varieties, but the same M varieties are produced in both countries. Firms (and thus varieties) are ranked such that the first N varieties are traded internationally, while the remaining $M - N$ varieties are produced and consumed locally. Write $q_i, \tilde{q}_i$ for domestic sales and exports of the representative firm at home, and $\tilde{q}_i^f, q_i^f$ for domestic sales and exports of the representative firm in the foreign country, respectively. p_i is the price on the home market and $\tilde{p}_i$ is the foreign price. Inverse demand for the N traded and $M - N$ non-traded varieties is given by (see Andersen and Sørensen, 2000)

$$
\begin{aligned}
p_i &= a - b(q_i + q_i^f) \qquad & \tilde{p}_i &= a - b(\tilde{q}_i + \tilde{q}_i^f) \qquad & i &= 1, \ldots, N \\
p_i &= a - b(q_i) \qquad & \tilde{p}_i &= a - b(\tilde{q}_i) \qquad & i &= N+1, \ldots, M.
\end{aligned}
$$

Production is linear in labour l_i such that $q_i + \tilde{q}_i = l_i$. Competition between the local and foreign producer of variety i is Cournot. Different from Andersen and Sørensen (2000), iceberg transport costs $\tau > 1$ make a quantity τq of a good has to be shipped for q goods to arrive, such that transport costs are proportional to the *value* of the shipped goods. This is equivalent to assuming an ad-valorem tariff. The profit function, optimal output and labour demand of a domestic trading firm then are

$$\begin{aligned} \pi_i &= p_i q_i + \tilde{p}_i \tilde{q}_i - w q_i - \tau w \tilde{q}_i & \tilde{q}_i &= \frac{a + w^f - 2\tau w}{3b} & & \\ q_i &= \frac{a + \tau w^f - 2w}{3b} & l_i &= q_i + \tilde{q}_i = \frac{2a + (1+\tau)(w^f - 2w)}{3b} & & i = 1, \ldots, N. \end{aligned}$$

A domestic non-trading firm operates as a monopolist in its sub-market and has following profit function and corresponding optimal output and labour demand

$$\pi_i = p_i q_i - w q_i \qquad q_i = l_i = \frac{a - w}{2b} \qquad i = N+1, \ldots, M.$$

As in Andersen and Sørensen (2000), assume that a sector-level union maximises the income of the representative worker with a reservation wage w^a, while ignoring the effect of its actions on the general price level (this amounts to assuming that the sector is small relative to the total economy). The union operates in a right-to-manage framework, where it optimally sets wages while taking into account that firms will subsequently adjust the demand for labour. Writing L for sector-level labour demand, the union objective function is

$$\begin{aligned} U = L(w - w^a)^\gamma &= \left(\sum_{i=1}^{N} (q_i + \tilde{q}_i) + \sum_{i=N+1}^{M} q_i \right) (w - w^a)^\gamma \\ &= \left(N \frac{2a + (1+\tau) w^f - 2(1+\tau) w}{3b} + (M - N) \frac{a - w}{2b} \right) (w - w^a)^\gamma. \end{aligned} \tag{3}$$

Also different from Andersen and Sørensen (2000) is the presence of $\gamma > 0$ which measures the union preference for 'supernumerary wages' $(w - w^a)$ relative to employment[3], which we will simply refer to as the wage-bias of unions. For convenience, and since the case of trade liberalisation will be studied in the empirical section rather than the effect of increasing transport costs, we write $\phi = (1 + \tau)^{-1}$. Lower transport costs τ correspond to higher values of ϕ, which serves a mnemonic for 'freer trade'. Standard calculations show that the optimal

[3]The model of Andersen and Sørensen (2000) corresponds to $\gamma = 1$. Specifications of union utility which allow for a different weight of wages relative to employment have been used by, for example, Dertouzos and Pencavel (1981) and Gaston (2002). Pemberton (1988) shows that γ can be interpreted as a measure of the bargaining power of wage-oriented union members relative to a union-membership oriented union 'management'. Dumont, Rayp, and Willeme (2006) estimate γ for a number of European countries and sectors.

union wage demand[4] then is given by

$$w^* = a\frac{\gamma}{1+\gamma}\frac{3M+N}{3(M-N)-4N\phi} - \frac{\gamma}{1+\gamma}\frac{2N\phi}{3(M-N)-4N\phi}w^f + \frac{1}{1+\gamma}w^a.$$

Union wage demands increase after trade liberalisation ($\partial w^*/\partial \phi > 0$), as in Naylor (1998) and Andersen and Sørensen (2000). Trade liberalisation has a positive effect on output as the increased market access abroad outweighs the effect of the increase in domestic competition. The subsequent increase in labour demand triggers higher union wage demands.

Increases in foreign wages w^f or the alternative wage w^a lead to higher union wage demands:

$$\mathfrak{d}^{w^f} = \frac{\partial w^*}{\partial w^f} = \frac{\gamma}{1+\gamma}\frac{2N}{3\phi(M-N)+4N} > 0 \qquad \mathfrak{d}^{w^a} = \frac{\partial w^*}{\partial w^a} = \frac{1}{1+\gamma} > 0.$$

One can see from the union objective function in equation (3) that, with iceberg transport costs, foreign wages do not disappear from the union utility function as the economy becomes more closed (τ increases) as one might expect, but rather gain in importance. The sensitivity of union wages with respect to foreign wages indeed decreases with trade openness, both when expressed as a derivative and as an elasticity:

$$\begin{aligned}
\frac{\partial\, \mathfrak{d}^{w^f}}{\partial \phi} &= \frac{\partial}{\partial \phi}\left(\frac{\partial w^*}{\partial w^f}\right) \\
&= -\frac{\gamma}{(1+\gamma)}\frac{6(M-N)}{(3\phi(M-N)+4N)^2} < 0 \\
\frac{\partial\, \mathfrak{e}^{w^f}}{\partial \phi} &= \frac{\partial}{\partial \phi}\left(\frac{\partial w^*}{\partial w^f}\frac{w^f}{w^*}\right) \\
&= -\frac{2\gamma N w^f (a\gamma(3M+N)+3(M-N)w^f)}{a\phi\gamma(3M+N)+2\gamma N w^f+(3\phi(M-N)+4N)w^a)^2} < 0.
\end{aligned}$$

An increase in the alternative wage w^a always leads to higher union wage demands ($\mathfrak{d}^{w^a} = \frac{\partial w^*}{\partial w^a} = 1/(1+\gamma) > 0$), but the partial derivative $\mathfrak{d}^{w^a}$ does not depend on trade openness such that $\frac{\partial\, \mathfrak{d}^{w^a}}{\partial \phi} = 0$. The elasticity $\mathfrak{e}^{w^a}$, however, decreases after trade liberalisation ($\frac{\partial\, \mathfrak{e}^{w^a}}{\partial \phi} < 0$) because union wage demands increase after trade liberalisation ($\partial w^*/\partial \phi > 0$, see also the

[4]Following the same steps for the original Andersen and Sørensen (2000) model results in the following optimal union wage demand, where we substitute $\phi^\dagger = 1/t$ and t are transport costs which are proportional to the *quantity* (rather than the value) of goods shipped: $w^* = \frac{\gamma}{1+\gamma}\frac{-2N+a\phi^\dagger(3M+N)}{\phi^\dagger(3M+5N)} + \frac{\gamma}{1+\gamma}\frac{4N}{(3M+5N)}w^f + \frac{1}{1+\gamma}\frac{(3\phi^\dagger M+5\phi^\dagger N)}{\phi^\dagger(3M+5N)}w^a$

expression for $\partial\, \mathfrak{e}^{w^a}/\partial\, \phi$ on page 6).

$$
\begin{aligned}
\frac{\partial\, \mathfrak{d}^{w^a}}{\partial\, \phi} &= \frac{\partial}{\partial\, \phi}\left(\frac{\partial\, w^*}{\partial\, w^a}\right) = 0 \\
\frac{\partial\, \mathfrak{e}^{w^a}}{\partial\, \phi} &= \frac{\partial}{\partial\, \phi}\left(\frac{\partial\, w^*}{\partial\, w^a}\frac{w^a}{w^*}\right) \\
&= -\frac{2\gamma N(2a(3M+N)-3(M-N)w^f)w^f}{a\phi\gamma(3M+N)+2\gamma N w^f+(3\phi(M-N)+4N)w^f)^2} < 0.
\end{aligned}
$$

It can also be shown that unions with a stronger preference for wages relative to employment make higher wage demands ($\partial\, w^*/\partial\, \gamma > 0$). A higher γ makes wages more sensitive to foreign wages ($\frac{\partial\, \mathfrak{d}^{w^f}}{\partial\, \gamma} > 0$ and $\frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \gamma} > 0$), and less sensitive to local alternative wage offers ($\frac{\partial\, \mathfrak{d}^{w^a}}{\partial\, \gamma} < 0$ and $\frac{\partial\, \mathfrak{e}^{w^a}}{\partial\, \gamma} < 0$).

Although these are interesting properties, the main point which is relevant for the purpose of this paper is that, by introducing iceberg transport costs in a standard model with international oligopolistic competition, the foreign wage sensitivity of union wages may unambiguously decrease after trade liberalisation, both when considering the sensitivity as a partial derivative $\mathfrak{d}^{w^f}$ and as an elasticity $\mathfrak{e}^{w^f}$. This holds for any level of $\gamma > 0$.

Before testing whether these predictions are reflected in the data we set up another model which introduces ambiguity as to whether trade liberalisation increases or decreases the sensitivity of union wages with respect to foreign wages: the sign of the effect will be shown to depend on the relative union preference for wages γ.

2.2. A monopoly union model with internationally mobile firms

Whereas firm location was assumed fixed in the previous section, this section describes a model where a monopoly union sets wages in the face of internationally mobile firms. When trade is liberalised, firms become more responsive to international differences in production costs and union wage demands decrease. The sign of the effect of trade liberalisation on the sensitivity of union wages to foreign wages is shown to depend on the union preference for wages relative to employment. We start from the assumption that union preferences are homogeneous and gradually impose more structure on the model to derive more properties of union wages.

2.2.1. The implication of homogeneous union preferences

In this section, union utility also changes with local labour productivity p, foreign labour productivity p^f, and a measure of the local market size m. As before, U is assumed to be sufficiently differentiable and concave over its domain. Importantly, in this section U is assumed to be homogeneous with respect to three subsets of arguments, $\{w, w^f, w^a\}$, $\{w, p, w^a\}$, and $\{p^f, w^f\}$. Whether U is also homogeneous with respect to other sets of arguments is irrelevant to our main results. We say U is homogeneous of degree k with respect to $\{w, w^f, w^a\}$ if for all positive λ it holds that

$$U(\lambda w, m, \phi, \lambda w^f, p, p^f, \lambda w^a) = \lambda^k U(w, m, \phi, w^f, p, p^f, w^a).$$

Excluding corner solutions, the first order condition $\frac{\partial U}{\partial w} = F(w^*(.), m, \phi, w^f, p, p^f, w^a) = 0$ defines the optimal union wage demand w^*. If U is homogeneous of degree k with respect to $\{w, w^f, w^a\}$, then $F = \partial U/\partial w$ is homogeneous of degree $k-1$ with respect to $\{w^*, w^f, w^a\}$

$$F(\lambda w^*(.), m, \phi, \lambda w^f, p, p^f, \lambda w^a) = \lambda^{k-1} F(w^*(.), m, \phi, w^f, p, p^f, w^a) = 0.$$

Taking derivatives on both sides with respect to λ and choosing $\lambda = 1$ shows that

$$\frac{\partial F}{\partial w^*} w^* + \frac{\partial F}{\partial w^f} w^f + \frac{\partial F}{\partial w^a} w^a = (k-1)F = 0.$$

Dividing by $\frac{\partial F}{\partial w^*} w^*$ and writing $\mathfrak{d}^x = -\frac{\partial F}{\partial x} \Big/ \frac{\partial F}{\partial w^*}$ and $\mathfrak{e}^x = \mathfrak{d}^x x / w^*$ for the partial derivative and elasticity of the union wage w^* with respect to some variable x, we obtain

$$\mathfrak{e}^{w^f} + \mathfrak{e}^{w^a} = 1.$$

Following the same steps, the homogeneity of U with respect to $\{w, p, w^a\}$ implies $\mathfrak{e}^{w^a} + \mathfrak{e}^p = 1$ and homogeneity with respect to $\{p^f, w^f\}$ in turn implies $\mathfrak{e}^{w^f} + \mathfrak{e}^{p^f} = 0$. Given these homogeneity assumptions the optimal union wage is therefore characterised by

$$\mathfrak{e}^{w^f} + \mathfrak{e}^{w^a} = 1, \qquad \mathfrak{e}^p + \mathfrak{e}^{w^a} = 1, \qquad \mathfrak{e}^p + \mathfrak{e}^{p^f} = 0. \tag{4}$$

When one of these four elasticities is known, the others can therefore be readily derived using the above constraints. The constraints also imply that whatever the effect is of some parameter change on, say, the sensitivity of union wages with respect to foreign wages as expressed by $\mathfrak{e}^{w^f}$, the effect on the sensitivity with respect to the alternative wage $\mathfrak{e}^{w^a}$ and foreign productivity $\mathfrak{e}^{p^f}$ must be opposite in sign and magnitude and the effect on $\mathfrak{e}^p$ must be of equal sign and magnitude. For changes in ϕ and γ, for example, the homogeneity assumptions imply

$$\frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \phi} = \frac{\partial\, \mathfrak{e}^{p}}{\partial\, \phi} = -\frac{\partial\, \mathfrak{e}^{w^a}}{\partial\, \phi} = -\frac{\partial\, \mathfrak{e}^{p^f}}{\partial\, \phi} \qquad \text{and} \qquad \frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \gamma} = \frac{\partial\, \mathfrak{e}^{p}}{\partial\, \gamma} = -\frac{\partial\, \mathfrak{e}^{w^a}}{\partial\, \gamma} = -\frac{\partial\, \mathfrak{e}^{p^f}}{\partial\, \gamma}.$$

Homogeneity in $\{p^f, w^f\}$ will for example hold if, as far as p^f and w^f are concerned, only the *ratio* of foreign wages to foreign labour productivity matters to the union (which might be called the foreign wage cost in effective labour units). Homogeneity in $\{w^*, w^f, w^a\}$ implies that a simultaneous change in $\{w^f, w^a\}$ to $\{\lambda w^f, \lambda w^a\}$ causes the same proportional change in the optimal union wage demand, from w^* to λw^*. The derivatives $\mathfrak{d}^{w^f}$ and $\mathfrak{d}^{w^a}$ are unaffected since homogeneity implies both derivatives of F in the nominator and denominator in the definition (1a) change proportionally by λ^{k-1}. Homogeneity with respect to $\{w^*, p, w^a\}$ has similar implications. In this sense the homogeneity restrictions impose various forms of scalability on the model. These properties are desirable as they imply neutrality with respect to units of measurement.

2.2.2. Imposing more structure on union utility

To quantify the elasticities and the effect of some parameter changes thereon more structure needs to be imposed on the functional form of U. As in section 2.1, union preferences are assumed to be given by $U = L(w - w^a)^\gamma$ where L is aggregate labour demand and $\gamma > 0$ expresses the union preference for supernumerary wages $(w - w^a)$. Aggregate labour demand is given by $L = nl$, where $l(\frac{w}{p})$ represents the labour demand in a representative firm and $n(m, \phi, \frac{w}{p}\frac{p^f}{w^f})$ is the number of firms in the country. It can easily be verified that under these assumptions the above assumptions on homogeneity and therefore the restrictions (4) hold.

A wide variety of models from the economic geography literature could serve to describe the number of firms n which locate in a country. This typically requires assumptions on consumer preferences, firm pricing behaviour, etc. Not all of these models will be characterised by n depending on the relative production costs, but many standard models are. Allowing for international wage differences in the footloose capital model of Martin and Rogers (1995) , as in Persyn (2009), resulted in a number of firms given by

$$n = c\,\frac{m(1-\phi^2) + \phi^2 - \phi c}{(\phi - c)(\phi c - 1)}, \tag{5}$$

where $c = ((wp^f)/(pw^f))^{\sigma-1}$. Here m is the appropriately normalised market size of the country, ϕ is a measure of the freeness of trade which is decreasing in transport costs and

σ is the elasticity of substitution between CES varieties in the model. The fact that wages w appear in a highly non-linear fashion makes it is impossible to express the optimal union wage demand explicitly except for special cases such as $\sigma = 2$.

As the derivations become lengthy and un-insightful using this theoretically underpinned specification for n, we use the following ad-hoc specification for the remainder of this paper

$$n(w, m, \phi, w^f, p, p^f) = m - \phi \left(\frac{wp^f}{pw^f} - 1 \right). \tag{6}$$

Close to autarky (for small but strictly positive ϕ), or in the absence of an international wage differential ($w = w^f$) the number of firms equals the (appropriately normalised) market size m. As trade becomes freer (increasing ϕ), the international wage differential becomes more relevant to firm location. The results obtained from this model are qualitatively similar to those obtained using n defined as in equation (5) from Persyn (2009). To be precise, it will be shown that with n defined by equation (6) the effect of trade liberalisation differs significantly depending on whether $\gamma > 1$ or $\gamma < 1$. With n defined according to equation (5), the effect is ambiguous for values of γ near 1, but unambiguous and identical to the predictions of the simpler model for sufficiently high or low γ.

For labour demand we simply assume $l(w, p) = p/w$.[5]

Taken together, U is defined as

$$U = nl(w - w^a)^\gamma = \left(m - \phi \left(\frac{wp^f}{pw^f} - 1 \right) \right) \left(\frac{w}{p} \right)^{-1} (w - w^a)^\gamma. \tag{7}$$

To guarantee that U is a smooth and concave function over its domain we impose $\phi > 0$ and $n = m - \phi \left(wp^f / pw^f - 1 \right) > 0$. All the results derived below are subject to these conditions.

2.2.3. The effect of labour productivity, foreign wages and trade costs on union wage demands

With union utility defined by equation (7), the optimal union wage demand w^* is a solution of

$$\frac{\partial U}{\partial w} = \frac{\phi \gamma p^f w^2 - (-1 + \gamma)(\phi + m) p w^f w - (\phi + m) p w^a w^f}{w(w - w^a)(\phi p w^f + m p w^f - \phi p^f w)} = 0.$$

Since the denominator is always positive provided $n = m - \phi \left(p^f w / pw^f - 1 \right) > 0$, the optimal union wage is defined by the roots of the numerator. Moreover, as one of these roots gives rise

[5] Our results would remain valid for $l(w, p) = (w/p)^{-\epsilon}$ for sufficiently high and low γ, if the long run unconditional labour demand elasticity ϵ exceeds 1/2 (which seems plausible given common estimates of $\epsilon \approx 1$, see for example Konings and Roodhooft, 1997; Hamermesh, 1996).

to $n < 0$, there exists a unique economically relevant solution to the first order condition. The optimal union wage demand w^* can be written as an explicit function of the model parameters

$$w^* = \frac{(\gamma-1)(\phi+m)pw^f + \sqrt{(\phi+m)pw^f\left((\phi+m)pw^f(\gamma-1)^2 + 4\phi\gamma p^f w^a\right)}}{2\phi\gamma p^f}. \tag{8}$$

The union wage demand is increasing in the alternative wage w^a, local labour productivity p, the home market size m, foreign wages w^f and γ, the weight of $w - w^a$ in union preferences. Wage demands decrease with foreign productivity p^f and with freer trade as measured by ϕ. Provided $\phi > 0$ and $n = m - \phi\left(wp^f/pw^f - 1\right) > 0$, the second order condition for a maximum holds.

Taking the derivative of w^* with respect to the foreign wage level w^f and rearranging shows

$$\mathfrak{e}^{w^f} = \frac{\partial\, w^*}{\partial\, w^f}\frac{w^f}{w^*} = \frac{1}{2} + \frac{(\gamma-1)(\phi+m)pw^f}{2\sqrt{(\gamma-1)^2(\phi+m)^2p^2{w^f}^2 + 4\gamma\phi(\phi+m)pp^f w^f w^a}}. \tag{9}$$

If unions care just as much about wages and employment ($\gamma = 1$) it holds that $\mathfrak{e}^{w^f} = 1/2$. Given the markedly different behaviour of the model depending on $\gamma < 1$ or $\gamma > 1$, we will refer to the case $\gamma < 1$ as an employment oriented union, and refer to $\gamma > 1$ as a wage oriented union. The sensitivity to foreign wage changes is increasing in γ, or

$$\frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \gamma} > 0, \tag{10}$$

such that if unions are biased toward wages ($\gamma > 1$), we have $\mathfrak{e}^{w^f} > 1/2$. For $\gamma < 1$ it holds that $\mathfrak{e}^{w^f} < 1/2$.

An important issue we want to address is how the sensitivity of the optimal union wage demand with respect to its determinants changes when trade costs fall. The effect of ϕ on $\mathfrak{e}^{w^f}$ is given by

$$\frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \phi} = \frac{(1-\gamma)\gamma m\sqrt{f}w^a}{\sqrt{\phi+m}\left((\phi+m)f(\gamma-1)^2 + 4\phi\gamma w^a\right)^{3/2}}.$$

As the expression is positive for $\gamma > 1$ and negative for $\gamma < 1$, freer trade decreases or increases the sensitivity of union wages to foreign wages depending on whether unions are wage or employment oriented, respectively. It is important to note that the sign of $\partial^2\mathfrak{e}^{w^f}/\partial\,\phi\partial\,\gamma$ is indeterminate. The only statement we can make is that $\partial\, \mathfrak{e}^{w^f}/\partial\, \phi$ is negative when $\gamma > 1$ and positive when $\gamma < 1$.

To investigate the case of small but strictly positive ϕ (high but finite trade costs) we consider the limit[6] and the expression simplifies to

$$\lim_{\phi \to 0^+} \mathfrak{e}^{w^f} = \frac{1}{2} + \frac{\gamma - 1}{2\sqrt{(\gamma-1)^2}} = \begin{cases} 1 & \text{if } \gamma > 1, \\ 0 & \text{if } \gamma < 1. \end{cases}$$

Close to autarky, union wages are unit elastic with respect to foreign wages in the case where unions prefer wages over employment, and are completely insensitive to the foreign wage level in the case unions are employment oriented.

The derivations above pertain to $\mathfrak{e}^{w^f}$, but given the constraints (4) these results define the behaviour of all four elasticities. The above results and the fact that $\mathfrak{e}^{w^f} = \mathfrak{e}^p$ imply that following proposition holds for the model derived in this section.

Proposition 1. *Close to autarky, if unions are wage (employment) oriented, wages are unit elastic (inelastic) with respect to foreign wages and local productivity. Wages become less (more) sensitive to the level of foreign wages and local productivity after trade liberalisation.*

From the other constraints it obtains that

Proposition 2. *If unions are wage (employment) oriented, wages are inelastic (unit elastic) with respect to alternative wage offers close to autarky. Wages become more (less) sensitive to local labour productivity after trade liberalisation.*

Proposition 3. *If unions are wage (employment) oriented, the elasticity of wages with respect to foreign labour productivity equals* -1 (0). *This elasticity increases (decreases) after trade liberalisation.*

Figure 1 illustrates the results on the effect of ϕ on wages (solid line), the sensitivity to foreign wage changes as expressed by $\mathfrak{e}^{w^f}$ (dashed line) and the sensitivity of wages with respect to alternative wage offers $\mathfrak{e}^{w^a}$ (dotted line). The left panel shows the case of an employment oriented union ($\gamma = 0.8$), the right panel the case of strong union preferences for wages ($\gamma = 1.5$). As the case $\gamma = 0.8$ is close to an equal weight of wages and employment ($\gamma = 1$), both elasticities are close to $1/2$ unless trade costs are high (ϕ is small, see equation (9)).

It might appear counter-intuitive that there exist configurations in which wages are more sensitive to the foreign wage level in a more closed economy. Some intuition on the effect

[6] Note that to analyse the behaviour for small but strictly positive ϕ we take the limit *after* solving the model, which differs from the behaviour of the model when taking the limit before solving for the optimal union wage demand.

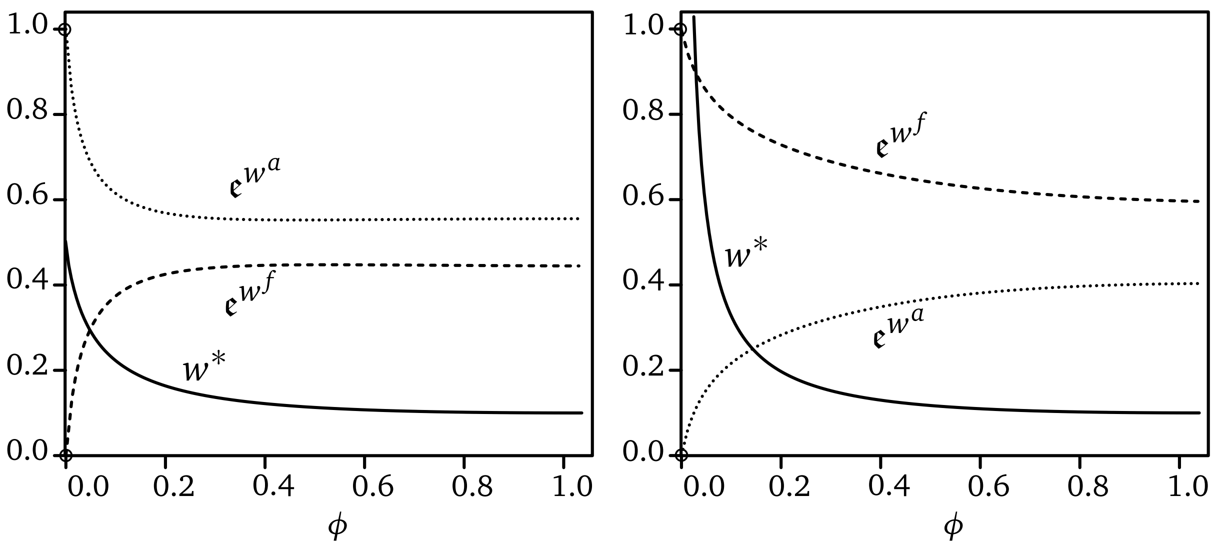

Figure 1: The effect of ϕ on wages (solid line), the sensitivity of wages to alternative wage offers (dotted line) and the sensitivity to foreign wages (dashed line). In the left panel unions value employment more than wages ($\gamma < 1$) and vice versa in the right panel ($\gamma > 1$).

of trade costs on the sensitivity of union wage demands with respect to foreign wages and productivity in this model can be gained by considering the role of the firms' location $n = m - \phi(p^f w^*/pw^f - 1)$ in union utility (equation (7)). As ϕ declines, the importance of the term $\phi(p^f w^*/pw^f)$ may be expected to wane. However, for $\gamma > 1$ unions increase their wage demands w^* faster than ϕ declines, causing the term $\phi(p^f w^*/pw^f$ to become larger when ϕ decreases. *Wage oriented unions make use of the relative closedness of the economy to inflate wage demands, but they skate on thin ice: small changes in foreign wages will then greatly affect union utility by causing small changes in the international distribution of firms, thus requiring large adjustment in the optimal union wage demand.* If unions attach more weight to employment ($\gamma < 1$), the wage demand w^* remains limited and the term $\phi(w^*/w^f)$ does become smaller as ϕ decreases. Foreign wages then become less important as ϕ declines, and become irrelevant altogether to the optimal union wage demand for small ϕ.

More formally, as shown in equation (2b), the effect of trade liberalisation on the sensitivity of union wages to foreign wages expressed as an elasticity can be decomposed as

$$\frac{\partial\, \mathfrak{e}^{w^f}}{\partial\, \phi} = \frac{\partial\, \mathfrak{d}^{w^f}}{\partial\, \phi}\frac{w^f}{w^*} - \frac{\mathfrak{d}^{w^f} w^f}{w^{*2}}\frac{\partial\, w^*}{\partial\, \phi}.$$

In contrast to the iceberg version of the Andersen and Sørensen (2000) model discussed in section 2.1, $\partial\, w^*/\partial\, \phi$ is always negative in our last model. It can be shown that $\gamma < \sqrt{2} - 1$ is a sufficient condition for $\partial\, \mathfrak{d}^{w^f}/\partial\, \phi$ to be positive. The effects of ϕ on w^* and on $\mathfrak{d}^{w^f}$ then both act to increase the foreign wage elasticity $\mathfrak{e}^{w^f}$. For $\sqrt{2}-1 < \gamma < 1$, the sign of $\partial\, \mathfrak{d}^{w^f}/\partial\, \phi$ is ambiguous, although we known that $\partial\, \mathfrak{e}^{w^f}/\partial\, \phi > 0$ holds for $\gamma < 1$. If $\gamma > 1$ then $\partial\, \mathfrak{d}^{w^f}/\partial\, \phi$ is always negative. $\gamma > 1$ is a sufficient condition for $\partial\, \mathfrak{d}^{w^f}/\partial\, \phi < 0$ but a necessary and sufficient condition for $\partial\, \mathfrak{e}^{w^f}/\partial\, \phi > 0$. With $\gamma > 1$ the sensitivity to foreign wages therefore decreases after trade liberalisation, both when expressed as the elasticity $\mathfrak{e}^{w^f}$ and as the partial derivative $\mathfrak{d}^{w^f}$. For $\gamma > 1$ the effect of ϕ on $\mathfrak{d}^{w^f}$ is sufficiently strong to result in a negative total effect of trade liberalisation on the foreign wage elasticity *despite* the fact that wages decrease when trade becomes freer ($\partial\, w^*/\partial\, \phi > 0$).

Taken together, the main predictions on the effect of trade liberalisation on the link between union wages and its determinants are clear. As was shown in section 2.1, both the original model of Andersen and Sørensen (2000) and our version with iceberg transport costs predict that trade openness decreases the elasticity of union wages with respect to foreign wages. Unlike the original Andersen and Sørensen (2000) model, this is not solely due to the fact that wages increase after trade integration in the version with iceberg transport costs. The last model with internationally mobile firms introduced in this section predicts that the effect depends on the relative union preference for wages relative to employment. For wage-oriented unions the effect is predicted to be negative, for employment-oriented unions it is predicted to be positive. Given the assumptions on the homogeneity of the union utility function, the last model also predicts simple relationships between the elasticities of the union wage relative to its various determinants, and therefore it also makes precise predictions on the effect of trade liberalisation and union preferences thereon. In the next section, we will estimate whether trade liberalisation has changed the sensitivity of wages with respect to foreign wages and its other determinants, and also how this effect differs between countries where union preferences are expected to differ. Section 4 then considers how this may affect the interpretation of regressions and tests often encountered in the literature.

3. Did trade integration change the link between wages of EU countries?

In this section some of the predictions of the models from the previous sections are tested using aggregate data on 12 industries in 13 EU-countries for the years 1980-2001. We proceed in three steps. Firstly, bilateral sector-level intra-EU trade data is used to show that intra-EU trade costs have significantly declined over the last decades. Secondly, it is shown that aggregate employment has become more sensitive to international relative wage cost differentials in those sectors and countries which experienced the largest drop in trade costs. Thirdly, it is shown that the sensitivity of wages with respect to the determinants of union wages from the previous section changed as trade cost declined.

There exist important differences between member states. The dependency of wages on the various determinants suggested in the previous section is markedly different in countries with and without a statutory minimum wage, and the effect of trade liberalisation is also different in both groups. Many of the observed differences between the groups of countries are in line with the model introduced in the previous section if we assume that countries with a statutory minimum wage have more wage oriented unions.[7]

3.1. Data description

Sectoral data on employment, wages and productivity was taken from the EUKLEMS database (see Timmer, O'Mahony, and van Ark, 2007). Market access and trade costs were calculated using the CEPII trade and production dataset assembled by Mayer, Paillacar, and Zignago (2008). The sectors used are 12 2-digit NACE manufacturing sectors. Sectors 23 (coke, refined petroleum products and nuclear fuel) and 16 (manufacture of tobacco products) were excluded as they are probably prone to government interventions and location decisions which are outside of the scope of our model. They are also very small relative to the other sectors in terms of employment (see table 12 in the appendix). Our results are robust to including these sectors, however. The sectors 17-18, 21-22, 27-28, 30-33, and 34-35 were aggregated due to the fact that trade data is not available for the separate underlying industries.[8] Table 12 in the appendix shows some descriptive statistics on the sectors.

We use data from all EU15 member states, excluding Luxembourg and Greece for which insufficient trade data was available.[9] As we require complete series the time-frame had to be limited to the years 1980-2001 and some country/sector combinations are not included (see table 11 in the appendix for a list of sectors and countries included in the sample). Throughout, although our theoretical predictions pertain to sector-level union wages, we consider sector

[7]An older working paper contained the relative variability of wages with respect to employment as a proxy for union preferences. Although this relative variability is likely to be influenced by γ, as suggested by Pehkonen (1990), it is endogenous to the model, however, as it is predicted to change with ϕ in our model, for example. We therefore consider only the existence of a statutory minimum wage. Table 10 in the appendix shows that countries with a statutory minimum wage experienced significantly higher unemployment rates during the crisis year 1980, which may signal that wages in these countries indeed deviated further from the market clearing level.

[8]The fact that no separate trade data is collected for these separate underlying 2 digit NACE sectors also reflects the fact that the underlying activities of these sectors are rather similar. These sectors are likely to be covered by the same union, or will have separate unions facing a similar environment.

[9]This leaves Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom in the sample.

level data which will be comprised of unionised and non-unionised firms and sub-sectors. We believe this is justified in that most sectors are unionised to a certain degree in the EU, and contracts in non-unionised firms are often subject to conditions which have been established by union bargaining at the sector level. Moreover, governments and other agents may in effect mimic the derived union behaviour in non-unionised sectors (cfr. the example of the government of Belgium given in the introduction).

Both the CEPII and EUKLEMS dataset are publicly available for download. STATA code showing how the results in this section were obtained are available from the author on request.

We now proceed by estimating the evolution of trade costs over the sample period and the sensitivity of employment to international wage and productivity differentials before we turn to the analysis of the effect of trade liberalisation on wages.

3.2. The evolution of intra-EU trade costs

As shown by Head and Mayer (2004) in a multi-country Dixit-Stiglitz-Krugman model of monopolistic competition and trade, the value of total imports from all firms located in country k to consumers in country j is given by

$$I_{jk} = n_k p_{jk} q_{jk} = n_k p_k^{1-\sigma} \phi_{jk} \mu_j Y_j P_j^{\sigma-1}, \tag{11}$$

where n_k is the number of firms in country k, p_{jk} is the price charged by these firms to consumers in j and q_{jk} is the quantity sold. The parameter μ_j is the expenditure share out of income Y_j which goes to manufacturing goods. Assuming an upper level utility function that is Cobb-Douglas, this share is independent of income. The price index $P_j = \left(\sum_s n_s p_s^{1-\sigma} \phi_{js}\right)^{1/(1-\sigma)}$ is calculated over the set of all countries. The parameter $\phi = \tau^{1-\sigma}$ is typical of economic geography models with Dixit-Stiglitz monopolistic competition and CES demand, and can be understood as a measure of the 'freeness of trade'. Here τ are iceberg transport costs ($\tau \geq 1$ units of a good have to be shipped to sell 1 unit at the destination) and $\sigma > 1$ is the familiar elasticity of substitution between CES varieties. ϕ is decreasing in transport costs and is bounded between 0 (autarky, infinite iceberg trade costs) and 1 (perfectly free trade, $\tau = 1$).

The value of the trade flow shown in equation (11) depends on variables such as the relative prices, and therefore wages, in all regions. However, a relationship can be established which involves only trade freeness parameters and the readily observable value of the trade flows m. More specifically, it holds that

$$\frac{I_{jk} I_{kj}}{I_{jj} I_{kk}} = \frac{\phi_{jk} \phi_{kj}}{\phi_{jj} \phi_{kk}},$$

where I_{nn} is the value of country n's production net of exports (which can be understood as 'exports to self').

It is standard practice in models of economic geography to assume costless trade within countries, or $\phi_{jj} = \phi_{kk} = 1$ and to impose symmetric trade costs between countries, or $\phi_{jk} = \phi_{kj}$. These assumptions[10] allow to calculate ϕ_{jk} as a measure of 'trade freeness' (decreasing in trade costs) using only trade and production data.

As the CEPII trade data which will be used to calculate trade freeness contain trade flows per year t and sector i separately, we can write I_{jkit} for the trade flow from country k to country j in sector i and year t. The above results hold for every sector and time period, and the country-pair/sector/year specific level of trade costs ϕ_{jkit} can therefore be calculated as

$$\phi_{jkit} = \sqrt{\frac{I_{jkit} I_{kjit}}{I_{jjit} I_{kkit}}},$$

In most studies the parameter ϕ is calculated bilaterally. For our purposes, however, it proves to be more practical to treat all EU trading partners of a country as a rest-of-the-world aggregate. Importantly, this measure of 'trade freeness' is independent of the relative wages in the countries involved, their market size or any other variable in the model except for the iceberg transport costs τ. This is a major advantage over more ad-hoc measures of trade liberalisation such as import and export penetration ratio's which have often been used in the literature on trade and wages. These measures are not independent from wages even in theory.

Figure 2 shows ϕ for a selection of EU member states and the non-member Norway (for comparison), aggregating trade flows over all manufacturing sectors. A clear upward trend is apparent, and new member states such as Spain (which joined in 1986) show an impressive increase in trade freeness, especially in relative terms. Clearly, long-time EU-member states and countries located close to the EU economic core regions have higher values of ϕ compared to more peripheral or non-member countries, such as Norway.[11] Despite advances in communication and infrastructure, the fact that Norway is not an EU member apparently implied that trade costs with respect to the EU did not decline substantially and have remained at a relatively high level. Large differences between sectors are revealed when estimating ϕ on the sectoral level, with trade freeness ranging from 0.016 for 'publishing, printing and

[10] Novy (2008) and Jacks, Meissner, and Novy (2008) consider similar measures of trade freeness, while controlling for measurement error and asymmetric trade costs.

[11] Note that for Finland, for example, trade with neighbouring countries such as Russia is not considered. Our estimate of ϕ for peripheral countries would underestimate their openness with respect to the world as a whole, but rather serves as a proxy for openness with respect to the EU15.

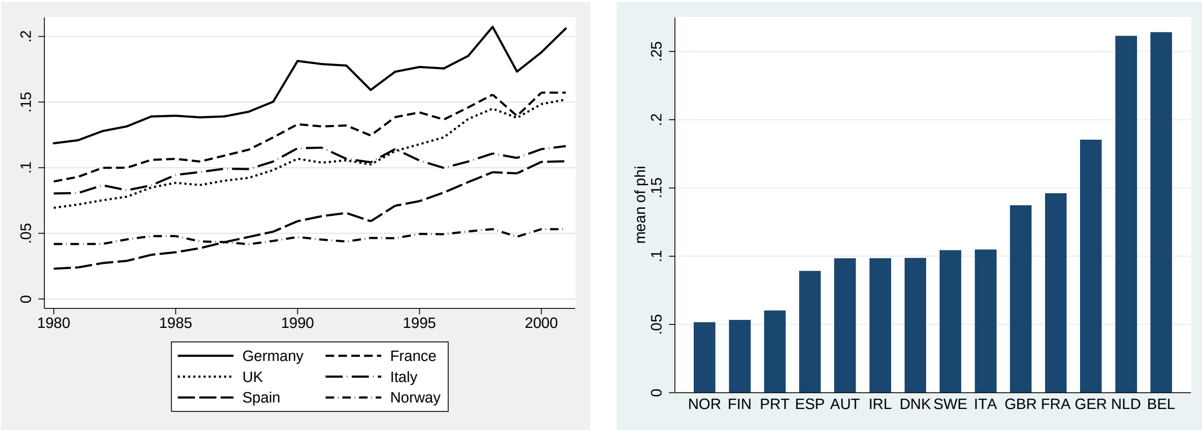

Figure 2: The evolution of ϕ in some large EU member states with Norway added for comparison (left) and a comparison of levels in 1999 for all countries in the sample, plus Norway.

reproduction of recorded media' to 0.28 for 'machinery and equipment'.[12] These magnitudes are plausible and consistent with the levels found by Head and Mayer (2004), especially when considering that they express trade freeness with respect to the entire EU15, and not bilaterally between neighbouring countries.

Summarising, the trade data reveals both a significant decrease in intra-EU trade costs over the last two decades and the existence of substantial differences in the level and evolution of intra-EU trade freeness between member states and industries. This confirms the European integration process can be used as an interesting experiment to analyse the labour market effects of economic integration.

3.3. Economic integration and the effect of relative wages on aggregate employment

Log-linearising aggregate labour demand assuming $l = p/w$ and $n = m - \phi(wp^f/pw^f - 1)$ suggests that the following estimation equation may be used to estimate sectoral labour demand in country k, sector i and year t

$$\begin{aligned} \log l_{kit} n_{kit} = \beta_0 &+ \beta_1 \log(w_{kit}) + \beta_2 \log(p_{kit}) \\ &+ \beta_3 \log(w_{kit}/w^f_{kit}) + \beta_4 \phi \log(w_{kit}/w^f_{kit}) \\ &+ \beta_5 \log(p_{kit}/p^f_{kit}) + \beta_6 \phi \log(p_{kit}/p^f_{kit}) + \beta_7 \log(m_{kit}). \end{aligned} \tag{12}$$

This specification allows to differentiate between what might be called the national and international effect of wage and productivity changes. The coefficients β_1 and β_2 measure the

[12] These numbers are for France in 1999.

wage and productivity elasticity of firm level labour demand, while keeping variables affecting the international distribution of production fixed. The coefficients β_3, β_5 and β_7 capture how relative wages, relative productivity and market size affects aggregate labour demand, keeping the determinants of firm level labour demand constant. These latter effects are allowed to change as a function of trade openness. Our model of firm location assumes that the effect of market size on the number of firms in a country is independent from transport costs. Adding a simple interaction between market size m and the measure of trade freeness ϕ in the model does not qualitatively alter any of the theoretical results derived above, but complicates the expressions. Many contributions from the economic geography literature (such as the model considered in Persyn (2009)), however, suggest that market access has an increasing effect on the attractiveness of a country for lower transport costs and an interaction term of ϕ and m was therefore added to the regression.

To obtain estimates of the coefficients determining the relationship described by equation (12), sectoral data from the EUKLEMS dataset was used, containing observations on wages, productivity and employment in 12 industries in 13 EU member states for the years 1980-2001. A more complete description of this dataset was given in section 3.1. For some country k, sector i and year t, sector level employment ln is proxied by *emp*, the total number of employees. The variables w and p are proxied by *wage* and *lp*, which are the average compensation and real output per employee, respectively. The relative wage and productivity *relwage* and *rellp* are calculated as the ratio of wages and productivity with respect to the EU average, excluding the country-sector under consideration. Market access m is proxied by *access*, a population-distance weighted average of GDP in the country and neighbouring regions. A more detailed description of the construction of these variables is given in appendix A.1. The construction of the measure of trade freeness ϕ was described in section 3.2.

The first column of table 1 shows the results of estimating the equation (12) by OLS, adding lagged sector level employment as a regressor to allow for sluggish adjustment[13], controlling for country-sector fixed effects, including year-dummies, and allowing for a linear trend in employment for each country and likewise for each sector. Overall, the results are as expected, although the effect of wages is insignificant. The coefficients β_3 and β_5 are estimates of the effect on sectoral employment of differences in wages and productivity relative to the EU average, evaluated close to autarky ($\phi \approx 0$). The insignificance of these coefficients, together

[13]Note that we ignore issues relating to the presence of a lagged dependent variable in combination with fixed effects, since the cross-sectional dimension of our dataset is relatively small compared to the time-span (N=199,T=22). In such cases the potential bias is both relatively small and difficult to correct using standard techniques.

with the strongly significant interaction effects with ϕ on the same variables, strongly suggest that international wage and productivity differentials only play a role in determining aggregate labour demand as trade costs decrease. There is strong evidence that trade integration increases the effect of market access.

Dependent variable: logemp		
	(I): OLS	(II): ECM
logemp_{t-1}	0.892^{***}	
	(0.00943)	
logwage	0.00277	0.0665
	(0.0381)	(0.471)
loglp	0.0784^{*}	0.906^{*}
	(0.0411)	(0.503)
logrelwage	−0.0544	−0.257
	(0.0372)	(0.455)
ϕ ×logrelwage	−0.141	-1.627^{**}
	(0.0947)	(0.754)
logrellp	−0.0424	−0.676
	(0.0395)	(0.483)
ϕ ×logrellp	0.194^{**}	1.533^{**}
	(0.0822)	(0.704)
logaccess	0.0890^{***}	0.338^{***}
	(0.0117)	(0.118)
ϕ ×logaccess	0.0542^{**}	0.699^{***}
	(0.0268)	(0.269)
ϕ	−0.576	-8.693^{**}
	(0.357)	(3.501)
Observations	2761	2487
Dummies		
Country × sector	Yes	Yes
Year	Yes	Yes
Trends		
Country	Yes	Yes
Sector	Yes	Yes

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1 : The effect of wages, productivity, relative cost competitiveness and market access on sectoral employment.

An important aspect in estimating relationships between long time-series is the risk of spurious estimation results in case some of the variables are non-stationary. After confirming the existence of a unit root in the aggregate employment, wages and labour productivity series, we tested the null of no-cointegration using the residual-based panel cointegration test of Maddala and Wu (1999) and the test of Persyn and Westerlund (2008) which considers the speed and significance of the adjustment towards a long-run equilibrium relationship between the variables. The results were mixed, with the Maddala and Wu (1999) test rejecting the null of no-cointegration, while the Persyn and Westerlund (2008) test is not able to reject the series are not cointegrated. This latter test has weak power if many covariates are present, or when some of the covariates are cointegrating themselves, however.

The second column of table 1 shows the result of estimating equation (12) in error correction form[14], which is our preferred specification. For this last specification, the Arellano and Bond (1991) test does not reject the absence of serial correlation in the residuals, and the tests of Maddala and Wu (1999) and Levin, Lin, and James Chu (2002) strongly reject the presence of a unit root therein. The results suggest that the basic assumptions of our model hold: controlling for wages and productivity, relative wages and productivity are relatively unimportant in explaining aggregate labour demand when trade costs are high. As trade freeness increases, the attractiveness of a country in terms of its relative wage and productivity becomes more important in explaining aggregate labour demand. Moreover, the effect of trade costs on the coefficient on relative wages and relative productivity is opposite but equal in magnitude.

3.4. Economic integration and union wage demands

So far, we have established empirically that trade costs have significantly declined in the EU. We also found that this was accompanied by an increase in the sensitivity of aggregate employment with respect to international differences in labour costs, which offers some support for our stylised model on the location of economic activity. To estimate whether trade liberalisation affected wages and the dependencies of wages on its determinants, we log-linearise equation (8) while allowing for interaction effects with ϕ and obtain the following estimation equation

$$\begin{aligned}\log w_{kit} = \beta_0 &+ \beta_1 \log(w^f_{kit}) + \beta_1' \phi_{kit} \log(w^f_{kit}) + \beta_2 \log(p^f_{kit}) + \beta_2' \phi_{kit} \log(p^f_{kit}) \\ &+ \beta_3 \log(p_{kit}) + \beta_3' \phi_{kit} \log(p_{kit}) + \beta_4 \log({w^a}_{kit}) + \beta_4' \phi_{kit} \log({w^a}_{kit}) \\ &+ \beta_5 \log(m_{kit}) + \beta_5' \phi_{kit} \log(m_{kit}) + \beta_6 \phi_{kit} + \nu_{ki} + \mu_t + \eta_k t + \epsilon_{kit}.\end{aligned} \tag{13}$$

[14] See appendix A.2 for details. The error-correction model includes first differences, and the first and second lags of the first differences of all variables.

The coefficients $\beta_1, \beta_2, \beta_3, \beta_4$ correspond to $\mathfrak{e}^{w^f}$, $\mathfrak{e}^{p^f}$, $\mathfrak{e}^{p}$ and $\mathfrak{e}^{w^a}$ respectively, evaluated close to autarky where $\phi \gtrapprox 0$. $\beta_1', \beta_2', \beta_3', \beta_4'$ are linear approximations of how increases in trade freeness affect these coefficients. Table 2 shows the predictions of the model of section 2.2 concerning the sign of these coefficients, as summarised in the propositions on page 15.

$\gamma < 1$		$\gamma > 1$		difference	
$\beta_1 = 0$	$\beta_1' > 0$	$\beta_1 = 1$	$\beta_1' < 0$	$\Delta\beta_1 > 0$	$\Delta\beta_1' < 0$
$\beta_2 = 0$	$\beta_2' < 0$	$\beta_2 = -1$	$\beta_2' > 0$	$\Delta\beta_2 < 0$	$\Delta\beta_2' > 0$
$\beta_3 = 0$	$\beta_3' > 0$	$\beta_3 = 1$	$\beta_3' < 0$	$\Delta\beta_3 > 0$	$\Delta\beta_3' < 0$
$\beta_4 = 1$	$\beta_4' < 0$	$\beta_4 = 0$	$\beta_4' > 0$	$\Delta\beta_4 < 0$	$\Delta\beta_4' > 0$

Table 2 : The predictions on the coefficients in equation (13) as summarized in the propositions on page 15. $\beta_1, \beta_2, \beta_3, \beta_4$ correspond to $\mathfrak{e}^{w^f}$ $\mathfrak{e}^{p^f}$, $\mathfrak{e}^{p}$ and $\mathfrak{e}^{w^a}$ evaluated close to autarky. $\beta_1', \beta_2', \beta_3', \beta_4'$ are linear approximations of the effect of ϕ on these elasticities. $\Delta\beta_i > 0$ indicates the coefficient β_i is predicted to be larger for countries where $\gamma > 1$ compared to countries with $\gamma < 1$.

Table 3 shows the result of estimating equation (13) when gradually introducing more variables and interaction effects. Column (I) shows the result of estimating the relation between wages, foreign wages and alternative wages, ignoring all other covariates and pooling all cross-sectional and time information. The sum of the estimated elasticities is significantly larger than one. If the omitted productivity and foreign productivity variables are correlated with wages, foreign wages and the alternative wage offers, these results will be biased. We nevertheless consider specifications without productivity, however, as it is unclear whether this omitted variable bias outweighs the bias caused by including poorly measured and possibly endogenous productivity.[15]

In column (II) local and foreign productivity are included, as well as market size and trade freeness, excluding interaction effects. Apart from the positive effect of trade freeness, all coefficients are of the expected sign and are highly significant. As predicted, the sum of the elasticities of foreign wages, foreign productivity, local productivity and alternative wage offers is estimated close to one (1.012) with a 95 percent confidence interval of [.983 ; 1.042]). Not

[15]Under the assumptions of the model the omitted variable bias on foreign wages, for example, is given by $E[\hat{\beta}_1] = \beta_1 + \beta_2 b_2 + \beta_3 b_3$, where b_2 is the coefficient on foreign wages in the regression $p^f = b_0 + b_1 altwage + b_2 wageEU + \epsilon$ and b_3 is obtained from the regression $p = b_0' + b_1' altwage + b_3 wageEU + \epsilon$. Since $\beta_2 = -\beta_3$ in the model, and b_2 and b_3 may be expected to be of the same sign and similar magnitude, the bias stemming from omitting labour productivity is likely to be small. If $b_2 \neq b_3$ then $b_2 > b_3$ seems the more likely case and β_1 will be positively biased. Similarly, the coefficient on the alternative wage may be expected to be negatively biased when omitting productivity. This does not seem to be the case in our empirical results, which again suggests the endogeneity of productivity might be of more concern compared to the omitted variable bias.

all of the restriction implied by the model (see equation (4)) hold, however. The hypotheses $\mathfrak{e}^{p} + \mathfrak{e}^{p^f} = 0$ and $\mathfrak{e}^{w^f} + \mathfrak{e}^{w^a} = 1$ are rejected at standard significance levels.

From column (III) onward the regressions include country-sector fixed effects and year-dummies. Column (III) includes only foreign wages and the alternative wage as independent variables (apart from the dummies). Again the sum of the elasticities is estimated at 1.04, close to the predicted value of 1, but with a much wider CI of [.683;1.394]. Column (IV) controls for local and foreign productivity and again the sum of the first four coefficients (0.995) is close to 1, with a CI of [.822;1.17]. The hypothesis $\mathfrak{e}^{p} + \mathfrak{e}^{p^f} = 0$ and $\mathfrak{e}^{w^f} + \mathfrak{e}^{w^a} = 1$ are rejected.

The theoretical framework suggests that union preferences have an important effect on the relationship between union wages and its determinants. More wage oriented unions are predicted to be more sensitive to foreign wages (have a larger $\mathfrak{e}^{w^f}$, see equation (10)), and therefore a higher $\mathfrak{e}^{p}$, and a lower $\mathfrak{e}^{w^a}$ and $\mathfrak{e}^{p^f}$. Specification (V) omits labour productivity and the predictions of the model on the included variables are found to hold to a large degree. In countries with a statutory minimum wage the effect of foreign wages is significantly higher and the effect of alternative wages is lower (although not significantly). Also the effect of ϕ on wages seems to be smaller for this group. In specification (VI) the introduction of local labour productivity seems to dwarf all other effects, some of which become insignificant (foreign wages in countries with a minimum wage) or even of wrong sign (alternative wages and market access in the minimum wage countries). Again, this may be due to endogeneity in the labour productivity measure.

In columns (VII) and (VIII) of table 3, the elasticities are allowed to change in function of trade freeness and depending on whether countries have a statutory minimum wage. The effect of trade integration on the various elasticities is predicted to be different if γ is different in both groups. The effect of γ is ambiguous if both group of countries would be characterised by $\gamma < 1$ or $\gamma > 1$. The predicted differences are striking if one group is characterised by $\gamma < 1$ and the other by $\gamma > 1$. We therefore allow union preferences (as proxied by the presence of a statutory minimum wage) to have a direct effect on the elasticities, as in specifications (V) and (VI), but also include an interaction effect of trade integration and minimum wages. Again, many prediction from theory fail to hold precisely: in column (VII) the sum of the coefficients on foreign wages and the alternative wage for the group of countries without a minimum wage is less then one. The effect of foreign wages for this group is significantly different from 0 (-0.260). This effect is only 0.573 higher for the group with a minimum wage, and the estimated elasticity of 0.313 for this group is significantly different from the predicted value of 1. Nevertheless, with the exception of the effect of ϕ on the sensitivity with respect to

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
wageEU	0.469***	0.437***	0.429***	0.105	0.126	0.0779	−0.260	−0.101
	(0.0173)	(0.0365)	(0.131)	(0.148)	(0.143)	(0.143)	(0.214)	(0.202)
lpEU		−0.414***		−0.0400		−0.116		−0.0924
		(0.0384)		(0.146)		(0.150)		(0.225)
lp		0.659***		0.741***		0.782***		0.606***
		(0.0175)		(0.0735)		(0.0698)		(0.0887)
altwage	0.838***	0.330***	0.608***	0.193**	0.719***	0.111	1.054***	0.450***
	(0.00974)	(0.0155)	(0.138)	(0.0797)	(0.137)	(0.106)	(0.110)	(0.0995)
access		0.0196***		0.00245	0.149*	0.0379	0.0232	−0.0351
		(0.00484)		(0.0648)	(0.0857)	(0.0538)	(0.0851)	(0.0498)
ϕ		0.375***		0.0483	1.906*	0.260	−7.086	−7.040*
		(0.0659)		(0.280)	(1.054)	(0.398)	(6.843)	(3.972)
min×wageEU					0.285*	0.0430	0.573**	0.390
					(0.169)	(0.176)	(0.248)	(0.242)
min×lpEU						0.182		0.0963
						(0.188)		(0.242)
min×lp						−0.0458		−0.0571
						(0.130)		(0.171)
min×altwage					−0.309	0.0932	−0.669***	−0.193
					(0.189)	(0.124)	(0.181)	(0.148)
min×access					0.0638	−0.0656*	0.186**	0.0525
					(0.0639)	(0.0385)	(0.0759)	(0.0386)
min×ϕ					−1.174	−0.498	18.03	15.73***
					(1.129)	(0.513)	(11.95)	(5.444)
ϕ×wageEU							4.103***	3.017*
							(1.531)	(1.524)
ϕ×lpEU								−1.488
								(1.577)
ϕ×lp								1.346
								(0.843)
ϕ×altwage							−4.084***	−3.183***
							(1.384)	(1.137)
ϕ×access							0.704*	0.531**
							(0.392)	(0.214)
min×ϕ×wageEU							−2.922	−3.527*
							(1.900)	(1.931)
min×ϕ×lpEU								0.641
								(1.908)
min×ϕ×lp								0.852
								(1.064)
min×ϕ×altwage							4.186***	2.197*
							(1.584)	(1.305)
min×ϕ×access							−1.308**	−1.241***
							(0.655)	(0.315)
constant	0.569***	−0.382***	0.0359	−0.313	−2.805**	−0.339	−2.230*	−0.188
	(0.0334)	(0.0774)	(0.423)	(0.828)	(1.269)	(0.749)	(1.306)	(0.674)
Observations	2618	2618	2618	2618	2618	2618	2618	2618

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3 : Estimating the effect of union preferences and trade liberalisation on the link between wages and foreign wages, foreign labour productivity, local labour productivity and alternative wage offers.

local labour productivity, the difference in the coefficients between both groups is as predicted. An increase in ϕ makes wages more sensitive to foreign wage changes in countries without a minimum wage, but the effect of increases in ϕ is much lower in countries with a minimum wage. ϕ decreases the sensitivity with respect to alternative wage offers in countries without a minimum wage, but significantly less so in countries with a minimum wage. Especially in column (VII), which does not control for possibly endogenous labour productivity, the change in the sensitivity with respect to foreign wages is of opposite sign but of similar magnitude as the change in the sensitivity with respect to the alternative wage and this holds in both groups of countries, as predicted.

Since the measured average labour productivity is almost surely endogenous to union wage setting, we repeated some of the regressions of table 3, but estimate the relationship in differences to remove the country-sector fixed effects while instrumenting the differenced productivity variables at t with their lagged levels at $t-2$ to $t-6$ (difference GMM), and using lagged differences (from $t-2$ to $t-6$) as instruments for estimation of the equations in levels (system GMM). We also included a lagged dependent variable to allow for sluggish adjustment in wages which is not captured by the fixed effects. After the inclusion of a lagged dependent variable, standard tests suggest that second order serial correlation is removed from the data and that the instruments are valid. The structure of the dataset is highly unsuited for this technique, however, as N=119 is rather small and T=22 is rather high. This gives rise to a large number of instruments and imprecise estimates.

Column (1) of table 4 shows the result of re-estimating the specification of column (IV) from table 3 using the Arellano-Bond GMM estimator. The effect of local labour productivity is clearly attenuated by controlling for endogeneity and now is even smaller than the effect of foreign wages. Only the effect of foreign labour productivity is imprecisely estimated (p-value 0.114). The long-run effects of the variables match the predictions from theory rather well. The sum of the long run effects equals 1.16 with a 95 percent CI of [0.907;1.41]. The sum of the estimated effects of foreign wages and the alternative wage equals 1.08 [0.352;1.82] and the sum of the coefficients on local and foreign productivity is estimated at 0.072 [-0.653;.797]. Column (2) of table 4 shows the result of repeating the specification in column (VIII) of table 3 while controlling for endogeneity using the Arellano-Bond technique. Again, most predictions of the model are found to be reflected in the results, although the large number of covariates in combination with the instrumenting approach implies that the coefficients are estimated very imprecisely. Nevertheless, the sum of the coefficients at autarky for the group without minimum wages is estimated at 1.28(0.18) and is not significantly different from one. Similarly

	(1)	(2)	(3)	(4)
wage_{t-1}	0.827^{***}	0.714^{***}		
	(0.0330)	(0.0462)		
wageEU	0.137^{**}	-0.00958	-0.934^{**}	-1.447^{***}
	(0.0643)	(0.178)	(0.476)	(0.430)
lpEU	-0.113^{+}	-0.0133	0.956^{*}	0.802^{*}
	(0.0718)	(0.175)	(0.505)	(0.475)
lp	0.126^{***}	0.0955^{+}	0.291^{**}	0.293^{***}
	(0.0321)	(0.0737)	(0.125)	(0.108)
altwage	0.0510^{*}	0.292^{***}	0.337^{**}	0.0585
	(0.0290)	(0.0800)	(0.171)	(0.208)
access	0.00154	0.000233	-0.0822	-0.0700
	(0.00416)	(0.00823)	(0.0980)	(0.105)
ϕ	0.0606	-0.0981	-1.767	5.897
	(0.0652)	(2.625)	(9.625)	(8.725)
min×wageEU		0.298^{+}	1.082^{*}	1.120^{**}
		(0.193)	(0.594)	(0.496)
min×lpEU		-0.153	-0.877^{+}	-1.031^{*}
		(0.188)	(0.598)	(0.534)
min×lp		0.0141	0.109	0.203^{+}
		(0.0762)	(0.148)	(0.133)
min×altwage		-0.120^{+}	0.154	0.373^{+}
		(0.0781)	(0.212)	(0.244)
min×access		0.00913	0.0999	0.0437
		(0.00810)	(0.0979)	(0.0853)
min×ϕ		-1.070	10.87	7.338
		(1.452)	(13.39)	(11.94)
ϕ×wageEU		1.780	12.19^{***}	13.07^{***}
		(1.748)	(3.731)	(3.365)
ϕ×lpEU		-1.278	-12.35^{***}	-11.42^{***}
		(1.760)	(3.688)	(3.270)
ϕ×lp		1.222^{+}	7.894^{***}	7.092^{***}
		(0.834)	(1.182)	(1.000)
ϕ×altwage		-1.680^{*}	-6.164^{***}	-4.411^{***}
		(0.873)	(1.613)	(1.474)
ϕ×access		0.0147	0.541	0.330
		(0.128)	(0.547)	(0.487)
min×ϕ×wageEU		-3.111^{+}	-11.20^{**}	-13.16^{***}
		(2.160)	(4.754)	(4.003)
min×ϕ×lpEU		2.365	9.294^{**}	11.61^{***}
		(2.278)	(4.529)	(3.888)
min×ϕ×lp		-0.722	-4.704^{***}	-5.064^{***}
		(0.995)	(1.337)	(1.169)
min×ϕ×altwage		0.923	4.639^{***}	3.763^{**}
		(0.927)	(1.773)	(1.592)
min×ϕ×access		-0.0322	-1.210^{+}	-1.133^{*}
		(0.122)	(0.754)	(0.679)
constant	0.0311	0.0835	-0.0415	1.421
	(0.0653)	(0.187)	(0.159)	(2.532)
α_{ec}			-0.156^{***}	-0.191^{***}
			(0.0119)	(0.0128)
Observations	2499	2499		

Standard errors in parentheses $^{+}$ $p < 0.2$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4 : The effect of various variables on wages; Columns (I) and (II) use the Arellano-Bond GMM approach to instrument for the lagged dependent variable and productivity. Column (III) repeats column (VII) from table 3 using an error-correction model; Column (IV) adds country and industry trends to this specification.

for the sum of foreign wages and the alternative wage which equals .988(0.644), and the sum of the coefficients on foreign and local productivity which is estimated at 0.288(0.590), which are not significantly different from 1 and 0, respectively (although they have very wide 95 percent CI's including both 0 and 1). Without going into detail, all coefficients except for the alternative wage are markedly small when evaluated close to autarky in countries without a minimum wage, as predicted. The effects of trade freeness in this group is of the expected sign and of strikingly similar magnitude. All coefficients shift in the expected direction in countries with a statutory minimum wage, although none of these effects is significant.

As before, statistical tests suggest that most variables (ignoring interaction terms) included in the regression contain a unit root, but the panel cointegration tests reject the residuals of the regressions presented in the table contain unit roots. The residuals are highly serially correlated, however. To control for serial correlation, column (3) of table 4 shows long-run coefficients from re-estimating column (VII) of table 3 in a simple error-correction model (ECM). After controlling for simple dynamic effects in the ECM, the residuals proved stationary and free of serial correlation. The results of this estimation confirm the results obtained before. Column (4) adds separate country and sector-level trends to an already very rich specification, and shows that the results are not driven by various omitted trending variables within countries and industries.

Summarising these empirical results on the effect of trade liberalisation on the relationship between wages and its various determinants for the EU, it was found that trade liberalisation affects labour markets very differently in different countries, depending on whether they have a statutory minimum wage. If the presence of a statutory minimum wage is a good proxy for the wage-orientation of unions, these results confirm the prediction of the theoretical model: only in countries without a statutory minimum wage wages became more sensitive to foreign wages after trade liberalisation. In countries with a statutory minimum wage, wages did not become more sensitive to foreign wages, and some specifications suggest that they became less sensitive. Moreover, the direction of the changes in the sensitivity to the other covariates, such as the alternative wage offers and local and foreign labour productivity, is as predicted.

It is important to repeat that the finding that wages became more or less sensitive to foreign wage changes is uninformative as to whether wages are converging. This is clear in the theoretical model, where both in the case $\gamma > 1$ and $\gamma < 1$ union wages converge towards the alternative wage level as trade becomes freer (see figure (13)). If the alternative wage is competitive, and productivity-corrected factor price equalisation holds for competitive wages in all countries, the model therefore predicts that wages converge internationally after trade liberalisation. Union wages may simultaneously become less or more sensitive to foreign wages, depending on γ.

In the data, the coefficient of variation of wages shows a markedly downward trend, and has been steadily decreasing from 0.56 in 1980 to 0.36 in 2001 (which is proof of σ-convergence). On average, countries and sectors with wages above the European average have experienced slower growth compared to countries with wages which are below the European average. Estimating a so-called β-convergence equation $\Delta logwage_t = \beta_0 + \beta_1(logwage_{t-1} - logwageEU_{t-1}) + \epsilon$, results in an estimate $\hat{\beta}_1 = -0.07(0.007)$ for the full sample, $\hat{\beta}_1 = -0.056(0.010)$ for countries without a minimum wages, and $\hat{\beta}_1 = -0.080(0.010)$ for countries with a statutory minimum wage. This strongly suggests that wages in the EU were converging in the countries, sectors and years under consideration. If anything, β-convergence was faster in the group with a statutory minimum wage, which is the group of countries which did not experience an increase, or even saw a decrease in the sensitivity to foreign wages.

4. What to think of regressions of wages on foreign wages?

The estimation equations used in the previous sections followed directly from theory. As the models presented in section 2 suggest that it is important to control for local and foreign productivity, alternative wage offers, as well as the interactions of these variables with trade openness and some measure of the relative union preference for wages, these variables and interaction effects were included in the estimation equations considered in section 3.

In the broader literature, however, it is common to consider estimation equations containing far fewer variables. When testing for cointegration between wages in different countries, such as in Burgman and Geppert (1993), it is common to consider only local wages and foreign wages as covariates. Other studies, such as Andersen, Haldrup, and Sørensen (2000), consider changes in the coefficient on foreign wages in a regression of wages on foreign wages (with and without controlling for productivity). Robertson (2000, 2005) considers an error-correction model containing Mexican and US wages and estimates how NAFTA affected the long run equilibrium between US and Mexican wages, how it changed the speed of convergence of wages toward this equilibrium, and how it changed the response of Mexican wages to changes in US wages.

Obviously, the theory presented in section 2 may be subject to critique and can hardly be considered a benchmark against which other empirical estimation approaches should be gauged. Nevertheless, it might be interesting to consider the predictions of this model regarding the effect of trade liberalisation on the coefficient on foreign wages in simpler specifications.

Such predictions can be made by considering the omitted variable bias which is implied by theory in these simpler regressions. The models of section 2 are static, however, and therefore do not make predictions on dynamic properties such as the speed of convergence towards a long-run equilibrium in wages, for example. To predict the effect of trade liberalisation on the dynamic adjustment of wages, we therefore opt to generate series of wages and productivity in accordance with the model of section 2.2 and estimate some standard dynamic regressions on these simulated data in a small Monte-Carlo study.

4.1. The size of the coefficient on foreign wages

In competitive labour markets, real wages are determined by marginal labour productivity. If technology is evolving similarly over time in different countries (as is very likely the case in our dataset with EU member states) and capital is mobile, this leads to similar movements in wages in those countries. In the long run, one then expects to find a one-to-one relationship between wages in different countries, both in levels and logs.

If the economy consists of a large competitive sector and a single unionised sector as described in section 2.2, the alternative (competitive) wage considered by the union equals the labour productivity in the competitive sector. Replacing the alternative wage w^a in the optimal union wage demand of equation (8) by a term proportional to labour productivity p, causes the union wage w^* in turn to become proportional to labour productivity p. Any (weighted) average of the wages in both sectors will again be proportional to labour productivity, and if this average is considered as an alternative wage offer by some third (new) unionised sector, its optimal wage demand will again be proportional to productivity. In short: both the union model of section 2.2 and the competitive framework predict that wages are proportional to productivity. If competitive and union wages in different countries are proportional to a common trend in labour productivity, one therefore again expects to find a one to one relationship between the logs of wages in different countries, even when some countries and sectors are unionised.

As was argued in the previous sections, however, there might exist other links between wages in different countries apart from a common trend in productivity. In the model of section 2.2, unions wages depend on the foreign wage level, alternative competitive wage offers, and on local and foreign labour productivity. All of these may depend on a common underlying productivity trend.

In the context of the union model of section 2.2, a regression of wages on foreign wages which omits labour productivity, alternative wages and other factors affecting union wages suffers from an omitted variable bias. In a log-linear regression of wages on foreign wages as the sole independent variable ($\log(w^*) = \beta_0 + \beta_1 \log(w^f) + \epsilon$), the expected value of the coefficient on foreign wages equals

$$E[\hat{\beta}_1] = \mathfrak{e}^{w^f} + b_2 \mathfrak{e}^{p^f} + b_3 \mathfrak{e}^{p} + b_4 \mathfrak{e}^{w^a},$$

where $b_2 = \text{cov}(p^f, w^f)/\text{var}(w^f)$, $b_3 = \text{cov}(p, w^f)/\text{var}(w^f)$ and $b_4 = \text{cov}(w^a, w^f)/\text{var}(w^f)$. These b-parameters may equivalently be obtained as the coefficients on foreign wages in regressions of, respectively, foreign labour productivity on foreign wages (b_2), local labour productivity on foreign wages (b_3), and the alternative wage on foreign wages (b_4). The b-parameters reflect how much of the variability in foreign wages ($\text{var}(w^f)$) can be explain by the co-movement of foreign wages with the omitted variables ($\text{cov}(., w^f)$). For sufficiently long time-series these ratio's of variances will tend to 1, given the long-run proportionality of the variables to the common productivity trend.[16] With $b_2 = b_3 = b_4 = 1$, the expected value on the coefficient on foreign wages simplifies to $E[\hat{\beta}_1] = \mathfrak{e}^{w^f} + \mathfrak{e}^{p^f} + \mathfrak{e}^{p} + \mathfrak{e}^{w^a} = 1$, where the last equality follows directly from theory (see equation (4)). With $E[\hat{\beta}_1] = 1$, parameter changes such as increasing openness to trade ϕ which affect $\mathfrak{e}^{w^f}$ do not have an effect on the estimated relationship between wages and foreign wages.

In a sense, while the omitted variable bias becomes more severe in long time-series which contain more variation in the underlying labour productivity trend, the estimates which are obtained in long samples may better reflect the relationship the researcher was interested in: in long samples, the coefficient on foreign wages will increasingly reflect the co-movement of wages in different countries around the common productivity trend.

In shorter samples, in contrast, the variability in the common productivity trend may be limited, such that the covariance between the omitted variables and foreign wages and the omitted variable bias remains small. The parameters b_2, b_3 and b_4 then are smaller than 1, and the relative weight of the direct link between wages $\mathfrak{e}^{w^f}$ in the expected value $E[\hat{\beta}_1] = \mathfrak{e}^{w^f} + b_2 \mathfrak{e}^{p^f} + b_3 \mathfrak{e}^{p} + b_4 \mathfrak{e}^{w^a}$ increases. If this is the case, one expects a coefficient smaller than 1 on foreign wages ($E[\hat{\beta}_1] < 1$), and the predicted effect of, for example, trade integration $\partial\, \mathfrak{e}^{w^f} / \partial\, \phi$ then may become observable when including an interaction term of foreign wages with ϕ in the regression.

Does this difference between short and longer series effectively show up in the data, or are

[16]For example, when the dependency of w^f and w^a on the underlying productivity trend p is described by $w^f = p+e$ and $w^a = p+e'$, we have $b_4 = \text{cov}(w^a, w^f)/\text{var}(w^f) = [\text{cov}(p,p)+\text{cov}(p,e')+\text{cov}(e,p)+\text{cov}(e,e')]/\text{var}(p+e)$. With a deterministic or stochastic trend in p and absent serious heteroskedasticity in the error terms, the numerator will be dominated by $\text{cov}(p,p) = \text{var}(p)$ and the denominator will tend to $\text{var}(p)$, such that $b_2 \approx 1$.

$logwage = \beta_0 + \beta_1 logwageEU + \epsilon$ $logwage = \beta_0' + \beta_1' logwageEU + \beta_2' logaltwage + \epsilon'$				
	β_1	β_1'	β_2'	$\beta_1' + \beta_2'$
Full sample	0.937(0.016)	0.381(0.028)	0.575(0.025)	0.956(0.015)
1980-1987	0.898(0.050)	0.309(0.052)	0.686(0.036)	0.995(0.042)
1988-1994	0.771(0.031)	0.204(0.046)	0.679(0.046)	0.883(0.028)
1995-2001	0.878(0.055)	0.395(0.052)	0.603(0.063)	0.998(0.055)

Table 5 : Regressions of wages on foreign wages (first column), and regressions of wages on foreign wages and the alternative wage (second to fourth columm); The first row shows the results for the full sample, the second to fourth row for shorter sub-samples.

commonly used datasets sufficiently long such that the estimate of the link between wages in different countries is totally dominated by a common trend? The first column of table 5 shows the estimated coefficient on foreign wages in a regression of wages on foreign wages as a sole covariate ($logwage = \beta_0 + \beta_1 logwageEU + \epsilon$). The first row shows the results of this regression when using the full sample, retaining only the 119 country/sector combinations with 23 yearly observations in the EUKLEMS dataset. The next three rows show the estimated coefficients when estimating this equation for three equally long, but substantially shorter sub-samples. Standard errors are shown in parenthesis. What pertains is that the coefficient on *logwageEU* for the full sample (0.937) does not correspond to the mean of the coefficients of the sub-samples, but is markedly higher. As suggested above, this might be due to the fact that the omitted variable problem is weaker in short samples, where the covariance between the omitted variables and the trend in productivity is small. In the full sample, the omitted variable bias will be larger, as the estimated coefficient will increasingly reflect the co-movement of foreign wages with the omitted variables and the common productivity trend. The second and third column report the coefficients β_1' and β_2' of a wage regression including both foreign wages and the alternative wage $logwage = \beta_0' + \beta_1' logwageEU + \beta_2' logaltwage + \epsilon'$. The last column shows the sum of these coefficients ($\beta_1' + \beta_2'$). The fact that the sum of the coefficients is closer to 1 compared to the regressions omitting *logaltwage*, both for the full sample and for the shorter sub-samples, suggest that controlling for *logaltwage* alleviates the omitted variable problem to a large extend.

Even when using the full sample containing 23 yearly observations as in the first row and column of table 5, the coefficient on foreign wages in the regression of local wages on foreign wages as a sole covariate resulted in an estimated elasticity which is significantly smaller than one. This suggests that the common trend in productivity does not completely dominate the relationship between wages, even when considering all 23 yearly observations. A direct link between local and foreign wages, apart from the productivity trend, then still may play a role. In the framework of the model of unionised labour markets presented in section 2.2, such a direct link exists due to union behaviour and is described by the elasticity $\mathfrak{e}^{w^f}$: unions adapt their wage demands as a function of foreign wages. The effect of changes in ϕ on this elasticity, $\partial\, \mathfrak{e}^{w^f} / \partial\, \phi$ then might become observable. Consider the simple regression of wages on foreign wages, which is reported in the first column of table 6. As reported above, the

	full sample	full sample	no min. wage	min. wage
logwageEU	0.937***	0.885***	0.666***	1.075***
	(0.0164)	(0.0273)	(0.0387)	(0.0383)
ϕ ×logwageEU		−0.220	1.418***	−1.286***
		(0.234)	(0.355)	(0.308)
ϕ		0.570	3.666***	−1.645***
		(0.445)	(0.667)	(0.588)
Observations	2618	2618	1254	1364

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6 : Regressions of local wages on foreign wages, with and without an interaction effect of trade openess ϕ. The last two columns show the results separately for the group of countries with and without a statutory minimum wage.

coefficient on foreign wages for the full sample which is reported in the first column is close to 1, but is significantly smaller than 1. For the full sample, the effect of ϕ on this coefficient is negative but not significant, as can be seen from the specification reported in the second column. Considering countries with and without a statutory minimum wage separately shows markedly different results: for countries without a statutory minimum wage, the intuitive result holds that wages become more sensitive to foreign wages with increasing trade liberalisation (third column). For countries with a minimum wage (fourth column), wages are more sensitive to foreign wages when the economy is relatively closed and increasing trade liberalisation lowers the sensitivity to foreign wages, as predicted by our model for the case $\gamma > 1$.

As argued above, in longer samples, the coefficient on foreign wages will increasingly reflect the common trend in labour productivity, if such a trend is present. The estimated elasticity of foreign wages then should tend to 1, and the effect of trade freeness would disappear. To asses whether this is the case in samples which are substantially longer than the sample from the EUKLEMS dataset (with 23 yearly observations) which was used up to this point, and as a robustness-check, a regression of wages on foreign wages was performed using publicly available long country-level time series from the OECD and the Penn-tables.

For Belgium, Denmark, Finland, France, Italy and the United Kingdom, both wage and trade data are available in both datasets for the years 1970 to 2008 (39 yearly observations). To allow for easy replication of the results, and to make sure that the results are not driven by the specific measure of trade freeness ϕ which was used up to this point, the trade-to-GDP ratio $open = (imports + exports)/GDP$ will be used as a measure of trade freeness. This measure is directly available from the Penn-tables. Because the trade-to-GDP ratio depends on country size, this openness measure was rescaled to express openness relative to the value in 1970 (which is also the lowest level of *open* in all countries). The openness measure shows a strong upward trend over time in all countries under consideration, with the average trade-to-GDP ratio tripling between 1970 and 2007. Wages *logwage* were measured as the logarithm of the hourly wage per employee, in USD PPP-adjusted terms, and were obtained from the OECD 'Unit labour costs' dataset. Foreign wages *logmeanwage* are computed as the logarithm of the simple arithmetic average of wages in all countries excluding the country under consideration. The results are reported in table 7. The first column of table 7 considers the relationship between

	full sample	full sample	no min. wage	min. wage
logmeanwage	0.964^{***}	1.096^{***}	1.132^{***}	1.013^{***}
	(0.0189)	(0.0456)	(0.0771)	(0.0456)
open×logmeanwage		−0.141	−0.0387	-0.518^{***}
		(0.0923)	(0.140)	(0.123)
open		1.376	0.108	5.984^{***}
		(1.108)	(1.663)	(1.486)
Constant	−0.110	-1.386^{***}	-1.290^{*}	-1.133^{***}
	(0.199)	(0.422)	(0.711)	(0.417)
Observations	234	228	114	114

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7 : The change in the sensitivity of wages with respect to foreign wages using data from the Penn-tables.

the local wage and the average foreign wage (both in logs), without controlling for any other covariate apart from country fixed effects. Local and foreign wages move almost perfectly in a one-to-one log-linear relationship. The elasticity is close to one and not significantly different from one. The specification reported in the second column in the table allows for an interaction effect with trade openness. Despite (or rather because of) the substantial move towards trade liberalisation and the overall decline in transport costs in the countries and years under consideration, there is some evidence that, on average, wages became less sensitive to foreign wages as trade was liberalised. The coefficient on the interaction effect of *open* and *logmeanwage* is not highly significant, however, with a p-value of 0.129. Splitting the sample in a group with and one without a statutory minimum wage, confirms an important regularity which was observed for the shorter EUKLEMS dataset: in countries with a statutory minimum wage, increasing openness to trade implied local wages became significantly less sensitive to foreign wages. The differences between the group of countries with a statutory minimum wage and those without are not significant, however.

4.2. Error-correction, speed of convergence and cointegration of wages

Up to this point, we have established both theoretically and empirically that trade integration may lead to a decrease in the sensitivity of wages with respect to the level of foreign wages. It is important to repeat that this finding is irrelevant as to whether wages converge or diverge. Wages in the EU indeed seem to have converged in the countries, sectors and years considered, as argued in the last paragraphs of section 3. Moreover, convergence appears to have been faster in those countries with a statutory minimum wage, as predicted, which is the group of countries in which wages are found to have become less sensitive to foreign wages as trade costs declined.

The last section of this paper addresses the question whether trade integration must necessarily lead to a greater sensitivity to temporary shocks in foreign wages, and to faster error-correction of wages towards an assumed long-run equilibrium between local and foreign wages, as suggested by Robertson (2000, 2005). As before with increases or decreases in the sensitivity to foreign wages, the question whether wages in two or more countries converge faster towards a long run equilibrium is very different from the question as to whether wages are converging in the sense that the distance between them becomes closer (as in the convergence definition of Bernard and Durlauf (1995), for example). This difference seems to have been overlooked in some of the existing literature.

To determine whether the theory presented in section 2.2 predicts faster error-correction and a greater sensitivity to foreign wage changes. We opted to generate random time-series which behave according to the model and test whether these hypothesis hold in the simulated data, rather than explicitly introducing dynamics in the model. A common stochastic trend (in labour productivity) is likely to be an important determinant of wages in the different EU member states under consideration. This common trend is modelled as a random walk with drift: ${p^c}_t = 0.01 + {p^c}_{t-1} + \epsilon_{1t}$, where ϵ_{1t} is distributed uniformly on the interval $[-0.5, 0.5]$. The term 0.01 constitutes a small deterministic trend which assures that the series remain positive. The starting value of p^c is set at 50. Foreign productivity is generated as $\Delta {p^f}_t = -0.02({p^f}_{t-1} - {p^c}_{t-1}) + \epsilon_{t2}$, local productivity as $\Delta p_t = -0.02(p_{t-1} - {p^c}_{t-1}) + \epsilon_{t3}$ and the alternative wage as $\Delta {w^a}_t = -0.02({w^a}_{t-1} - {p^c}_{t-1}) + \epsilon_{t4}$. These variables are therefore assumed

	$\phi = 0.7$				
	w^*	w^f	w^a	p	p^f
w^*	1				
w^f	0.961	1			
w^a	0.236	0.192	1		
p	0.454	0.313	0.559	1	
p^f	0.224	0.272*	0.587	0.645	1

	$\phi = 100$				
	w^*	w^f	w^a	p	p^f
w^*	1				
w^f	0.933	1			
w^a	0.378	0.192	1		
p	0.520	0.313	0.559	1	
p^f	0.303	0.272	0.587	0.645	1

Table 8 : Correlation tables for the simulated data

to be cointegrated with the common productivity trend p^c, and are subject random shocks which are uncorrelated and uniformly distributed on $[-0.5, 0.5]$. Foreign wages are generated by $\Delta {w^f}_t = -0.02({w^f}_{t-1} - {p^c}_{t-1}) + \epsilon_{t5}$ where ϵ_{t5} is again uncorrelated to all other shocks and uniformly distributed on $[-0.1, 0.1]$. The local union wage w is set according to $\Delta w_t = -0.1(w_{t-1} - {w^*}_{t-1}) + \epsilon_{6t}$. Here, w^* is the optimal union wage demand derived in section 2.2 and was given in equation (8). The random shock ϵ_{6t} is distributed uniformly on $[-0.01, 0.01]$ and is independent from all other shocks and variables. The union wage w is subject to small random shocks which cause it to deviate from the optimal union wage demand, but corrects back rather fast to the optimal level. Market size and the union preference for wages are set at $m = 5$, $\gamma = 1.4$.

Two cases are studied. In a first simulation ϕ is set at 0.7, such that the economy is rather closed. A second simulation assumes the economy is very open, with $\phi = 100$. In both cases, we simulate 80 time-periods of which the first 50 are discarded. Different from our empirical approach, where the foreign wage is calculated as an average over wages in different countries, the same data generating process for p^c, p^f, p, w^a and w^f is now repeated independently for a cross section of $N = 15$ countries, to obtain a $N = 15, T = 30$ panel. Given these parameter settings, union wage demands are high for the low ϕ case with an average of about 200, compared to a labour productivity of 50. For $\phi = 100$ the wage demand is 52. Table 8 shows the correlation between the variables in the simulated data.

Table 9 shows the median and the empirical 90-percent confidence interval of the coefficients after running one thousand simulations. The first column shows the results for the case $\phi = 0.2$, the second column for $\phi = 100$. A first observation is that the Levin, Lin, and James Chu (2002) unit root test is unable to reject the presence of a unit root in both the w^* series (and similar results hold for unit root tests on w^f). This is unsurprising, given the presence of the common stochastic labour productivity trend which is driving these variables.

The coefficient on foreign wages in a simple fixed-effects regression β_1 is higher the economy is closed ($\phi = 0.7$), compared to when trade is quite free ($\phi = 100$). Also, in the

Fixed-effects: $w_i = \beta_0 + \beta_1 w^f + \eta_i + \epsilon_{it}$ Error-correction: $\Delta w = \beta_0' + \beta_2 \Delta w^f + \beta_3 w_{t-1} + \beta_4 w^f{}_{t-1} + \eta_i + \epsilon_{it}'$		
	$\phi = 0.7$	$\phi = 100$
β_1	0.83 [0.79,0.89]	0.75 [0.71,0.80]
β_2	0.718 [0.709,0.724]	0.588 [0.581,0.593]
β_3	-0.0258 [-0.034,-0.0189]	-0.0185 [-0.0249,-0.0131]
β_4	0.022 [0.016,0.029]	0.014 [0.01,0.02]
$-\beta_4/\beta_3$	0.84 [0.79,0.88]	0.77 [0.68,0.81]
Levin et al. (2002) unit root test on w^*	14 percent α_{14} rejection median p-value: 0.30	14 percent α_{10} rejection median p-value: 0.41
Persyn and Westerlund (2008) cointegration test on w^*, w^f	78 percent α_{10} rejection median p-value: .023	13 percent α_{10} rejection median p-value: .44

Table 9 : The left panel shows simulations for the case $\phi = 0.7$, the right panel shows the case $\phi = 100$. The reported statistics are the median union wage demand, the median coefficient on foreign wages in a simple fixed-effects regression of union wages on foreign wages, and the median of various coefficients from an error-correction regression. The Levin, Lin, and James Chu (2002) test shows the rejection rejection rate at the 10-percent level and the median p-value of a test of H_0: w^* contains a unit root. The Persyn and Westerlund (2008) test shows the rejection rejection rate at the 10-percent level and the median p-value of a test of H_0: w^* and w^f are *not* cointegrated.

error-correction regression, a foreign wage change triggers a larger immediate response (β_2) in local wages when trade costs are high ($\phi = 0.7$), and the coefficient on foreign wages in the long-run equilibrium ($-\beta_4/\beta_3$) is higher. These result may be counter-intuitive, but they are unsurprising given the properties of union wages which were derived in section 2.2 for the case $\gamma > 1$.

What is new is the observation that the coefficient β_3 is higher when trade costs are high, indicating that error-correction is faster when trade costs are high. The Persyn and Westerlund (2008) test for cointegration uses the size and significance of this error-correction term to test for cointegration between w and w^f. The Persyn and Westerlund (2008) test is able to detect cointegration in the case of high transport costs, but not in case trade is freer. Local wages are -by construction- cointegrated with foreign wages both when $\phi = 0.7$ and $\phi = 100$. Although local and foreign wages are far apart in the high transport cost case, the stronger link between local union wages and foreign wages caused by union behaviour implies a higher signal-to-noise ratio for standard cointegration tests. This leads the cointegration tests to lend more support to the cointegration hypothesis in the high transport cost case (see Ziliak and McCloskey, 2008, for more on the dangers of interpreting significance).

These simulation results clearly illustrate the problem with interpreting the following as proof of convergence between variables: 1/ finding proof for cointegration, 2/ a high speed of convergence towards the long-run equilibrium, 3/ a high coefficient in regressions either in levels and differences. Although all these elements are present in the high trade cost case $\phi = 0.7$ presented above, the difference between local (union) wages and foreign wages is much larger in this case, compared to when $\phi = 100$. When trade is liberalised up to the level $\phi = 100$, cointegration tests no longer find proof for cointegration, convergence towards the long-run equilibrium is slower and the reaction to temporary or permanent shocks of foreign wages is smaller, despite the fact that local union wages are actually much closer to the foreign wage level in this case.

Whereas the finding of proof of cointegration indeed implies that the variables involved are tied closely together and the difference between them remains bounded, not finding proof for cointegration or finding weaker proof for cointegration does not imply the difference between the variables is less stable or smaller. Similarly, a slower speed of convergence towards the common long-run equilibrium may be found in a first sample, compared to some reference group or time-period, although the difference between the variables under consideration is actually smaller in the first sample. As argued in throughout this paper, the size of a coefficient on a variable in a regression is uninformative regarding the distance between the dependent variable and this independent variable. A large body of empirical literature, such as Andersen, Haldrup, and Sørensen (2000); Robertson (2000, 2005) and a host of contributions comparing cointegration test-statistics, fails to take this into account and the claims they make on factor price convergence and labour market integration therefore are not supported by their findings.

5. Conclusion

In this paper, we have attempted to shed light on how trade liberalisation affects unionised labour markets and the relationship between wages in different countries. In a model with a monopoly union facing internationally mobile firms, it was shown that the elasticity (and the derivative) of the optimal union wage demand with respect to foreign wages decreases after trade liberalisation if unions are sufficiently wage-oriented. Simultaneously, the sensitivity of the optimal union wage demand with respect with some local alternative wage offer which is considered by the union increases. For employment-oriented unions, the reverse holds: trade liberalisation makes union wages more sensitive to foreign wages and less sensitive to the alternative wage. Several other properties of union wages were derived using restrictions concerning the homogeneity of the union utility function.

The model predicts that union wage demands decrease after trade liberalisation, and increasingly tend towards the level of the alternative wage. This implies international wage convergence if, for example, the alternative wage and foreign wages are competitive and technology is not too different between countries. Simultaneously, however, wages in countries with wage oriented unions become less sensitive to foreign wages, and investigating the correlation between wages in different countries as a proof for factor price convergence can therefore be highly misleading.

Moreover, model simulations show that if unions are wage oriented, trade liberalisation causes union wages to become less responsive to temporary shocks in foreign wages, show slower error-correction towards a long-run equilibrium between local and foreign wages, and appear less cointegrated with foreign wages. All of this occurs despite the fact that trade liberalisation decreases the difference between local and foreign wages.

We then provided some empirical tests of the theory, and considered some of its implications. Our main empirical strategy consisted of two parts.

We first took the developed theory rather seriously and estimated a rich model-based wage regression using a sample of time-series from the EUKLEMS dataset containing 22 yearly observations for a selection of 13 EU member states and 12 manufacturing sectors. A measure of trade freeness was calculated using bilateral sector level trade data from the CEPII database. The existence of a statutory minimum wage in a country was taken as a proxy for the relative union preference for wages relative to employment. Many of the model predictions were found to hold. Importantly, the coefficient on foreign wages increases significantly slower with trade liberalisation in countries with a statutory minimum wages, or even decreases, which is as predicted. Simultaneously, wages converged between the countries considered in the sample, and if anything convergence turns out to be faster in the group of countries with a statutory minimum wage.

Simple regressions of wages on foreign wages were then considered, as they are often encountered in the empirical literature. The omitted variable bias predicted by the theoretical model was derived for these specifications. If the assumptions of the union model hold, one expects to find a one-to-one relation between local and foreign wages in a simple regression of wages on foreign wages (irrespective of the level of transport costs, for example), provided that the sample is sufficiently long such that there exists sufficient variation in a supposed common omitted trend driving wages in the different countries. In shorter samples or samples with less variation in the common trend, in contrast, the predictions of the model will hold. For countries with wage oriented unions, the coefficient on foreign wages then decreases after trade liberalisation.

We first confirmed that these predictions indeed hold for the EUKLEMS dataset: including foreign wages as a sole covariate in a wage regressions results in a coefficient on foreign wages which is close to one. In countries with a statutory minimum wage, this coefficient decreases with freer trade, in countries without a statutory minimum wage it decreases. To find out whether this effect disappears using longer time-series, and as a robustness check, this regression was repeated for a sample of long country-level time-series obtained from the Penn-tables and the OECD, on 6 EU countries. Even with 39 yearly observations, trade liberalisation is found to have significantly decreased the sensitivity of wages on foreign wages in countries with a statutory minimum wages (and there is some proof the sensitivity decreased in the sample as a whole). Again, it is important to repeat that this finding does not have implications regarding the convergence or divergence of wages between the countries and years under consideration.

A large empirical literature fails to take into account this ambiguous relation between, on the one hand: genuine wage convergence between countries in the sense that the difference between wages in different countries decreases, and on the other hand: the correlation between wages in different countries, the transmission of temporary shocks, cointegration test statistics, and the speed of convergence towards a long run equilibrium. Some examples of studies which seems to confound these are Andersen, Haldrup, and Sørensen (2000), who assume that trade liberalisation and wage convergence between countries imply a larger coefficient on foreign wages in a simple wage regression. Robertson (2000) and Robertson (2005), who assumes that trade integration and wage convergence imply a greater responsiveness to foreign wage shocks and faster convergence towards a long run equilibrium, and a host of contributions comparing cointegration test-statistics which fail to take into account the fact that trade integration and international wage convergence may coincide with less proof of cointegration. The claims these contributions make regarding wage convergence are therefore are not supported by their empirical results, although they are nevertheless interesting in their own respect.

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A. Appendices

A.1. Variable definitions

For Eurozone countries all nominal values were deflated using sector-country level producer price deflators. For Sweden, the UK and Denmark the constant local currency values where then converted to euros using a fixed conversion rate.

The definition and derivation of the measure of trade freeness ϕ is discussed in detail in section 3.2.

The variable *logwage* is calculated as the logarithm of real total labour compensation per person engaged in a specific sector and country.

loglp is calculated as the log of real output per person engaged in a specific sector and country.

The foreign wage *wageEU* is calculated as a macro concept: for some country n and sector i, the foreign wage is defined as the sum of total labour compensation in all other EU member states in the sample in sector i, excluding country n, divided by the sum of the number of persons engaged in these member states in sector i, excluding country n. This implies that large countries have more weight in our measure of foreign wages. The variable *logwageEU* is the log of *wageEU*.

Foreign productivity *lpEU* is calculated accordingly: for some country n and sector i, foreign labour productivity is defined as the sum of total labour compensation in all other EU member states in the sample in sector i, excluding country n, divided by the sum of the number of persons engaged in these member states in sector i, excluding country n. The variable *loglpEU* is the log of *lpEU*.

The variable *logrelwage* equals the difference between the logarithm of local wages *logwage* and the logarithm of foreign wages *logwageEU*.

The variable *logrellp* equals the difference between the logarithm of local average labour productivity *loglp* and the logarithm of foreign average labour productivity *loglpEU*.

The alternative wage *altwage* in some country n and sector i is similarly defined as the sum of labour compensation in all sectors in country n, excluding sector i, divided by the sum of the number of employees in all sectors in country n, excluding sector i. This implies large sectors within the country have a larger weight in the calculation of the alternative wage. The variable *logaltwage* is the log of *altwage*.

The variable *access* serves as a proxy of the variable m in the model. To derive a measure of the market size of sector i in country n and year t we take the distance-weighted total demand for output of sector i, from the perspective of country n, in year t. The distance weighted variables are calculated as follows

$$m_{nit} = \sum_j \omega_{nj} C_{jit}$$

$$\omega_{nj} = \left(\sum_{r \in n} (\text{pop}_r/\text{pop}_n) \sum_{k \in j} (\text{pop}_k/\text{pop}_j) d_{rk} \right).$$

Here d_{rk} is the geographic distance between regions r and k in countries n and j respectively and pop_z is the population in region z. The variable C_{jit} is the total consumption in country j of the output of the sector i in year t. Data for the weights ω_{nj} and consumption C were obtained from Mayer, Paillacar, and Zignago (2008). This type of weighting takes into account the distribution of demand among the regions bordering the country of interest. Belgium, for example, would have a larger market access than its GDP would suggest, as major industrialised and urbanised regions such as Paris, the German Ruhr area and the Netherlands are in close proximity.

The variable *logaccess* equals the logarithm of the variable *access*.

A.2. Error-correction specification

To allow for sluggish adjustment in a relationship $Y_t = \beta_0^* + \beta_1^* X_t$, it may be redefined as a simple auto-regressive distributed lag (ARDL) model $Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 X_t + \beta_3 X_{t-1} + \beta_4 X_{t-2}$. In a long run equilibrium $Y_t = Y_{t-1}$ and $X_t = X_{t-1} = X_{t-2}$ and therefore $Y_t = \beta_0 + [(\beta_2 + \beta_3 + \beta_4)/(1 - \beta_1)]$. The ARDL specification does not allow to distinguish between short and long-run effects (see Banerjee, Dolado, Galbraith, and Hendry, 1993). Through some simple transformations, however, the ARDL can be rewritten in the following error-correction form: $\Delta Y_t = \alpha_0 + \xi_0 \Delta X_t + \xi_1 \Delta X_{t-1} + \alpha_{ec} Y_{t-1} + \alpha_1 X_{t-1}$, where the short run effects of changes in X are allowed to differ from the long run effects. In the long run, the differenced terms drop out of the equation, and $Y_{t-1} = \alpha_0 + [-\alpha/\alpha_{ec}] X_{t-1}$. The coefficient α_{ec} shows how fast the series return to this long run equilibrium. The long run effect of a change in X on Y in the error-correction model is given by $\beta_1^* = -\alpha_1/\alpha_{ec}$.

The tables in the main text only report these long run estimates. The full tables are available from the author upon request.

A.3. *Minimum wages, unemployment & wage orientation*

Table 10 shows the unemployment rate of all countries included in the sample and whether the country has a statutory minimum wage.

Austria	1.85
Sweden	2.22
Germany	3.24
Finland	4.69
United Kingdom*	5.71
Netherlands*	6.16
France*	6.51
Denmark	6.93
Ireland*	7.39
Italy	7.66
Portugal*	7.84
Belgium*	8.09
Spain*	11.51

Table 10 : Unemployment rates (in %) in 1980 (source: OECD). Countries with a statutory minimum wage are indicated by a star.

Table 11 shows which sector/country combinations were included in the sample. Table 12 reports the employment in 1000 employees and the EU-wide average hourly wage for a selection of sectors contained in the EUKLEMS dataset.

Sector	AUT	BEL	DNK	ESP	FIN	FRA	GBR	GER	IRL	ITA	NLD	PRT	SWE	Total
15	X	X	X	X	X	X	X	X	X			X	X	11
17/18	X	X	X	X	X	X	X	X	X	X		X	X	12
19				X	X	X	X	X		X		X		7
20	X	X	X	X	X	X	X	X	X	X	X	X	X	13
21/22	X	X	X	X	X	X	X	X	X	X	X	X	X	13
24	X	X	X	X	X	X	X	X	X	X		X	X	12
25	X	X	X	X	X	X	X	X	X	X	X	X	X	13
26	X	X	X	X	X	X	X	X	X	X	X	X	X	13
27/28	X	X	X	X	X	X	X	X	X	X	X	X	X	13
29	X		X	X	X	X	X	X		X		X	X	10
30-33	X			X	X	X	X	X		X		X		9
34/35				X	X	X	X	X		X		X	X	8
Total	10	8	9	12	12	12	12	12	8	11	5	12	11	134

Table 11 : Country/sector combinations included in the sample.

NACE	Description	Employment	Wage
15	Food and beverages	3701	13
16	Tobacco	65	20
17	Textiles	1140	16
18	Wearing apparel, dressing and dying of fur	1132	11
19	Leather, leather and footwear	507	13
20	Wood and products of wood and cork	955	12
21	Pulp, paper and paper	681	19
22	Printing, publishing and reproduction	1881	18
23	Coke, refined petroleum and nuclear fuel	142	35
24	Chemicals and chemical products	1600	32
25	Rubber and plastics	1434	23
26	Other non-metallic minerals	1346	17
27	Basic metals	947	25
28	Fabricated metals	3338	19
29	Machinery, nec	3147	25
30	Office, accounting and computing machinery	215	21
31	Electrical machinery and apparatus, nec	1404	22
32	Radio, television and communication equip.	783	24
33	Medical, precision and optical instruments	903	22
34	Motor vehicles, trailers and semi-trailers	1973	28
35	Other transport equipment	733	24

Table 12 : NACE rev 1.1 codes, EU15 employment in 1000 employees and the EU-wide average hourly wage in 1995 PPP-adjusted euro's, for the year 2000. Sectors 16 and 23 are not included in the sample. Sectors 17-18, 21-22, 27-28, 30-33, and 34-35 were aggregated as no separate trade data is collected for these sectors.