Solidaristic Wage Setting

in

General Oligopolistic Equilibrium

by

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Contents

Preface

This thesis is based on an idea formed by my mentors Frode Meland and Kjell Erik Lommerud. I have been privileged to have been trusted with the assignment of testing their theory. Though it has been a struggle at times, I have had an interesting and rewarding year. Never before have I had the opportunity to go this deep into a project, and I feel I have come out on the other side both a little wiser, and a little more aware of my ignorance. All in all it has been a good year and a proper conclusion of my time as a student.

I would like to thank my mentors sincerely for follow-up and guidance. It has been an inspiring process.

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Inger Sommerfelt Ervik

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Abstract

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Mentors: Frode Meland and Kjell Erik Lommerud

Under the slogan "equal pay for equal work", the Scandinavian countries has strived for small wage differences between different sectors.

The origin of solidaristic wage policies can be found in the 1930s, where internationally competing industrial sectors were afraid that wage claims in shielded sectors, as construction, could become too high – and ultimately hurt the export sectors.

Solidaristic wage setting appear appealing from a fairness view point, but the heighday of these politics – the 1950s and 1960s – also were times with rapid growth. Was this luck or coincidence? Had the Scandinavian countries discovered a winning recipe?

In this thesis we will look at the welfare implication of compressed wages. The approach we have used also gives us the opportunity to look at implications of globalisation, and how globalisation and wage compression are interlinked.

Wage compression will, through changes in production costs, change the distribution of production within the economy. We find that, not surprisingly, compressed real wages gives less variance of output prices across industries. This result by it self makes the consumer worse off, as the possibility of

substitution towards cheaper goods is lost. What, on the other hand, is surprising, is that the compressed prices have other general equilibrium effects that are strong enough to make the end outcome higher consumer utility.

When studying globalisation, wage compression has especially one noteworthy effect. When wages are not compressed, globalisation creates higher wages in all sectors.[1] When wages are compressed, we find that in some cases globalisation will give lower wages to workers outside the unions.

To investigate the issues as these, we need a model where the economy is described as imperfectly competitive (where agents act strategically) and where we can study general equilibrium effects. Models combining there traits are rare, but research is moving in this direction. When wages are compressed, this will have implications both directly as a change in production costs, and indirectly through readjustments in labour demand. Unless we can look at both partial equilibrium effects and general equilibrium effects in the same model, we could not find the dominating effect in cases where the two pull in different directions.

[1] This result was found by Naylor (1999) in an partial equilibrium model, and is highly critizied. The objections will be presented later on.

Chapter 1

Introduction

The Nordic model, the Scandinavian model, the Swedish model, it has many names, but the content, and the fascination for it, is the same. The story of the Scandinavian countries where focus seems to be on solidarity, has managed to bring with it impressive growth. Is it really possible for a welfare economy based on naivistic solidarity, to prosper? Or is it all luck and coincidences? Apparently there still is no consensus on the subject.

Even though solidaristic wage setting was implemented in several places, the programme has been particularly successful in Sweden and Norway after the Second World War. Both countries had a social democratic government and a well established welfare state before the war. The expression "solidaristic wage policy" was first used in Sweden.[1] Norwegian economists looked to their successful neighbour when they searched for ways to repair the economic situation in the aftermath of the war. The programme includes a number of measures, but the heart of it was the ideology of "equal pay for equal work".[2]

In Norway, the prelude of the regulated wage system started in 1935, when an agreement between LO, the labour association, and N.A.F.[3], the employer union made an agreement to cooperate in wage negotiations on firm level across the sectors.[4] In Sweden, a similar agreement was made in 1938, between their labour union and employer federations LO and SAF. Even though the parties were not under government control, these agreements

[1] Schulten (2002)
[2] Meidner (1993)
[3] N.A.F. is now a part of NHO, etstabished 1989.
[4] Moene (2007)

lead to highly centralised wage bargaining in both countries.[5]

The pre-war years in Norway was characterised by social reforms and economic growth. Norway experienced a steady growth the in both real capital and GDP the entire 20^{th} century. Before the war, growth can be explained as catch-up. The war years caused an abrupt standstill in growth. But while the economy was down, the ideas of how to get it up and running again when the war was over, flourished.

Sweden was neutral during the war, and was not hit at hard as the Norwegian economy. But as the threat was present, and trade partners were affected, the economy had to be adapted to war-time conditions.[6] This was done by massive government regulations. The war-time economy was a success with good utilisation of resources. While unemployment was a problem before the war, they now experienced near full employment. Because regulation seemed to work, the idea arose they could work also in a peacetime setting. Rehn (1957) describes how an important part of the regulations had been to reduce differences in income. Gösta Rehn, and fellow Swedish trade union confederation economists, Rudolf Meidner, were the front promoters and theorists behind the ideas of solidaristic wage policy.[7]

Norwegian politics were heavily influenced by the Swedish success. Several important principles for economic control were developed by the government in cooperation with the trade unions.[8] The post war growth in Norway was exceptional. The period was also characterised by an increase in labour productivity above the earlier trend.[9]

In the post war period in Sweden, regulations were reduced but in no way terminated. An important justification for this was the improved employment situation. Even with less regulation, the industries that had traditionally received smaller pay-checks had strengthened their bargaining position. Combined with the ideal of equal pay for equal work, the compressed wages were maintained. As an example, Rehn (1957) mentions how workers in the sheltered sectors lost some of their relative advantage compared to workers in heavier industries.

Contrary to what was expected, unemployment turned out not to be a problem in Sweden. Being relatively unharmed by the war, exporting firms

[5] Meidner (1993)
[6] Meidner (1993)
[7] Hibbs and Locking (1996)
[8] Kuhnle (1992)
[9] Aukrust (1957)

faced massive output demand, this lead to excess labour demand, and troubles with inflation.[10] In an attempt to restrain wage growth, the government, unable to limit wages directly, signalled that wage increases would be followed by massive tax increases. The unions decided that there was no point to wage increases, and in 1949, a central-union bargained wage freeze was implemented. During the wage freeze, firm level negotiations resulted in higher wages for some union members. Inevitably, the wage freeze was followed by a wage explosion when the workers not favoured by the firm level negotiations were to catch up with the others.[11]

In the early 1950s, in order for the inflation not to get out of hand, a programme that later was to be known as the Meidner-Rehn model was implemented. Now wage negotiations were moved from firm level to central-union level, thus creating more coordinated wage negotiations. It is at this point the true solidaristic wage setting, and "equal pay for equal work" begins. As a consequence, the sectors that were engaged in trade had to set the standard for union wages. If the standard were to be set according to the workers in the higher paid industries, the wage would have put a lid on export as the internationally competing industries would have lost large market shares to foreign firms.[12]

Though Norway had practiced union wage compression for some time, the formal distinction between firms that trade, and firms that do not was not made until in the early 1960s. Aukrust (1977) draws a picture of an industry that was, and is, divided into two sectors, one that is exposed to foreign competition, and one that was shielded from it. It was recognised that the foreign competition in the open sectors resulted in lower wages compared to workers in the shielded sectors, while productivity in the open sector was in fact higher. In Sweden, Lindbeck expressed that "*unions should rely on wage policy based on "the solidarity principle," implying that the labour unions in sectors with low wages and profit should not hesitate to push for as high wages as those prevailing in other sectors*".[13] He argued that since the wage difference had nothing to do with productivity, it was hard to justify. At the same time, Lindbeck accepted wage differences based on productivity level, and had no objections towards wage differences *within* the sectors.

This last detail was an important one, but was nevertheless undermined in

[10] Erixon (2011)
[11] Rehn (1957)
[12] Moene (2007)
[13] Lindbeck (1968, p. 20)

the 1960s when what Hibbs and Locking (1996) call a shift from an ideology of "equal pay for equal work" to an ideology of "equal pay for all work" took place. The idea was to improve the conditions for the lowest paid workers, and even though the intention was noble, such wage setting has negative implications for efficiency.[14]

Exactly when the system in Sweden failed is hard to pin down. According to Hibbs and Locking (1996) this happened in 1983. Meidner (1993) blames the economic crisis in the 1990s, and claims that after years of decay the centralised bargaining in Sweden collapsed in the early 1990s. Norway did not experience the same sudden change. Inflation troubles during the rapid growth in the 1980s had lead to a wage conflict. After rough negotiation, wages were set high, and the industry suffered. In the following years, both parties wanted to keep the centralised wage bargaining. Employees because they had been favoured in the conflict, and employers because they relied on a strong union in their weakened position.[15]

In these days, the principles of the Rehn-Meidner model have gained renewed interest. According to Olberg (2007), discussions around a new form of regulations in the Nordic countries, has engaged in a second round of evaluating solidaristic wage setting. The discussion has changed with the changes in the economy. Because of globalisation, the issue of trade has been of increasingly interest. Though the ideology is still important, Hibbs and Locking's[16] discovery that too much equalisation can have unwanted effects, has turned the focus more towards growth.

1.1 Theory

The implications of solidaristic wage policy have been widely studied. The field has been particularly interesting due to the rapid growth Norway and Sweden experienced in the period compressed wages were implemented. A discussion of whether this was because of, or despite of the wage setting policy emerged. Mobilisation of labour and increased exports managed to maintain rapid growth in spite of the wage policies, or was the growth amplified or even created by the wage policy. In both countries, the aftermath of the war had created a complex economic situation that makes it difficult to distinguish

[14] Hibbs and Locking (2000)
[15] Olberg (2007)
[16] Hibbs and Locking (2000)

what effects the wage policy had.

The theoretical discussion has focused mainly on growth. This is not very surprising as this was one of the easiest observable characteristics of the period, and also because one of the ideas behind wage compression was to promote efficiency. The strong government control can be compared to a major economic experiment,[17] and the empirical data[18] indicate that it just might have worked.

Of course, since the ideology behind the wage bargaining was to promote a more equitable distribution of resources, the welfare aspect is also important, but at the same time not as tractable. One approach has been to divide the work force into two groups, high skill, and low skill workers, and evaluate what happens to the two.

Further we have the increasingly relevant subject of globalisation. Particularly in small, open economies like Sweden and Norway, factors that influence international competitiveness have massive effects on the economy.

So, growth, welfare and globalisation are three aspects to consider within the context of solidaristic wage setting, but before going into these, a few basic insights on unionisation is called for.

1.1.1 Unions

In an ideal market with perfect competition, there is a consensus that unions will only distort the markets, and make the economic surplus smaller. By setting a union wage higher than the market clearing wage, production will decrease, and there will be an efficiency loss. If unions are market distortions, can they create a more efficient economy? The answer is yes, if the initial situation is not one of perfect competition, unions may make the aggregate production rise.

After the second world war, research on unionisation was a fairly active field, but the interest declined towards the 1970s. The problem, according to George Johnson (1975) was that there was no agreement on formalisation of bargaining tactics and union goals. When these problems were overcome, and a theoretical foundation was laid, the field expanded again. As models became more detailed, Oswald (1985, p. 184) found that "Only the simplest kinds of general equilibrium models (...) generate uncomplicated predictions

[17] Moene (2007)
[18] Hibbs and Locking (2000)

about the welfare consequences of unions' actions". By this he stated that when more factors were included, unions did no longer necessarily have negative welfare implications.

Union wage setting models

Two workhorse models of union wage setting are used today, the right-to-manage model[19] and the efficiency wage model. The type of union model is relevant to the level of union wages.

The right-to-manage model is called so because after the union wage is set, the firms are free to decide upon employment level.[20] Within this model, the union wage is determined based on negotiation between the firms and the union. When the wage is set, firms choose employment level so that wage equals marginal production of labour. The union typically obtain rents by high union wages and by high employment within the union, two factors that are negatively correlated. The firm achieves higher profits when wages are lower. The wage is determined based on negotiations between the union and the firms, and the outcome is affected by how much power the parties have.[21] A special case of a right-to-manage model, is the monopoly union model. In this case, the firms have no power, and only union rents are maximized. The outcome is a wage higher than in any other form of the right-to-manage model.

The rigth-to-manage model is not efficient. The union has more power over wages than employment. When wages are driven up, this immediately leads to lower employment. No contract between union and firm that specifies both wage and employment is feasible.

In the efficiency wage model, on the other hand, there are negotiations on both wage and employment.[22] The wage is set at the point of tangency between the isoprofit curve for the firm, and the indifference curve for the union. This produces a Pareto optimal union wage.[23]

[19] Andrews and Nickell (1983)
[20] Andrews and Nickell (1983)
[21] Manning (1987)
[22] Manning (1987)
[23] Oswald (1985), McDonald and Solow (1981)

Insider outsider theory

Another element, which in principle can be combined with both these wage setting models, is the insider outsider union theory.[24] This theory is built on the assumption that staying in a position within a union for a while makes a worker an insider, and that replacing an insider with an outsider gives the employer turnover costs. Thus, being an insider means being in a position of power that can be used to achieve higher wage. We have a situation where imperfect mobility of workers enables unionised workers to exploit their position.

In inefficient models, as the rigth-to-manage model, wages are driven up, and employment suffers. With insider power, some workers can drive up wages and benefit from this, while other workers suffer the unemployment consequence of this.

Wage-drift

Deciding on union wages is not the same as controlling actual wages. When wages are set nationally, there is room for firm level wage-changing behaviour. Wage-drift is increases in wages over the rates originally set in the negotiations. Wage drift can be due to increases in overtime, or it can be caused by employee-firm negotiations after the union rates are set. Wage drift has for example been blamed for the wage explosion after the wage freeze in Sweden.

1.1.2 Centralisation

The degree of unionisation is significant for the implications of union wage setting. Calmfors and Driffill (1988) introduced the famous hump shape hypothesis, the theory of the connection between real wages and centralisation. Small unions will set moderate union wages, as market forces will restrain them. As unions grow, their market power will increase, and so will union wages. If unions are sufficiently large, the union interests typically coincide with society's broader interests as the union organise almost the entire workforce. Centralised unions will take into account how the nominal wages, through the nominal price level, will influence the real wages. Centralisation tend moderate union wages.

[24] Lindbeck and Snower (2001)

Degree of centralisation and wage differentials

Moene and Wallerstein (1997) compares the effect of centralised wage bargaining with firm level bargaining. Evidence seems to indicate that a moderate level of centralisation gives the highest unemployment, but which is better of the two extremes? The answer relates to wage compression. Decentralised wage bargaining gives rise to wage differentials, while unionised wage bargaining compresses wages. Decentralised wage bargaining causes workers to demand higher wages after investments that raise marginal productivity of labour have been made. This results in a string of events: fewer firms will enter the market, and aggregate labour demand decline. Lower labour demand will give lower wages outside the union, and if there is a minimum wage, it will give higher unemployment. All this is avoided if centralised unions determine the wage, and as long as unions take care not to set the union wage too high, then unemployment may be unchanged.

Because of the different interpretations of centralised bargaining, it is not an easy field to explore. As pointed out by Calmfors (1993 p.182) "the extent of centralisation is likely to have different effects depending upon whether it refers to sectors, profession, regions or uniosation" This being said, Calmfors, and others with him agree that it seems to be a connection between centralisation and smaller wage differentials. Freedman and Nickell (1988) go to the extent that they conclude that a small wage difference is the key indicator of level of centralisation.

1.1.3 Wage compression and growth

One of Rehn's initial reason for wage compression was the argument that it would rearrange labour to a more efficient allocation, and retire less efficient firms. Both these aspects has been looked into, and theoretically, under certain conditions wage compression can give higher economic growth.

Compressed wages and labour allocation

Agell and Lommerud (1993) point out that new technology typically comes with a positive externality as production in innovative sectors generates further progress. This, combined with sluggish labour mobility, due to preferences towards the traditional sectors, causes too big a part of the labour force to stay put in the traditional sector. Preferences towards the tradi-

tional sector will make the wages there lower than the marginal product of labour. The extra labour in the traditional sector will increase the marginal product of capital, and ensures that too much of the capital stays put in that sector as well. Agell and Lommerud argue that compressed wages will force the traditional firms to hire less workers, as labour becomes more expensive, while innovative firms will hire more, as they experience cheaper labour. The shift in labour towards the innovative sector will, if the new wages are carefully determined, incorporate the positive externality. In this manner, compressed wages have much the same effect as a subsidy on inventive sectors, implemented to make up for market imperfections created by an externality.

An important aspect of growth created by wage compression is that the wage level is moderate. Agell and Lommerud speculate that as moderate wages can be difficult to achieve, compressed wages will not always be a possible growth inducing policy. The growth rate was high when solidaristic wage setting was implemented in Norway and Sweden, a wage moderation strategy then still implied rapidly rising wages.

Compressed wages and plant efficiency

Moene and Wallerstein (1997) found similar results. Based on the argumentation presented above, in which they concluded that centralisation was superior to decentralisation in terms of unemployment, they also found that centralisation promotes efficiency. With bigger wage dispersion due to decentralised bargaining, old and less productive, plants can stay in business longer. Production will sink, while employment is unchanged. Wage compression through centralised bargaining induce old and less efficient firms to exit the industry quicker, which can keep aggregate production at a higher level.

It should be mentioned, and was explicitly so by Agell and Lommerud (1993), that even though wage compression may encourage growth in some ways, the picture is complex. No general statement can be made even though these two models demonstrate a connection.

Wage compression and welfare

A less enthusiastic view about the effects of compressed wages was promoted by Lindquist (2003). He argued that solidaristic wage setting will increase un-

employment amongst the low skilled workers. Lindquist bases his analysis of the effect of a monopoly union that compresses all wages, also between workers that have different marginal product of labour. Lindbeck (1968) explicitly expressed that this was not the intention with solidaristic wage bargaining. Still, unions do tend to try to compress wages within the firms even though this is not encouraged from an economic point of view.[25] Lindquist finds that wage compression decreases the number of high skilled labour. Though they are not exactly the same, there is a similarity in the effect of high skilled labour and of innovation. In this respect, Lindquist's findings goes against Agell and Lommerud's point, that compressed wages encourages more innovation. Thus, Lindquist illustrates that a specific set of factors must be present for this to apply.

Lindquist found that the welfare loss from the unemployed low skill workers is far greater than the gain from more human capital. The high unemployment among low skilled workers occurs because the wage is forced above their level of marginal productivity. The lower education level occurs because the returns to education sink. So not only does he find that the effect from wage compression on welfare is negative, but he also reasons that more attention should be turned towards how compressed wages affect unemployment. In conclusion Lindquist mentions that the heaviest burden from wage compression is carried by low skill workers. These welfare effects were no doubt not what Lindbeck and Aukrust had in mind, as compressed wages were meant to give a more fair distribution of income.

1.1.4 Globalisation

Wage compression clearly interacts with trade openness. Will a compressed wage distribution imply that the high skill or the low skill sector expand or contracts, in the face of international competition? What is the implications of some sectors being shielded from international competition while others are not? Because trade is important, so are alterations in trade conditions, and thus, globalisation. Implications of globalisation will influence all parts of the economy, also the ones not situated directly in the crossfire. Davis (1998 p.409) puts it like this; "Even when factor markets are strictly national, with idiosyncratic institutional features, they cannot be considered in isolation when goods markets are global."

[25] Hibbs and Locking (1996)

Globalisation is a fact, not an instrument. We need to understand it in order to adapt to it, but we can probably not control it without massive efficiency loss. Globalisation defines the environment, and alters the implications of policy. In order to adjust the policy in the most optimal way, we need to understand what happens in the economy at different degrees of globalisation.

Globalisation and output

First, without dwelling on them, specialisation and economies of scale should be mentioned. Both possibilities arise under globalisation, and will give a more efficient way of producing. Costs will go down, and production will increase. Aside from this, when markets are not perfectly competitive, as they most realistically are not, globalisation can have more implications.

Imperfect competition means firms with profits. This will lead to a phenomenon that Brander and Krügman (1983) named *reciprocal dumping*. Reciprocal dumping arises when there is oligopolistic competition, and output is sold in two or more separate markets. If a firm has monopolistic power in one market, and sees an opportunity to sell in a additional, separate, market, the firm will make the production decision for sale in the two markets independently. The firm will exploit the opportunity to sell goods in the foreign market because an increase of goods sold there have no influence on prices in the domestic market. If we assume two countries that have monopoly power in one market each, both will ignore the fact that dumping goods in the other market will be mirrored as the other country will dump goods in the domestic market. As a result, total amount of goods in both markets will increase, and prices will decrease. As long as trade costs are sufficiently low, reciprocal dumping will increase consumer welfare because is distorts market power.

When two countries are symmetrical, the dumping will be symmetrical. If they have different production costs, reciprocal dumping can still persist, but the country with the lower wages will account for most of the dumping. After a threshold level of difference in production costs, only one country will do the dumping.

Globalisation and union wages

A well-known theory of unionised wages under globalisation takes so-called reciprocal dumping as its starting point. This means that firms both sells at home and abroad, possibly at different prices. Naylor (1998) created a partial equilibrium model with imperfect competition. According to Naylor's model, lower trade costs and thus higher degrees of globalisation, will increase the extent of reciprocal dumping. Higher production will increase labour demand, and the union wages will rise.

The argument above neglects the possibility of capital flight. Naturally, if globalisation leads to higher wages, the incentives for offshoring or outsourcing may increase. Lommerud et al. (2003) formalised a model of FDI that can shed some light on the relationship between globalisation, union wages and capital flight. There are two countries. In the domestic market, monopoly unions lead to high wages, whereas workers in the non-unionised foreign country receive lower wages. The firm has three options: It can produce at home for one or both markets, it can do partial FDI and move the production of the goods it wants to sell in the foreign market abroad, or it can move the entire production capacity abroad. Given no FDI and low trade costs, the domestic union keeps wages low to induce exports and high employment. Further reductions in trade costs produces the Naylor effect; wages go up, and for the same reasons. With the assumption that unions can not commit to low wages because investments are more long-term than the determination of wages, this globalisation-induced wage increase will lead to a larger incentive to do FDI. However, there may be a disadvantage related to doing only partial FDI - it leads to a wage increase at home relative to the no FDI option if trade costs are low. This is because under these circumstances, unions are keeping wages low to induce exports, and the incentive for doing so is totally erased once partial FDI is undertaken. For low trade costs and low costs of FDI, therefore, the typical result is that the firm undertakes full FDI, thus escaping the union influence altogether. Lower levels of trade costs can thus create capital fight that can be detrimental to unionised labour.

Friedman (1995) made a gloomy prediction that at some point in the future, wages will be competed down to the same level as countries with far lower living costs. Lommerud et al. argues that this prediction is probably too negative. Trade will, because of the physical distances, never be completely costless. Thus, it is unlikely that more globalisation always creates lower wages because of more competition amongst the workers. If the cost

is high enough to keep some production in the domestic market, a marginal change in trade costs can still increase union wages.

It is worth noting that in the model part of this thesis, the Naylor effect will surface, but capital flight is assumed not to be possible.

1.2 Practice

So how does these theories on unionisation, compressed wages and globalisation apply to the story of compressed wages in Norway and Sweden?

Let us first look at centralisation. In addition to wage differences that were easier to defend from a socialistic point of view, common wage negotiations in the open and the shielded sector means that the unions in the two sectors will need to cooperate. The result is more centralised wage bargaining, according to Calmfors and Driffill and this should have positive implications in form of lower inflation.

At first glance, this does not fit very well. Sweden struggled with inflation problems from the post war, and the problems persisted even after the wage bargaining became highly centralised in the 1950s. One explanation could be the same mechanics that caused the sudden jump in wages after the wage freeze in Sweden; wage-drift. According to Hibbs and Locking (1996) this was not the case. They found that wage drift seemed to be taken into account when union wages were decided upon.

Moene (2007) expresses that in his view, the Rehn-Meidner agreement was designed to gain control of the inflation problems. The agreement between SAF and LO expressed their autonomous relationship to the government. When employment is full, it is hard for the union to maintain moderate wage growth, and at the same time maintain good spirits amongst the workers. The Rehn-Meidner agreement included a number of Keynesian government control measures that would ensure lower inflation. Because the period with compressed wages was also a period of economic growth and very high employment, centralisation might actually have improved the situation even though it did not completely mend the problem.

This brings us to the core of the interest in the Scandinavian model, namely the subject of wage compression and growth. According to Meidner (1993) at least part of the reason why solidaristic wage setting, and the welfare state, is a success, is that the money spent is in fact an investment in positive externalities. This is in accordance with Agell and Lommerud's

theory. Further, as both the previous mention, and Moene and Wallerstein claim, equal wages did lead to the demise of less productive firms.[26]

So, if the Scandinavian model worked according to the theory, as Meidner (1993) so harshly put it: why did it fail? Hibbs and Locking blame the turn towards equal pay for all.[27] They suggested that the positive effect from lower inter industry wage dispersion was significantly dampened when the policy turned towards lower intra industry wage dispersion.[28] The same effects also were at work under the decentralisation process, when both wage differences reversed, and thus, growth was not heavily affected. This is in accordance with Lindquist's presentation of the inefficiency of equal wages for different levels of labour productivity. If this is what the centralisation promoted, it will no longer be as attractive to join in the common negotiations.[29]

1.3 GOLE

We have now presented a fracture of the implications of solidaristic wage setting. But one aspect seems to be missing in the material; an evaluation of the effect of solidaristic wage setting on aggregate welfare. The reason is that until recently, no model has been designed in a way that made it possible to consider the partial *and* the general equilibrium implications of solidaristic wage setting, and the welfare effects that goes with it. In order to clarify, we need to take a de-tour.

Welfare is, at least in the stylised world of Economics, given by consumption. The consumption bundle is determined by commodity prices and income. When we are interested in what effect solidaristic wage setting has on welfare,[30] we need to look at what it does to output prices, which again are determined in coherence with production. In order to evaluate welfare implications, we need to look at compressed wages and production. For us to be able to assess what happens to production we want to have a model

[26] Olberg (2007, p. 19)
[27] Hibbs and Locking (1996)
[28] Hibbs and Locking (2000)
[29] Meidner (1993)
[30] The most obvious effect is the direct effect on the individual budgets, we will neatly avoid this issue as we consider the aggregate welfare by looking at one representative consumer. Even though there is no room for it in this thesis, our approach does allow for looking at welfare implications' for the individual consumer.

that is as realistic as possible and includes the most important factors in a unionised, open economy.

Traditionally, there have been two main, but *separate* approaches to international trade. One is comparative advantage and perfect competition, the other is increasing returns and monopolistic competition.[31]

When we want to look at an economy that is characterised by unions, market power is important. Without it, unions can not operate with union wages that are higher than non-union wages. Consequently, a model based on perfect competition is unusable to this purpose. This rules out the first approach.

The second approach, where monopolistic behavior is taken into account, the common approach has been to assume one monopolist in each market, thereby rule out the possibility of strategic behavior. This is an unrealistic assumption, and thus, this approach is not satisfactory either.

What we need is a model where we can incorporate both strategic behaviour and general equilibrium. This is the missing link that Neary (2010) addresses in the paper accurately named "Two and a half theories of trade". Neary points to that the two dominating theories do give a number of insights, and should not be underestimated, but in some respects they fall short. Evaluating welfare implications of compressed wages is, for the reasons presented above, an example of this.

At this point, we can go back to the issue of welfare and commodity prices, and give a more intuitive explanation: Compressed wages will influence good prices in two ways. Directly, through changes in production due to different production costs, and indirectly as changes in demand for goods in one sector, this in turn will influence allocation of purchases in all the other sectors. To assess welfare, we need the results from the combined effect.

Neary (2002) presented us with a tractable tool for this job: His model of general oligopolistic equilibrium, or GOLE. By allowing for each firm to be big in their market, but small in the economy, he combined strategic behaviour and a general equilibrium. The strategic behaviour allows oligopolistic implications in small markets, thus the model can encompass the oligopolistic phenomenon reciprocal dumping. In addition, the general equilibrium is affected by the strategic behaviour of the firms, but as each individual firm is assumed to be infinitesimal, they will ignore this in their decisions.

Neary has demonstrated a number of arenas to use GOLE. Within the

[31] Neary (2003a)

frames of this model, numerous extensions can be made. We will make use of two of these, both divides the economy into different sectors. Neary opened up for applying different traits to different parts of the market, and, most important to us, he demonstrated how this would play out in when there is a possibility of trade.[32] In this case the imperfect market makes trade profitable (between two identical countries) even though a trade costs give the exporting country a disadvantage. Bastos and Kreickemeier (2009) presented an extension that allowed for unions, and demonstrated the differences between a shielded and an open economy with unions. Unionised general oligopolistic equilibrium, or UGOLE was born. The particular setup of the UGOLE model we will use is developed by Kreickemeier and Meland (2011); both shielded and open sector with separate unions, all in one economy. All the results derived in this thesis, before implementing solidaristic wage setting, are the same results they found.

This model incorporates all the main factors in an economy that we are interested in when looking at welfare implications of solidaristic wage setting, which is the main mission in this thesis. But, as mentioned, the model also opens up to the possibility of achieving insights on another important area, namely how compressed wages influence the implications of globalisation. Kreickemeier and Meland (2011) gave a review of globalisation in the version of UGOLE that they generated, and in this thesis we will compare some of their results to the results derived under compressed wages.

1.4 Structure

Now that we have taken a glance on the field, we can narrow it down again. In this thesis will look on solidaristic wage setting, and the implications it has on welfare and globalisation. We will use a monopoly union model, with two types of unions, one in the shielded sector and one in the open. To implement solidaristic union wages in UGOLE, we will see what happens if both union types promote the same wage. Because of this we will, from now on, call solidaristic wage setting *union wage equalisation.* The results given in the model without union wage equalisation, will be denoted Kreickemeier-Meland results. All mentioning of union wages before we explicitly introduce union wage equalisation and UGOLE combined, (in the end of section 3),

[32] Neary (2003b, 2009), Eckel and Neary (2010)

are Kreickemeier-Meland wages. Before we derive the general equilibrium, all discussion will be concerning partial equilibrium results.

We start, in section 2, by presenting the model using all the assumptions presented by Kreickemeier and Meland (2010). Then, in section 3 we derive the partial equilibrium. We find the optimal output levels, and wages under the assumption that the competitive wage is fixed. We also find the levels of trade cost under which trade will take place. In section 4 we derive the general equilibrium, and at this point we can implement union wage equalisation. We will derive two states, the Kreickemeier-Meland equilibrium, and the union wage equalisation equilibrium. We will then look at the difference in the wages in the two models. In section 5 we insert all our obtained information into the utility functions, and assess what happens to welfare under union wage equalisation compared to Kreickemeier and Meland's model. In section 6 we look at implications of globalisation in both equilibriums. In section 7 we will discuss some of the main objection to combining wage compression and UGOLE, and finally, in section 8, we will present our concluding remarks.

Chapter 2

The Model

To be able to look at the implications of union wage equalisation, we need a framework where the market is divided into parts that are shielded from outside competition, and parts that are exposed to outside competition. We also need to allow for unions. For union wages to exceed market wages, we need market power. To evaluate welfare we need to be able to look at general equilibrium implications of wage alterations. We have argued why Peter Neary's model of General Oligopolistic Equilibrium fulfils all these criteria, and that the Kreickemeier-Meland version has all the features we need to apply this model to the topic of solidaristic wage setting.

The key factor to GOLE, is that it can encompass both partial equilibria in small markets with oligopolistic competition *and* a general equilibrium in the economy as a whole. The implications of these model characteristics, are that the firm assumes no influence on factor prices. Neary pointed out that while economists acknowledge the lack of perfect competition, there is an absence of models that take into account both the facts that firm view factor prices to be fixed, and that, due to macro level effects, they are in fact not. Neary remarks that

"Models of industrial organization typically take factor prices and aggregate income as given, and pay little attention to interactions between markets. General-equilibrium models of monopolistic competition typically ignore strategic behaviour by incumbents, and assume a perfectly elastic supply of identical new firms, ready and able to enter in response to the smallest profit opportunity."[1]

[1] Neary (2002, p.1)

Neary addressed this problem by creating a model where each firm produces goods in a market with a limited number of firms. In this market, the output level is determined by oligopolistic competition, where each firm takes the output produced by the other firms as given according to Cournot competition. Output in this market will be lower than the perfect competition level, and prices will be higher.

To make each firm conceive factor prices as exogenous, all markets need to be small enough to be negligible in the economy. This is accomplished by defining the economy as continuum of oligopolistic markets. We assume that labour is the only factor of production, and that there is no unemployment. Lower demand will decrease the wage rather than push workers out of the market; hence, the equilibrium factor price outside the unions, is the competitive wage that clears the labour market.

Changes that influence demand for labour in the unionised sectors will cause a reallocation of workers, and this will lead to changes in the wages in the non-unionised sectors. If the union wages increases, the excess workers will be pushed into the non-union sectors. Likewise, if the union wages decrease, the extra workers demanded will be drawn from the non-union sectors. This will result in a change in the market clearing wage.[2]

In the continuum of markets, each market is denoted z, where $0 < z < 1$. Every market has a limited number of producers, denoted n, and $1 < n < \infty$. The degree of market power is given by the number of firms in each sector. As n goes to infinity, production increases until it reaches the perfectly competitive level. This is an unlikely scenario, and the model will be more interesting when n is relatively small.

We divide the markets into four different sectors. Firstly we assume one part that produces tradable goods, and one that produces non-tradable goods, these will be referred to as respectively open and shielded sectors. The portion of the economy that is open is defined by α, and the portion that is shielded is $1 - \alpha$, where $0 < \alpha < 1$. Further, we assume that part of both open and shielded sectors are unionised, and to the same degree, β, where $0 < \beta < 1$.[3]

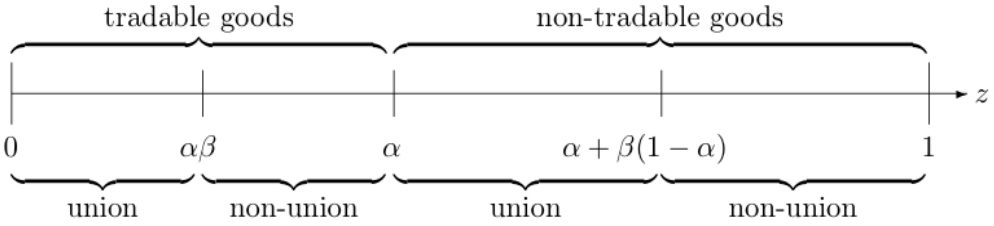
To look at the implications of trade we look at an economy consisting of

[2] This happens because we assume no unemployment. If we had allowed for unemployment, and had a lower limit to the competitive wage, (either minimum wage or reservation wage), demand changes would create changes in unemployment.

[3] Realistically, it is seldom the case that open and shielded sector has the same union density, this is an assumption made to simplify the model.

two countries, one domestic and one foreign. To simplify, we assume that the two countries are perfectly symmetric.

The economy will be sectioned like this:[4]



(2.1)

In the two unionised sectors, the unions set the wage by maximising a union rent function. There is one union in each market in the unionised sectors, and unions within each defined sectors act identically. This is a monopoly union model, and the unions single-handedly decide the wage. The firms represented by the unions hire workers so that marginal income from labour equals this wage. This way, the union indirectly controls employment through wage setting.

The unions are interested in high employment and high wages in their markets. Wages are firstly decided in the unionised sectors. Then firms in the unionised sectors choose employment given the union wage. The rest of the workers end up in the competitive sectors. Because we have assumed that all workers are employed, the competitive wage will be the wage that ensures this. The Cournot game is solved by backward induction.

2.0.1 Partial and general equilibrium effects

There are two different mechanisms that will induce changes in wages and production. They have been mentioned, but a more thorough definition is in order. The first one is the partial equilibrium effect, or more intuitively, the direct effect. This is how changes in e.g. trade cost directly affect the optimal decision for firms and unions through changing the costs. The second effect is the general equilibrium effect, this is more of an indirect effect. When a factor in the economy changes, this will lead to adjustments in all sectors.

[4]Illustration from Kreickemeier and Meland (2011)

These adjustments will rearrange labour, and in the last instance, impose changes in the wage in non-unionised sectors. Production and wages in all sectors depend on the competitive wage, and will be indirectly affected. The direction of this effect is, contrary to partial equilibrium effects, influenced by the relative sizes of the sectors. General equilibrium effects can also originate from changes in sector sizes.

An intuitive insight that might come in handy later on is the difference in how wages are determined in the unionised versus the non-unionised sectors. In the unionised sector, the wage is decided based on a balance between the wage level and the employment level. When the unions are satisfied, the "left over" workers will end up in the non-unionised sectors, and the amount of workers here will determine the competitive wage.

2.1 Preferences

Individual utility is a function of the continuum of goods consumed. Neary (2002) argues that a quadratic utility function is the most convenient one, because it assures a demand curve that is conceived to be linear by producers. Models with linear demand are easy to solve in partial equilibrium, and one avoids problems with non-monotonic reaction functions.

The utility function is

$$u(z) = ax(z) - \frac{1}{2}b(x(z))^2, \tag{2.2}$$
$$U = \int_0^1 (u(z))\, dz.$$

This is a version of utility in Gorman polar form. When we assume this form, we can treat the aggregated utility as if it were the utility of one single, representative individual.

$x(z)$ indicates the amount of good z consumed by a representative individual. The amount of goods consumed will vary from market to market as prices will differ across the sectors. $u(z)$ represents the utility gained from consumption in market z. Marginal utility declines with consumption.[5] The

[5] A quadratic function has the trait that it decreases after maximum. Using this kind of function to illustrate utility implies that after the maximum, marginal utility decreases per extra unit consumed. We must ensure that the consumption level derived in the model

aggregate utility U is determined by taking the integral of utility across all markets of the economy.

The maximal amount of goods consumed is given by the budget constraint. We assume no saving, thus income I must equal price multiplied by quantity consumed throughout the continuum of sectors.

$$I = \int_0^1 \left(p\left(z\right) x\left(z\right)\right) dz. \tag{2.3}$$

To find the optimal level of consumption in each market, we use the Lagrangian method, and from this we find the inverse demand function and the marginal utility of income λ. Optimising[6]

$$\int_0^1 \left(ax\left(z\right) - \frac{1}{2} b \left(x\left(z\right)\right)^2\right) dz - \lambda \left(\int_0^1 \left(p\left(z\right) x\left(z\right)\right) dz - I\right)$$

yields

$$p\left(z\right) = \frac{a - bx\left(z\right)}{\lambda}, \tag{2.4}$$

$$\lambda = \frac{a\mu - Ib}{\sigma^2}, \tag{2.5}$$

where μ is the integral of prices, and thus represents the price level. σ^2 is the second moment of prices and, represents price variation between the sectors.

$$\mu = \int_0^1 p\left(z\right) dz, \tag{2.6}$$

$$\sigma^2 = \int_0^1 \left(p\left(z\right)\right)^2 dz. \tag{2.7}$$

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is realistic in the respect that it always gives the individual positive marginal utility. This is achieved as long as consumption never exceeds the level that gives the highest possible level of utility.

$$x\left(z\right) = \frac{a - p\left(z\right)\lambda}{b} < \frac{a}{b} = \arg\max_x u\left(x\right)$$

This is guaranteed as no market will exist as long as the price is negative, and because marginal utility of income can never be negative.

[6]The utility function is concave in $x\left(z\right)$, and the budget restraint is linear in $x\left(z\right)$. We can use the rule that the sum of a concave and a linear expression yield a concave function, therefore we know we have found a maximum.

To be more technically precise, μ is the first moment of prices. It represents the aggregate price level in the economy, and portrays somewhat the same as, and acts like, the average price. μ provides information on changes in the price level in the economy when factors change in the model, and enables us to evaluate the effect of higher or lower price level. The marginal utility of income depends positively on the price level. Higher price level gives lower utility, and thus higher *marginal* utility.

This is because the marginal utility of income decreases when utility increases. Because higher price level makes the consumer worse off, marginal utility increases.

Correspondingly, σ^2 is the second moment of prices, and may be used as a parameter for the variance in prices. Neary (2002), quite accurately, calls this the un-centered variance of prices. Two different changes in the economy will cause σ^2 to change. Because it is indeed un-centered, higher prices will create a higher σ^2. Further, because the price is squared, larger difference in prices across the market will cause σ^2 to rise. As we will demonstrate, we can derive a simple expression that represents the price level. This will come in handy as it gives us the opportunity to filter out the pure effect of a change in the *variance* of prices. The marginal utility of income depends negatively on the un-centered variance of prices because price variance makes the consumer better off, and decreases the extra utility obtained by the last income spent. As will become apparent, the un-centered variance of prices is the key factor to consumer utility in this model.

From the consumers' point of view, λ represents the general equilibrium effect from prices all the other sectors on consumption in the last sector. If prices increase in all markets but one, the consumer would still adjust consumption in the last market. This happens because a bigger portion of the income would be spent in the other markets. λ is positive, so $a\mu - Ib > 0$.

This all adds up to a demand function, (2.4), that increases with a, and decreases with b, $x(z)$ and λ. As each producer in the economy is big in their market, they will be able to influence prices via production. As we defined them to be small in the economy, we have assumed that they perceive to have no influence on I, μ or σ^2. Therefore, the firms will perceive λ to be fixed, and product demand as linear.

Because demand always depends on what happens in the other markets, all prices and wages will depend on λ. As long as we are operating within partial equilibrium, where λ is treated as an exogenous parameter, we will not discuss the implications of this.

2.2 Indirect utility

The indirect utility function that we are about to derive, plays a central part in this thesis. It provides us with a seemingly simple measure of consumer welfare, however the mechanics behind it are complex, and we will now present them thoroughly. Before doing this, one thing should be pointed out. Welfare depends on income, and in this model, income is, even though we do not explore it, an endogenous variable. When we look at the utility of a representative individual, we look at the aggregate welfare. Implementing union wage equalisation means lower income to some consumers, and higher income to some. This means that the direction of the welfare effect on the representative individual does not necessarily reflect the welfare effect on the individual.

From the utility function (2.2), we can derive the indirect utility by substituting for consumption from (2.4). Inserting for (2.7) yields

$$U = \frac{a^2 - \lambda^2\sigma^2}{2b}. \tag{2.8}$$

(See appendix, A.1.1)

Utility depends negatively on marginal utility of income, again this is because of diminishing marginal utility. Inserting for λ gives us

$$\tilde{U} = \frac{1}{2b}\left(a^2 - \frac{(a\mu - Ib)^2}{\sigma^2}\right). \tag{2.9}$$

At this point, we have obtained two expressions for the indirect utility. (2.8) depends on a product of two endogenous variables, $\lambda^2\sigma^2$, and (2.9) depends on three separate endogenous variables, μ, I and σ^2. Later on, we will use $\lambda^2\sigma^2$ to evaluate the welfare effect of union wage equalisation, therefore, we need to consider the relationship between welfare and the un-centered variance of prices.

Firstly we derive the difference in utility solely brought forward by a change in the un-centered price variance, from (2.8) , ignoring $\frac{\partial\lambda}{\partial\sigma^2}$. We find that by considering only this aspect of welfare change when prices change, higher price variance gives a lower utility.

$$\frac{\partial U}{\partial\sigma^2} = -\frac{\lambda^2}{2b} < 0.$$

But prices are not the only factor changed by union wage equalisation; as prices change, the marginal utility of income, λ, will be affected. By looking at (2.9), and by deriving the effect of a change in σ^2 in this expression we find that utility is affected positively when the un-centered variance of prices increases.

$$\frac{\partial \tilde{U}}{\partial \sigma^2} = \frac{(a\mu - bI)^2}{2b\sigma^4} > 0.$$

This important point, that the effect of higher price variance on welfare changes direction when $\frac{d\lambda}{d\sigma^2}$ is ignored, was identified by Kreickemeier and Meland (2011). Though the theoretical model functions perfectly without looking into this aspect, the bit that relates to intuitive understanding is lost when λ is not taken into account.

There are several reasons for the seemingly opposite effects from a change in the un-centered price variance. σ^2 affects utility through two different channels, directly, and through the marginal utility of income.

Let us consider the effect when the marginal utility of income is assumed to be unaffected, as shown in (2.8). When marginal utility of income is constant, the consumer must have the same marginal utility of income after the increase in σ^2, therefore, the increase must be compensated by a corresponding increase in $(a\mu - bI)^2$. Ignoring $\frac{\partial \lambda}{\partial \sigma^2}$ means ignoring the effect from all of the other markets in the equation. To make this clear, let us consider (2.5). If $\frac{\partial \lambda}{\partial \sigma^2} = 0$, then

$$\Delta (a\mu - Ib) = \Delta \sigma^2.$$

Thus, the effect of an increase in the price variance is accompanied by lower purchasing power.[7] Because σ^2 is un-centered, the increase can be interpreted as an increase of price level, as an increase in variance of prices, or both of the above. The overall result is lower welfare, but we can not know what caused this.

$\tilde{U}$ enables us to filter out the pure effect of a bigger price variance. This expression contains the first moment of prices. When $(a\mu - Ib)$ is constant and we can be sure that the increase in σ^2 is due to more differentiated prices in the sectors, the increase will lead to an increase if welfare. Kreickemeier

[7] Since we have assumed that $a\mu > bI$, we have ruled out that $(a\mu - bI)^2$ will decrease when μ decreases.

and Meland (2011) explain the opposite reactions to a change in the price variance with the fact that (2.9) incorporates general equilibrium effects, while (2.8) portrays partial equilibrium effects.

α and β determine the size of each sector, and the strength of the effect from a price change in one sector will be determined by the size of the sector. For instance, if for some reason the output price falls in the open, unionised sector, and stays put in all others, μ will be effected more if $\alpha\beta$ is large.

Even though (2.9) gives the most accurate description of welfare, (2.8) is mathematically tractable as well. As (2.8) contains fewer endogenous parameters, this is more practical to handle, and will hence forth be the used when evaluating utility.

Chapter 3

Partial equilibrium

The partial equilibrium in UGOLE, produces the same results as Naylor's previously mentioned model. When ignoring general equilibrium effects, the two models are built on the same assumptions. In UGOLE, because each firm is small in the economy, we have defined them to consider the competitive wage to be fixed. The firms will optimise production based on output in their sector. Since each firm is infinitely small in the economy, they will treat the competitive wage parametrically, and assume no influence on prices in the other sectors. Thereby, they also assume no influence on marginal utility of income, and will believe demand to be linear. In the Naylor model linear demand is an assumption.

The profit, π is maximised based on a Cournot-model. The firms consider the competitors production as given, and optimise production based on the prices of goods and production costs. We assume identical firms in the respect that they have identical production functions. They will all take into account that a marginal increase in production lowers output price, and consequently also profits from all units sold. The result is a market with less production, and therefore higher prices, than in a perfectly competitive market.

Unions will predict the firm decisions, and use this information when deciding the union wage. The unions care about two aspects, they want their members to have a high wage compared to the market wage, and they want their sector to have numerous employees. One way of portraying this, which will be used throughout this model, is

$$\Omega = \lambda(w^u - w^c)\ell(z). \tag{3.1}$$

When optimising union rents, the unions have to take into account that as

wages increase, the firms in the sector will hire fewer workers. The union will never allow for negative union rents, so the union wage will always exceed, or in extreme cases be equal to, the competitive wage. Unionised firms will have production costs given by the union wages, and firms in the competitive sectors will have production costs equal the market clearing competitive wage. This will lead to different levels of production between the unionised and the non-unionised sections of both the open and the shielded part of the economy.

The difference between the shielded and the open sector is, naturally, that while firms in shielded sector take into account only the actions of the other producers in the sector, firms in the open sector also interact with the open sector in the foreign country. In addition, the open sector faces a trade cost, t, on exports. We will use trade costs as the only indication of degree of globalisation. Another way to go about it is to evaluate degree of openness, measured by the size of the open sector.[1] This is also relevant to union wage equalisation, as the degree of openness was an important factor in implementing it. Going into this is a big project, and we will save it for another time.

An implication of considering level of trade cost to be the degree of globalisation, and designating trade costs to be the only factor that determines the degree of globalisation, is that we also assume that there are no other factors, such as politics or consumer preferences, to influence trade.

We will denote goods sold in the home sector y_1, and goods exported y_2. Foreign quanta will go by the same notation, but will be denoted with an additional asterisk.

Marginal productivity of labour is set to unity, this implies that wage equals marginal cost of production. It also implies that quantity produced by one firm, equals the number of workers hired in this firm $y_i(z) = l_i(z)$. Unions will secure their members a wage that exceeds the competitive wage, and production costs $c(z)$ will be different across the sectors accordingly.

$$c(z) = \begin{cases} w_t^u & \text{if} \quad 0 \leq z \leq \alpha\beta \\ w^c & \text{if} \quad \alpha\beta < z \leq \alpha \\ w_s^u & \text{if} \quad \alpha < z \leq \alpha + (1-\alpha)\beta \\ w^c & \text{if} \quad \alpha + (1-\alpha)\beta < z \leq 1 \end{cases} \tag{3.2}$$

The superscript u denotes unionised wage and superscript c denotes com-

[1] See Kreickemeier and Meland (2010)

petitive wage. Subscript s indicates shielded sector and subscript t indicates open sector. Corresponding notation will be used on all components that take different value in the different sectors.

Shielded sector

Firm profits are given by earnings from each output sold multiplied by quantity produced. All goods produced are sold in the domestic market. The production level is the level that maximises

$$\pi_i(z) = (p(z) - c(z)) y_i(z).$$

Each additional unit sold on the market will cause the price of the product to fall. We find that production is optimal when marginal change in revenue from the last unit produced, equals profit per unit:[2]

$$-\frac{dp(z)}{dy_i(z)} y_i(z) = p(z) - c(z).$$

Production as a function of production costs is derived by substituting for price from (2.4). We assume that there is no surplus production or demand, and aggregate consumption equals total production in the sector. To find the effect of this firm's additional production on price, we need to derive it from the price given the total production in the economy. To achieve this we substitute by $\sum_{i=1}^{n} y_i(z)$ for $x(z)$ in the inverse demand function. All firms are identical, so that in equilibrium, $\sum_{i=1}^{n} y_i(z) = ny(z)$. To attain the optimal production per firm in the shielded sector we substitute $\sum_{i=1}^{n} y_i(z)$ for $ny(z)$ and find

$$y_s(z) = \frac{a - \lambda c(z)}{b(1+n)}. \tag{3.3}$$

As the number of firms increases, the firms will predict a higher aggregate production, recognise that this means a lower market price, and the production of each firm decreases. The difference between production in the unionised and non-unionised sector will be determined by the difference in production costs.

[2] *The second order conditions confirm that we have a maximum.*

Shielded, unionised sector When we are looking at one specific sector, like we are here, all prices and production levels are determined thereafter. At this point we can exclude z from the equations, and insert for the sector-specific levels of cost and production. Whenever we go back to discussing components that are not sector-specific, we will use z to emphasize this.

The total employment in the sector equals the total output, $l_s^u = ny_s^u$. The union rent equation, (3.1) , becomes

$$\Omega_s = \lambda(w_s^u - w^c)ny_s^u.$$

Substituting for production, (3.3) , into the union rent function with production cost w_s^u, and maximising the union utility yields the optimal union wage as a function of the competitive wage.[3]

$$\lambda w_s^u = \frac{1}{2}\left(a + \lambda w^c\right). \tag{3.4}$$

Through the wage level, the union regulates the production in the sector. By imposing a union wage on the firm that is higher than the competitive wage, production in the sector falls.

Open sector

Producers in the open sector must find both the optimal amount to sell in the domestic market, and the optimal export level. Even if there were no trade cost, the firms would behave as if there were two separate markets, but, because of reciprocal dumping, their output level would increase.

The firms that produce tradable goods have two separate markets where they can obtain profits, the domestic and the foreign. In both markets, the price is influenced by foreign production. Profits equal

$$\pi_i = \left(p\left(z\right) - c\left(z\right)\right) y_{1i}\left(z\right) + \left(p^*\left(z\right) - c\left(z\right) - t\right) y_{2i}\left(z\right).$$

In the same manner as in shielded sector, the marginal revenue obtained by the last output sold must equal the profits obtained from the last output sold. In the open sector, this must apply separately both to the marginal product sold in the domestic market, and to the marginal product exported.

[3] *The second order condition confirm that we have a maximum.*

The production for the domestic market is optimal when

$$-y_{1i}(z)\frac{d(p(z))}{dy_{1i}} = p(z) - c(z)$$

and the level of export is optimal when

$$-y_{2i}(z)\frac{d(p^*(z))}{dy_{2i}} = p^*(z) - c(z) - t.^4$$

We can see that the firm will make separate production decisions in the two markets. Exports are more costly because of the trade cost, and when foreign prices equal domestic prices, the level of exports will be the lower of the two. By the same principle as in the shielded sector, but now with additional export, we use $x(z) = \sum_{i=1}^{n} y_{1i} + \sum_{i=1}^{n} y_{2i}^*$ in the domestic, inverse demand function(2.4) to derive the effect of a marginal change in production. Similarly we insert for $x(z) = n(y_1(z) + y_2^*(z))$ before solving for the optimal level of domestic production.

The foreign inverse demand is equivalent to domestic inverse demand. Likewise, the procedure to obtain the optimal exports is equivalent to obtaining optimal domestic production. Optimal domestic production and export depends on the foreign output in both markets. The optimal levels are

$$\begin{aligned} y_{1i}(z) &= \frac{a - \lambda c(z)}{(n+1)b} - y_2^*(z)\frac{n}{(n+1)}, \\ y_{2i}(z) &= \frac{a - \lambda(c(z) + t)}{(n+1)b} - y_1^*(z)\frac{n}{(n+1)}. \end{aligned} \tag{3.5}$$

From these equations, we can observe how foreign competition influence domestic production. Foreign export, $y_2^*(z)$, is import in the domestic market. Production in the domestic market, $y_{1i}(z)$, decrease as import increases. More imports will still lead to an increase in the total amount of goods in the home market. This is evident as $y_{1i}(z)$ decreases by less than the extra import:

$$-\frac{d}{dy_2^*}y_{1i}(z) = \frac{n}{(n+1)} < 1.$$

[4] *Because the markets are separate, so are the optimalisation problems. The second order conditions confirm that we have maximums in both cases.*

The increase of total amount of goods is caused by reciprocal dumping. By using the assumption of symmetry, we can insert the foreign equivalents of y_1 and y_2. We now have the Cournot-Nash equilibrium of goods sold at home, and exports.

$$y_{1i}(z) = \frac{a + \lambda\left(n\left(c^*(z) + t\right) - c(z)(1+n)\right)}{(2n+1)b}, \tag{3.6}$$
$$y_{2i}(z) = \frac{a + \lambda\left(nc^*(z) - \left(c(z) + t\right)(n+1)\right)}{(2n+1)b}.$$

At this point we can find the aggregate production in firms in the open sector.

$$y_t(z) = y_{1i}(z) + y_{2i}(z) = \frac{2a - \lambda t - 2\lambda c(z)(n+1) + 2n\lambda c^*(z)}{(2n+1)b}. \tag{3.7}$$

Lower trade costs affect production to the domestic market negatively, because imports increase. It naturally increases exports as the cost goes down. Lower production costs leads to an increase both in exports, and in domestic sale.

Open, unionised sector

Open sector unions find their optimal union wage using the same routine as in the shielded sector, but now total employment is determined by production both in the domestic market *and* exports, $l_t^u = ny_t^u$. The union rent function, (3.1) becomes

$$\Omega_t = \lambda\left(w_t^u - w^c\right) ny_t^u.$$

By inserting for (3.7), setting $c(z) = w_t^u$ and $c^*(z) = w_t^{u*}$, and optimising,[5] we derive

$$\lambda w_t^u = \frac{2a + 2n\lambda w_t^{u*} + 2\lambda w^c(1+n) - \lambda t}{4(1+n)}. \tag{3.8}$$

After the union in the open sector has found the optimal wage based on the foreign union wage, we can use the assumption of symmetry. When

[5] The second order conditions confirm that we have a maximum.

$\lambda w_t^u = \lambda w_t^{u*}$, the optimal union wage becomes

$$\lambda w_t^u = \frac{2a + 2\lambda w^c (n+1) - \lambda t}{2(n+2)}. \tag{3.9}$$

We see in (3.9) the same pattern as we can see concerning production in the open sector; trade costs have a smaller effect on the wage than the other factors which influence the cost of production to both markets.

$$-\frac{\partial \lambda w_t^u}{\partial \lambda t} = \frac{1}{2(n+2)} > 0. \tag{3.10}$$

From (3.10), it is evident that globalisation increases the union wage in the open sector through partial equilibrium effects (i.e. if we assume that λ and w^c are exogenously given). Lower trade costs will make production in this sector increase, and thus labour demand will increase. The union will find it optimal to trade some of the additional employment for higher wages. It achieves more union rents when the marginal utility from increased wage equals marginal utility from increased employment. The result that wages increase when trade costs decrease is, as mentioned, identical to the results in Naylor's partial equilibrium model.

Symmetrical countries is a strong and unrealistic assumption, but it makes the model easily solvable. In addition, it provides us with information in the extreme case when trade occurs only because of imperfect competition in the markets. If we were to loosen this assumption, it would, to some extent be possible to predict in what direction trade would be affected. Neary (2003b) explores some implications of unsymmetrical countries in GOLE.

3.1 Comparison, wages

We have already justified union wage equalisation on the grounds that the union wage will be higher in the shielded sector. We have derived both wages, and now we can check if this is true in this model. Before doing this, one matter must be taken care of. The union wage in the opens sector depends on trade costs, while the union wage in the shielded sector does not. To be able to compare the two, we need to get rid of this parameter. As mentioned, globalisation causes the union wage in the open sector to rise. We are interested in looking at the difference caused by trade, not by additional costs in the shielded sector, so we assume the highest possible wage in open

sector, which occur when $t = 0$. Comparing the two union wages under these conditions, λw_s^u and $\lambda w_t^u|_{\lambda t=0}$, we find that the difference is

$$\lambda w_s^u - \lambda w_t^u|_{t=0} = n\frac{a - \lambda w^c}{(n+2)\,2} > 0. \tag{3.11}$$

We know that $a - \lambda w^c > 0$, otherwise there would be no production, see (3.3) . The union wage in the shielded sector is higher than the union wage in the open sector when trade costs are zero. This implies that union wages in the shielded sector will always be higher, and the gap will increase when the trade cost increase.

The lower union wage in the open sector is the result of the additional competition that comes with trade. In the open sector twice as many firms operate in the market.

The difference in production levels in the shielded sector, (3.7), and the open sectors, (3.3), is:[6]

$$y_t^c - y_s^c = \frac{a - \lambda w^c - \lambda t\,(1+n)}{b\,(2n+1)\,(1+n)}. \tag{3.12}$$

When comparing the production in the two sectors, we find that there will be more production in the open sector when λt is small. From (3.3) and, (3.5) we can see that if λt reaches the level where there is no export, production in the open sector will be equal to production in the shielded sector.[7] Thus, production can only either be equal or bigger in the open sector. This is along the lines of Brander and Krugman's theory of reciprocal dumping.

3.2 Threshold levels of trade costs

Even though we have defined one part of the market as open, the decision on whether to trade or not, lies in the hands of the firms. Of course, the unions have a finger in the pie, as they set the wage.

Huizinga (1993) was one of the first to look into output market integration, and union wages. His findings were important because he suggested that trade might be more beneficial than what had traditionally been assumed. He demonstrated how, in a shielded monopoly market with unions

[6] In order to look at the difference due to trade, not different production costs, we look at production in the two competetive sectors.

[7] Bastos and Kreickemeier (2009)

present, opening up to trade can benefit both unions and firms. Huizinga uses a case where the initial situation is one of monopoly, but the results may easily be translated to a situation with oligopoly. A couple of traits has to be present for this to apply. Firstly, the competition between firms must be Cournot style, and demand must be linear. The theory is that when the open sector in two identical countries starts to export, the quantum of output in both domestic markets will increase. He assumes no trade costs. Each firm will recognise that their own influence on the output price is smaller, and will produce more than when there was no export. Huizinga found that under trade, production increases and prices decreases, this is in line with the theory of reciprocal dumping. In addition, he found that union wage decreases. Huizinga's principle can be recognised in UGOLE model from the difference between union wage and production in the shielded, unionised sector, and in the open, unionised sector. See (3.11) and (3.12). According to Huizinga these positive results arises because the initial equilibrium originates in monopoly market, and thus is inefficient, while under trade, there are more competing firms in the market. The findings by Huizinga that is most relevant to us, is that engaging in trade will lead to lower union wages, and increased union rent.[8]

In our model, Huizinga's result does not always apply. He assumes no trade costs, while in our model, increasing trade costs will gradually devour the union rents.

We have demonstrated how the unions set the wage in the open sector, and what this wage is. But, when we derived the wage, we implicitly assumed that the unions want and are able to induce the firms to engage in trade. There is indeed a pure strategy wage game equilibrium where this is the case, but it only exists for low trade costs. Because of this, we need to put restrictions on λt. Finding the threshold level of trade costs is an untidy affair, and will be left in the appendix together with the intuition behind it. The procedure we have followed is the one used by Bastos and Kreickemeier (2009) (See A.2.1) The threshold level is

$$\lambda t^* = 4\frac{(a-\lambda w^c)(n+1)}{2n^2+7n+4+2\sqrt{2}\left(n+\frac{1}{2}\right)(n+2)}. \tag{3.13}$$

For any trade cost level below this, unions set low wages that will make firms export. Under this level, if the trade cost decrease, the unions will consider

[8] given no trade costs.

this as a cut in production costs and rise the union wage.

There exists a second threshold level of trade costs. This is the level where it is not profitable to trade when production costs are given by the competitive wage (i.e. the lowest possible level of union wage in the open sector). This level is easier to find. This is simply the level of trade cost where optimal export is zero.

$$\lambda t^{**} = \frac{a - \lambda w^c}{\lambda (n+1)}. \tag{3.14}$$

(See appendix, A.2.2)

The relationship between the two threshold levels of trade cost is determined by the higher wages faced by the firms within the union. But for the sake of clarity:

$$\lambda t^* < \lambda t^{**}.$$

As mentioned, we will operate with a economy where we assume that $\lambda t < \lambda t^*$, where it is possible to determine an equilibrium. The threshold level λt^{**}, is still useful because this expression is more orderly than the threshold level, t^*. This will come in handy because it can provide answers that will apply for this level of trade cost, and all levels of trade cost below this level. If something applies when trade costs are sufficiently low, it is adequate to a general statement that it applies when $\lambda t = \lambda t^{**}$.

Union wages, due to partial equilibrium effects, decline in λt until it reaches λt^*. The competitive wage is affected through general equilibrium effects, has a more complex relationship to λt. After deriving the general equilibrium, and finding the competitive wages we will demonstrate that in the Kreickemeier-Meland model, globalisation will always lead to an increase in competitive wage, but under union wage equalisation, there are cases where globalisation leads to a decrease in the competitive wage.

3.3 Union wage equalisation and UGOLE combined

We have now come to the point where we can merge UGOLE and union wage equalisation. The principle in union wage equalisation is to make the wage differences smaller across the sectors. One can not force the lowest wage,

namely the competitive wage, to be higher without causing unemployment. However, the union wages may be tampered with.

We have shown that the union wage in the shielded sector is higher than the union wage in the open sector. By imposing open sector union wage in the shielded, unionised sector, we achieve a solidaristic union wage structure. This change will also lead to a set of adjustments in production that will affect the competitive wage. When the union in the shielded sector have to offer their members a lower union wage in the open sector, production in the shielded, unionised sector will increase. The union in the shielded sector will find themselves receiving lower union rents, as they would prefer higher wage and lower employment. The union in the open sector will be indifferent as far as partial equilibrium effects go, but more production in the shielded unionised sector will initiate *general* equilibrium effects. We will soon look into what alterations these result in.

We have implied that the elevated union wages are made possible by the market power in the market fragments, and that the market power is weaker in the open sector because the number of firms is doubled. As long as the higher union wage in the closed sector is caused by monopolistic power, this alone may be a argument for interference.

Now that we have derived the wages in both sectors, we will use these, rather than just general production costs, to evaluate production. But, as the competitive wage will be different with and without union wage equalisation, we can not compare the two scenarios yet.

As a result of collapsing the union wages, we get an economy with only two different wages, one in the unions, and one outside the unions. All volumes unique to union wage equalisation will be denoted by an E. Whereas before, when the union in the shielded sector were allowed to choose its own preferred wage, and the sector wages were in accordance with (3.2), the economy now operates with two different wages and the following allocation.

$$c_E(z) = \begin{cases} w_E^u & \text{if} \quad 0 \leq z \leq \alpha\beta \quad \text{and} \quad \alpha < z \leq \alpha + (1-\alpha)\beta \\ w_E^c & \text{if} \quad \alpha\beta < z \leq \alpha \quad \text{and} \quad \alpha + (1-\alpha)\beta < z \leq 1 \end{cases}$$

3.3.1 Production levels in the two regimes

The production levels in the sectors are found by inserting the wages into the production function belonging to the corresponding sector. Changing

the wage in shielded, unionised sector will change production. By inserting successively (3.4) , (3.9), w^c and w_E^c into (3.3) and (3.7), we eventually get expressions for production in all sectors:

$$\begin{array}{ll}
\text{Production} & \text{Kreickemeier-Meland output} \\
\text{Union, open} & y_t^u = \frac{(2a-\lambda t-2\lambda w^c)(n+1)}{(2n+1)(n+2)b} \\
\text{Non-union, open} & y_t^c = \frac{2a-\lambda t-2\lambda w^c}{(2n+1)b} \\
\text{Union shielded} & y_s^u = \frac{a-\lambda w^c}{2b(n+1)} \\
\text{Non-union, shielded} & y_s^c = \frac{a-w^c\lambda}{b(1+n)} \\
 & \text{Union wage equalisation output} \\
\text{Union, open} & y_{tE}^u = \frac{\left(2a-\lambda_E t-2\lambda_E w_E^c\right)(n+1)}{(2n+1)(n+2)b} \\
\text{Non-union, open} & y_{tE}^c = \frac{2a-\lambda_E t-2\lambda_E w_E^c}{(2n+1)b} \\
\text{Union shielded} & y_{sE}^u = \frac{2a(n+1)+\lambda_E t-2\lambda_E w_E^c(n+1)}{2(n+2)(n+1)b} \\
\text{Non-union, shielded} & y_{sE}^c = \frac{a-\lambda w_E^c}{b(1+n)}
\end{array} \tag{3.15}$$

Preliminary, only production in shielded, unionised sector appears to have changed, but keep in mind that the competitive wage and λ will be different under union wage equalisation.

Relative production

Aside from different competitive wages with and without union wage equalisation, the only significant difference in production occurs in the unionised, shielded sector. Naturally, as wages are higher in the two unions, production will be lower there compared to the non-unionised parts.

In the open sectors, the relative relationship between production in the unionised and the non-unionised sector will stay constant, no matter what happens to wages and trade costs:

$$\frac{y_t^u}{y_t^c} = \frac{y_{tE}^u}{y_{tE}^c} = \frac{n+1}{n+2} < 1.$$

In the shielded sector without in the Kreickemeier-Meland model, the relationship between production in unionised and non-unionised sectors is completely rigid, and the difference will always be greater than in the open sector:

$$\frac{y_s^u}{y_s^c} = \frac{1}{2}.$$

The relative production does not depend on the number of firms in the sector, and there will always be produced twice the amount in the non-unionised sector compared to the unionised sector.

Now we can explore the implications of union wage equalisation:

$$\frac{y_{sE}^u}{y_{sE}^c} = \frac{\lambda_E t + 2\left(n+1\right)\left(a - \lambda_E w_E^c\right)}{2\left(n+2\right)\left(a - \lambda_E w_E^c\right)}.$$

By forcing the union in the shielded sector to use the wage optimised by the union in the open sector, the relationship between the unionised and the non-unionised sectors in the open sector becomes more complex. This is because the union wage, unlike in the Kreickemeier-Meland case, now depends on both number of firms in the market, and level of trade costs. We find that when only looking at partial equilibrium effects, globalisation will increase production in firms in the unionised sector compared to firms in the non-unionised sector. As there originally is less production in the shielded sector, the relative production gap will decrease.

$$\frac{y_{sE}^u}{y_{sE}^c}|_{\lambda_E t=0} = \frac{y_t^u}{y_t^c} = \frac{y_{tE}^u}{y_{tE}^c} = \frac{n+1}{n+2} < 1.$$

When trade costs are zero, the relationship becomes like the relationship between the unionised and non-unionised sectors in the open part of the economy. Union wage equalisation manages to some extent to internalise the effect of globalisation in the shielded sector. This is done by making the shielded union react on the globalisation by increasing wage. The result is an echo of the effect of reciprocal dumping in the shielded sector.

Chapter 4

General equilibrium

The partial equilibrium gave us the production and wages in each market of the economy. Because we have calculated the production in the different sectors, we can now move from partial equilibrium to general equilibrium. The general equilibrium in UGOLE is found when we consider each partial market as a segment in the continuum that constitutes the economy.

With no unemployment, general equilibrium must be the state where the aggregate labour force (L) equals labour demand across all sectors. We have defined labour to be equal to production, and we get:

$$\begin{aligned} L &= \int_0^1 \left(\ell(z)\right) dz \\ &= n \int_0^1 \left(y_1\left(z\right) + y_2\left(z\right)\right) dz, \end{aligned} \tag{4.1}$$

where $y_2\left(z\right) = 0$ in the shielded sectors.

As mentioned, there is a difference in how workers end up in the unionised versus the competitive sectors. Unions will always offer wages higher than the competitive wage, and will therefore have the opportunity to choose any number of workers. When firms in the unionised sectors have all the workers they wish for in accordance with their optimisation problem, the rest of the workers are distributed in the two sectors with competitive wages. The amount of workers in each of these two sectors is determined by trade costs and by the degree of export. The competitive wage takes on the level that enables the firms in the competitive sectors to hire all workers that are pushed out from the unionised sectors. In this manner the competitive

wage is a product of all the other factors of the economy, thereof the general equilibrium effect. As costs in all the part of the economy are dependent on the competitive wage, a change in one part of the market will create a spiral of adjustments.

4.0.2 Numeraire, or no numeraire

At this point we have obtained a model where production is homogenous in three prices: Trade cost, the competitive wage, and the inverse of the marginal utility of income,[1] see (3.15). This applies both in the Kreickemeier Meland output levels, and in the union wage equalisation output levels. While t and w^c are prices in the standard meaning, λ^{-1} is the marginal cost of utility. At this point in the model presentation all present papers on GOLE and UGOLE choose a numeraire. The most convenient price to normalise is λ^{-1} because this consequently occurs together with the two other prices. Because λ^{-1} is no ordinary price, this normalisation will lead to different interpretations of the other prices. Wages become what Neary (2007) calls "wages deflated by the marginal cost of utility". Under normalisation, the interpretation of the output prices and trade costs, changes to prices and costs at the margin.

In this thesis, mathematically, it mostly does not make a difference to bring λ along. Because the interpretation changes when λ is set to unity, we will keep it in order to simplify the intuitive bit. There are some exceptions, because λ will be different in the two regimes, there are some occasions when we need to make some assumptions. When we want to demonstrate the difference between Kreickemeier-Meland results and union wage equalisation results, λ and λ_E will be two unknown variables that prevent us from reaching a conclusion. We will present a way to solve these problems when we get to them.

The real wage is the wage deflated by the average price level, $\left(\frac{w\lambda}{\mu\lambda} = \frac{w}{\mu}\right)$. A point that can be made knowing this, even though retrospect, is that when we looked at $-\frac{d\lambda w_l^u}{d\lambda t}$, we did not look at nominal sizes, but how the wage *at the margin* is affected by a change in trade costs *at the mar*gin. This does not give a good intuitive understanding of what actually happens. However, this turns out not to be very problematic. If we instead look at how the real wage is affected by changes in the real trade costs, we find the same answer.

[1] Kreickemeier and Meland (2011)

We will demonstrate this after we have derived the aggregate price level.

Even though $w\lambda$ is not the true real wage, but it will behave like the true real wage. This means that we can discuss the changes as changes in the real wage, from a marginal change in the real trade cost.

4.1 The competitive wage in the two regimes

Total production is dependent on production in each sector and the size of the sectors. The sectors are represented as different parts of the integral, according to the illustration, (2.1). To find the total production, we multiply by the number of firms.

$$L = n\left(\int_0^{\alpha\beta} y_t^u dz + \int_{\alpha\beta}^{\alpha} y_t^c dz + \int_{\alpha}^{\alpha+(1-\alpha)\beta} y_s^u dz + \int_{\alpha+(1-\alpha)\beta}^{1} y_s^c dz\right).$$

4.1.1 The competitive wage in the Kreickemeier-Meland model

As we already have determined the production specific to all sectors (3.15), we will insert for the Kreickemeier-Meland production levels:

$$\begin{aligned}\frac{L}{n} = {} & \alpha\beta\left(\frac{(2a-\lambda t-2\lambda w^c)(n+1)}{(2n+1)(n+2)b}\right) + \alpha(1-\beta)\left(\frac{(2a-\lambda t-2\lambda w^c)}{(2n+1)b}\right) \\ & + (1-\alpha)\beta\left(\frac{(a-\lambda w^c)}{2(n+1)b}\right) + (\alpha-1)(\beta-1)\left(\frac{(a-\lambda w^c)}{b(1+n)}\right).\end{aligned}$$

By definition, this is the equilibrium where all workers are employed. This allows us to use this equation to solve for the competitive wage that clears the market.

$$\lambda w^c = a - 2(n+1)\left(\lambda t\frac{\alpha(2+n-\beta)}{K} + Lb\frac{(5n+2n^2+2)}{Kn}\right), \qquad (4.2)$$

where

$$K \equiv 2(2+2\alpha-\beta(1+\alpha))+n(10+2\alpha-(5-\alpha)\beta)+n^2(4-2\beta(1-\alpha)) > 0.$$

We can now look at general equilibrium effects that influence the economy through the competitive wage.

$$-\frac{d\lambda w^c}{d\lambda t} = 2\left(n+1\right)\frac{\alpha\left(2+n-\beta\right)}{K}. \tag{4.3}$$

We find that globalisation will make the competitive wage rise. This is because the in the unionised, open sector will increase production and draw labour from the competitive sector, thereby increasing the competitive wage.

A larger aggregate workforce (an increase in L) will lower the wage in the competitive sectors as the extra workers will accumulate there. A higher b will work much in the same way as a higher L because when consumers purchase less, there will be less production, and reduced demand for labour. As the effects are caused by the same mechanism, both will later be referred to as demand adjusted workforce.

4.1.2 The competitive wage under union wage equalisation

We find the competitive wage under union wage equalisation in the same manner as before, by deriving it from a state of general equilibrium, using (3.15) . We get

$$\begin{aligned}\frac{L}{n} = {} & \alpha\beta\left(\frac{\left(2a-\lambda_E t-2\lambda_E w_E^c\right)\left(n+1\right)}{\left(2n+1\right)\left(n+2\right)b}\right)\\ & +\alpha\left(1-\beta\right)\left(\frac{\left(2a-\lambda_E t-2\lambda_E w_E^c\right)}{\left(2n+1\right)b}\right)\\ & +\left(1-\alpha\right)\beta\left(\frac{2a\left(n+1\right)+\lambda_E t-2\lambda_E w_E^c\left(n+1\right)}{2\left(n+2\right)\left(n+1\right)b}\right)\\ & +\left(\alpha-1\right)\left(\beta-1\right)\left(\frac{\left(a-w_E^c\lambda_E\right)}{b\left(1+n\right)}\right),\end{aligned}$$

which gives us

$$\begin{aligned}\lambda_E w_E^c = {} & a+\lambda_E t\frac{\beta\left(2n+1+\alpha\right)-2\alpha\left(n+2\right)\left(n+1\right)}{2\left(n+2-\beta\right)\left(2n+\alpha+1\right)}\\ & -bL\frac{\left(2n+1\right)\left(n+2\right)\left(n+1\right)}{n\left(n+2-\beta\right)\left(2n+\alpha+1\right)}.\end{aligned} \tag{4.4}$$

The competitive wage under union wage equalisation increases as bL decreases, as it did before implementing union wage equalisation. The effect of globalisation on the other hand, no longer is unambiguous. Depending on the size or the sectors, the general equilibrium effect can go in both directions. This will be discussed in detail later on.

4.2 Union wages in the two regimes

Now that we have found the general equilibrium both with and without the union wage equalisation model, we can insert the two competitive wages into the union wages and compare and evaluate the effects of union wage equalisation.

4.2.1 Union wages in the Kreickemeier-Meland model

By inserting (4.2) into (3.4) we find an expression for the union wage in the shielded sector.

$$\lambda w_s^u = a - (1+n)\left(\lambda t \frac{\alpha\left(n+2-\beta\right)}{K} + Lb\frac{\left(n+2\right)\left(2n+1\right)}{Kn}\right). \tag{4.5}$$

This expression, unlike (3.4) contains trade costs, and reveals how trade costs will affect the union wage in shielded sector indirect via the competitive wage.

The union wage in shielded sector will increase as trade costs decrease. This was expected, one can easily spot from (3.4) that changes that effect w^c will influence w_s^u in the same direction.

By inserting (4.2) into (3.9) we get the union-wage in open sector.

$$\lambda w_t^u = a - \frac{\lambda t}{\left(n+2\right)2} - \frac{2\left(1+n\right)^2}{K}\left(\frac{\lambda t\alpha\left(n+2-\beta\right)}{\left(n+2\right)} + \frac{Lb\left(2n+1\right)}{n}\right). \tag{4.6}$$

When presented like this, we may observe the general equilibrium effect of trade cost on union wage as the second fraction, and the partial equilibrium effect of trade cost through the competitive wage in the third fraction. Both will give a negative effect on the union wage. The partial effect we have

discussed before. The general equilibrium effect is also negative. The reason is the same as in the shielded sector.

$$-\frac{d}{d\lambda t}\lambda w_t^u = \frac{1}{2\left(n+2\right)} + 2\left(n+1\right)^2 \alpha \frac{\left(n+2-\beta\right)}{K\left(n+2\right)} > 0.$$

It is interesting to note that the general equilibrium effect pulls in the same direction as the partial equilibrium effect that Naylor found, and that the aggregate effect in the Kreickemeier-Meland model is actually stronger.

Even though the size of the sectors does not affect the direction of the general equilibrium effect, they can influence the strength. If the open sector is small (α is small), the general equilibrium effect will be small. Further, if the open sector is sufficiently large (α is large), the general equilibrium effect from trade cost through w^c will be bigger than the partial equilibrium effect.

$$-\frac{d}{dt\lambda}w_t^u\lambda = \frac{1}{\left(n+2\right)}\left(\frac{1}{2} + 2\left(n+1\right)^2 \alpha \frac{n+2-\beta}{K}\right),$$
$$2\left(n+1\right)^2 \alpha \frac{n+2-\beta}{K}|_{\alpha=1} = \frac{1}{2}n + \frac{1}{2} > \frac{1}{2}.$$

4.2.2 The common union wage under union wage equalisation

By inserting (4.4) into (3.9) we find the union-wage with union wage equalisation.

$$\begin{aligned}\lambda_E w_E^u &= a - \frac{\lambda_E t}{2\left(n+2\right)} \\ &+ \lambda_E t \frac{\beta\left(2n+\alpha+1\right) - 2\alpha\left(n+2\right)\left(n+1\right)}{\left(n+2\right)2} \frac{\left(n+1\right)}{\left(n+2-\beta\right)\left(2n+\alpha+1\right)} \\ &- bL\frac{\left(2n+1\right)\left(n+1\right)}{n} \frac{\left(n+1\right)}{\left(n+2-\beta\right)\left(2n+\alpha+1\right)}.\end{aligned} \tag{4.7}$$

The second part is the partial effect of trade cost on the union wage, and we have established that this will always be negative. The third part is the general equilibrium effect of globalisation via λw_E^c, and this can, as mentioned be both negative and positive. The indirect effect is sufficiently

large to make sure the combined effect of globalisation always will be an increase in $\lambda_E w_E^u$.

$$-\frac{d}{d\lambda_E t}\left(\lambda_E w_E^u\right) = \frac{2\alpha n\left(n+2\right)+\alpha\left(3-\beta\right)+\left(1-\beta\right)\left(2n+1\right)}{2\left(n+2-\beta\right)\left(2n+\alpha+1\right)} > 0.$$

4.3 Union wage equalisation's effects on wages

We are now close to the point where we can compare the union-wages and the competitive wage in the Kreickemeier-Meland model, and under union wage equalisation. But because of the issue with the different marginal utility of income, we have to get a couple of things in order before we can get that far.

First, for reasons that will become apparent, we need to find the aggregate price levels, (μ and μ_E).

4.3.1 The aggregate price level

Before we can obtain the aggregate price level, we need the prices. These are found by inserting total production with the competitive wage into (2.4). We find

$$\begin{array}{lcl}
\text{Price} & & \text{Kreickemeier-Meland model} \\
\lambda p_t^u & = & a+\lambda t\frac{n(n+1)(2-\beta)(1-\alpha)}{K}-Lb\frac{4(n+1)^2}{K} \\
\lambda p_t^c & = & a+\lambda t\frac{n(n+2)(2-\beta)(1-\alpha)}{K}-Lb\frac{4(n+2)(n+1)}{K} \\
\lambda p_s^u & = & a-\lambda t\frac{\alpha(2+n-\beta)n}{K}-Lb\frac{(n+2)(2n+1)}{K} \\
\lambda p_s^c & = & a-\lambda t\frac{\alpha 2(2+n-\beta)n}{K}-Lb\frac{2(n+2)(2n+1)}{K} \\
 & & \text{Union wage equalisation} \\
\lambda_E p_{tE}^u = & & a+\frac{\lambda_E tn(n+1)(1-\alpha)}{(2+n-\beta)(2n+\alpha+1)}-\frac{bL2(n+1)^2}{(2+n-\beta)(2n+\alpha+1)} \\
\lambda_E p_{tE}^c = & & a+\frac{\lambda_E tn(n+2)(1-\alpha)}{(2+n-\beta)(2n+\alpha+1)}-\frac{bL2(n+2)(n+1)}{(2+n-\beta)(2n+\alpha+1)} \\
\lambda_E p_{sE}^u = & & a-\frac{\lambda_E t\left(\alpha\left(2n^2+4n+3-\beta\right)+(1-\beta)(2n+1)\right)n}{2(n+1)(2+n-\beta)(2n+\alpha+1)}-\frac{bL(2n+1)(n+1)}{(2+n-\beta)(2n+\alpha+1)} \\
\lambda_E p_{sE}^c = & & a+\frac{\lambda_E tn(\beta(2n+1+\alpha)-2\alpha(n+2)(n+1))}{2(n+1)(2+n-\beta)(2n+\alpha+1)}-\frac{bL(2n+1)(n+2)}{(2+n-\beta)(2n+\alpha+1)}.
\end{array} \tag{4.8}$$

The first moment of prices is found by inserting prices into their respective part of the integral in (2.6). See appendix, A.3.1.

$$\lambda\mu = \lambda_E\mu_E = a - Lb. \tag{4.9}$$

The general price level at the margin is determined solely by the difference between α and bL. More demand adjusted workers will give a lower price level, because this will give higher production. Compared to the Kreickemeier-Meland results, union wage equalisation will have no effect on the aggregate price level at the margin.

The effect of a higher price at the margin in one sector will shift demand, and the price difference will be cancelled out by corresponding lower prices at the margin in the rest of the economy. This happens no matter the size of the sectors. The reason is that high output price at the margin in one unionised sector cause low production/ labour demand. More workers will end up in the competitive sectors, wages at the margin there will decline, production will increase, and output price at the margin will go down. Lower prices at the margin in unionised sectors, mean higher prices at the margin in competitive sectors. Changes in the price at the margin forced through under union wage equalisation, is perfectly compensated for by changes in the price at the margin in the competitive sector. The general price level at the margin remains as it was.

Because prices and income are different in the two regimes, the marginal utility of income will be different. When we start comparing prices in the two regimes, we need to get around this issue. As mentioned, we have three prices in our model. Trade cost is the only one we treat as exogenous. This is a little inaccurate because the three prices will operate in interaction with each other. Therefore, one may argue that the trade costs are specific to the regimes, and that they should be denoted t_E and t.[2] Knowing this, we can assume that the real trade costs are identical in the two regimes, $\left(\frac{\lambda t}{\lambda \mu} = \frac{\lambda_E t_E}{\lambda_E \mu_E} = \tau\right)$.We have found that the aggregate price level at the margin is identical in the two regimes, and we insert for (4.9) in the parts that do not depend on endogenous sizes. We use (4.5) and (4.6), and find that the real competitive wages are

$$\frac{\lambda w^c}{\lambda \mu} = \frac{a}{(a - bL)} - 2\,(n+1)\left(\tau \frac{\alpha\,(2 + n - \beta)}{K} + \frac{Lb}{(a - bL)} \frac{(5n + 2n^2 + 2)}{Kn}\right)$$

[2]We will not actually denote trade costs according to regime. This is mostly unproblematic, and we will adress the issue when it is problematic.

$$\frac{\lambda_E w_E^c}{\lambda_E \mu_E} = \frac{a}{(a-bL)} + \tau \frac{\beta(2n+1+\alpha) - 2\alpha(n+2)(n+1)}{2(n+2-\beta)(2n+\alpha+1)} - \frac{bL}{(a-bL)} \frac{(2n+1)(n+2)(n+1)}{n(n+2-\beta)(2n+\alpha+1)}.$$

Before we go further, we will get back to the issue of changes in wages at the margin from a change in trade costs at the margin, versus changes in real sizes. We can address this issue now because at this point we have established that $\lambda\mu$ is a constant.

If we derive the change in real wages from a change in real trade costs, we find

$$-\frac{d\frac{w^c}{\mu}}{d\tau} = 2(n+1)\frac{\alpha(2+n-\beta)}{K}.$$

If we compare this to (4.3), we can confirm that the result is the same whether we look at real wage $\left(\frac{w}{\mu}\right)$, or real price at the margin, (λw) .Because wages are linear in trade cost, we get this result no matter what form of prices we convert them into.

And now back to comparing the two real competitive wages.

4.3.2 Union wage equalisation's effect on the competitive wage

When we converted the prices, the problem with the different trade cost is gone, and we can find the difference.

$$\begin{aligned}
&\left(\frac{w_E^c}{\mu_E} - \frac{w^c}{\mu}\right) \\
&= \tau \frac{2\alpha(n+n^2+1) + 2n(2-\beta) + (2-\beta(1+\alpha))}{2K} S_1 \\
&+ \frac{Lb}{(a-bL)} \frac{(n+1)(2n+1)}{K(a-bL)} S_1 \\
&> 0,
\end{aligned}$$

where

$$S_1 = \frac{\beta\left(n+2\right)\left(2n+1\right)\left(1-\alpha\right)}{\left(n+2-\beta\right)\left(2n+\alpha+1\right)} > 0.$$

We find that the real competitive wage is strictly higher under union wage equalisation. This should come as no surprise as in the Kreickemeier-Meland model, the union wage in the shielded sector was higher than union wage in open sector. Lower wages in one sector will, through partial equilibrium effects, lead to increased production and labour demand. The union will draw workers from the competitive sectors, this will make the competitive wage increase. The latter is the general equilibrium effect.

The difference between the two competitive wages decreases when the degree of globalisation increases. Under union wage equalisation, the shielded, unionised sector responds more strongly to a change in trade costs. Under this regime, a lower λt will induce a partial equilibrium effect on the wage in addition to the previous general equilibrium effect through the competitive wage. As a result the aggregate economy will be affected harder when λt changes under union wage equalisation. The competitive wage will echo the responsiveness in the rest of the economy, and thus, the competitive wage under union wage equalisation will react stronger to globalisation.

The difference also increases as the demand adjusted workforce increases. A change in Lb affects the union wage equalisation competitive wage more than it affects the competitive wage without the union wage equalisation model. Compared to the real union wage in the shielded sector (3.4) the real union wage in open sector (3.9) is more sensitive to changes in the market that affects the real competitive wage. With union wage equalisation, the open sector real union wage will be used in both sectors, and this will produce an economy where demand alterations will cause changes of a greater magnitude, than without union wage equalisation.

4.3.3 Union wage equalisation's effect on the union wages

Simple algebra will give us the order, by size, of the different real union-wages. See appendix, A.3.2

$$\frac{w_t^u}{\mu} < \frac{w_E^u}{\mu_E} < \frac{w_s^u}{\mu}.$$

By forcing shielded sector to take on the same wage as open sector, one would expect the two wages to end up somewhere between the two former union wages. This would imply that the union wage in the open sector would have to increase, and the only way this can happen, *ceteris paribus*, is by an increase in the competitive wage.

We have found that compared to an economy where both unions choose their own union wage, solidarity wages creates a higher real competitive wage, and a lower common real union wage. Union wage equalisation thus produces an economy where there is a smaller gap between the highest and the lowest wage.

Chapter 5

Welfare

We have shown that union wage equalisation has accomplished a more solidaristic wage structure. So far, so good, but what we are looking for is welfare implications. As discussed, in UGOLE, we need to look at the prices when we want to evaluate welfare.

Modified wages will cause changes in production and consequently also prices. As wages get compressed, prices in the different sectors will get compressed. A smaller variance in prices considered as an isolated event leads to lower consumer utility because the opportunity to substitute towards cheaper goods is lost. This was first demonstrated by Frederick Waugh (1944), and was at that time quite opposite to common belief. He discovered that if the consumer spent money across a series of periods, as long as the consumer has a given sum of money and is indifferent to the allocation of money spent in each period, the consumer will be better off when the price is unstable. In UGOLE, the dimension is a series of markets instead of a series of times, but the theory still applies. The theory is founded on the fact that if the demand is downward sloping in prices, the surplus lost from higher prices will always be smaller than the surplus gained from equally lower prices.

This fits to our model in both regimes. We have discussed the indirect utility function, and we found that bigger price variance increases utility *ceteris paribus*, but we concluded that mathematically, it is easier to use (2.8) where welfare depends negatively on the product $\lambda^2\sigma^2$. In order to do this, we need to find these in both regimes. For a detailed representation of how these are derived, see appendix, A.4.1.

The un-centered price variance without union wage equalisation setting is

$$\begin{aligned}\lambda^2\sigma^2 &= a\left(a-2bL\right) \\ &+\frac{\alpha\left(\left(n+2\right)^2-\beta\left(2n+3\right)\right)\left(\lambda tn\left(2-\beta\right)\left(1-\alpha\right)-bL4\left(n+1\right)\right)^2}{K^2} \\ &+\frac{\left(1-\alpha\right)\left(4-3\beta\right)\left(\lambda tn\alpha\left(2+n-\beta\right)+bL\left(n+2\right)\left(2n+1\right)\right)^2}{K^2}.\end{aligned} \tag{5.1}$$

The first part represents the whole economy, while the second part represents only the open sector, and the third part represents only the shielded sector.

Inserting for the union wage equalisation prices, gives us the second moment of prices with union wage equalisation.

$$\begin{aligned}\lambda_E^2\sigma_E^2 &= a\left(a-2bL\right) \\ &+\alpha\frac{\left(2bL\left(n+1\right)-\lambda_E tn\left(1-\alpha\right)\right)^2\left(\left(n+2\right)^2-\beta\left(2n+3\right)\right)}{\left(2+n-\beta\right)^2\left(2n+\alpha+1\right)^2} \\ &+\left(1-\alpha\right)\beta\frac{\frac{\left(\lambda_E t(2n\alpha(n+2)+(1-\beta)(2n+1)+\alpha(3-\beta))n+2bL(2n+1)(n+1)^2\right)^2}{4(n+1)^2}}{\left(2+n-\beta\right)^2\left(2n+\alpha+1\right)^2} \\ &+\left(1-\alpha\right)\left(1-\beta\right)\frac{\frac{(\lambda_E tn(2n\alpha(n+3)-\beta(2n+1)-\alpha(\beta-4))+2bL(2n+1)(n+2)(n+1))^2}{4(n+1)^2}}{\left(2+n-\beta\right)^2\left(2n+\alpha+1\right)^2}\end{aligned} \tag{5.2}$$

Like before, the first part represents the whole economy, and the second part represents only the open sector. Under union wage equalisation, the new wage in the shielded, unionised sector complicates the relationship between the two shielded sectors, and we need to present them in two parts. The third part represents the unionised shielded sector, and the forth part represents the non-unionised, shielded sector.

5.1 Does union wage equalisation enhance welfare?

Even though we have shown that utility depends positively of the un-centered variance of prices, we have also established that we can use utility at the margin to evaluate whether union wage equalisation enhances welfare. Inserting

the un-centered variance of prices into (2.8) yields the utility functions. For the sake of visualisation, the question of welfare boils down to

$$U_E - U = \frac{\lambda^2\sigma^2 - \lambda_E^2\sigma_E^2}{2b}.$$

Once again, before solving this, we need to take into account the issue with the trade cost. Because we are looking at utility, we can not simply convert into real prices. But because we have assumed $\frac{\lambda t}{\lambda \mu} = \frac{\lambda_E t_E}{\lambda_E \mu_E}$, and we have found that $\lambda\mu = \lambda_E\mu_E$, see (4.9) , we also implicitly assumed that $\lambda t = \lambda_E t_E$.

Henceforth, this assumption will be used in all calculations regarding relative utility in the two regimes. We now have two indirect utility functions that depend on the same variables, and we may solve the difference.

It can be demonstrated that $\frac{d^2}{d(\lambda t)^2}(U_E - U) < 0$, (see appendix, A.4.3) thus, we know that the difference in utility with and without union wage equalisation is concave in trade costs. Knowing this, it is evident that as long as the difference is positive for the smallest *and* the highest level of trade costs possible within this model, union wage equalisation will always give higher welfare. The threshold levels of trade costs will be different in the Kreickemeier-Meland version and in the union wage equalisation version because of the different competitive wages. All threshold levels of trade costs are found in the appendix, (A.4.2).

We find that $(U_E - U)\,|_{\lambda t=0} > 0$ and $(U_E - U)\,|_{\lambda t=\lambda t_F^*} > 0$. (See appendix, A.4.4 and A.4.5). We can conclude that union wage equalisation does in fact yield higher utility for the consumers. This applies no matter the number of firms in each sector, or the relative size of the sectors.

The reason is closely intertwined with the effect on the un-centered variance of price on utility. As we just saw, the higher welfare with union wage equalisation is brought on by lower un-centered price variance. A quick recap; union wage equalisation forces the union in the shielded sector to implement the wage from the open, unionised sector. This wage is lower than their optimal union wage. This gives a lower wage in the shielded, unionised sector, which used to be the highest wage in the economy, and higher wages in all other sectors. In other words, the wages were compressed.

Changing wages will lead to changes in production; the direction is pretty straight forward and in accordance with the direction of the wage changes in the different sectors. Intuitively it sounds plausible that compressed wages and production costs lead to compressed prices. To be certain, we will check.

To be able to look at the effect of union wage equalisation wages, we first need to rank the production in the different sectors.

We find that

$$y_t^c \geqslant y_s^c > y_t^u > y_s^u.$$

(See appendix, A.4.6)

As all sectors face the same demand function (2.4), production changes in the four sectors create price changes along the same scale, but in the opposite direction. This implies that

$$\lambda p_t^c \leqslant \lambda p_s^c < \lambda p_t^u < \lambda p_s^u.$$

Comparing these prices with union wage equalisation prices show that

$$\begin{aligned}
\lambda p_s^u &> \lambda_E p_{sE}^u \\
\lambda p_s^c &< \lambda_E p_{sE}^c \\
\lambda p_t^c &< \lambda_E p_{tE}^c \\
\lambda p_t^u &< \lambda_E p_{tE}^u.
\end{aligned}$$

(See appendix A.4.7.)

So, the highest price in the economy have decreased, whereas all of the other prices has increased. This means that the prices have indeed been compressed. This would explain the decrease in un-centered variance of prices under union wage equalisation, but, this does not give sufficient information. A decrease in aggregate price level could also be the reason for the decrease. Luckily, in addition to the price variance, we have information on the price level. We have shown that $\lambda\mu$ is unaffected by the rearrangements implemented by union wage equalisation, so the average price level is constant.

In conclusion; union wage equalisation creates lower variance in price. This alone gives lower welfare, but the positive effect on welfare through marginal utility of income is large enough to ensure that the individual will be better of.

Chapter 6

Globalisation

We will now look at what implications union wage equalisation have on the effect of globalisation. Within the UGOLE framework, globalisation can take two forms, either the trade cost diminishes, making trade more attractive, or the sector that produces tradable goods can increase in size, this can be represented by an increase in α. We have, and will, focus on lower trade costs. We will look at what happens to wages in the different sectors and welfare when trade costs sink. We have already shown Naylor's result, that partial equilibrium effects will cause the union wage to increase as trade costs decrease. We also found that union wages, both with and without union wage equalisation increase with globalisation, because the sum of partial and general equilibrium effects always yields this result. When we look at the general equilibrium effects alone, in other words, when we look at globalisation and competitive wages, the results are more complex. In the Kreickemeier-Meland model, the general equilibrium effects go in the same direction as the partial equilibrium effects. Under union wage equalisation the general equilibrium effect can, in some cases, go in the opposite direction from the partial equilibrium effects.

First, let us consider the competitive wage without union wage equalisation.

$$-\frac{d\lambda w^c}{d\lambda t} = \frac{2\alpha\left(n+1\right)\left(2+n-\beta\right)}{K} > 0.$$

The equation demonstrates that globalisation causes the competitive wage to increase, which means that the general equilibrium effect from globalisation is positive. Production in firms in the shielded sectors will not change

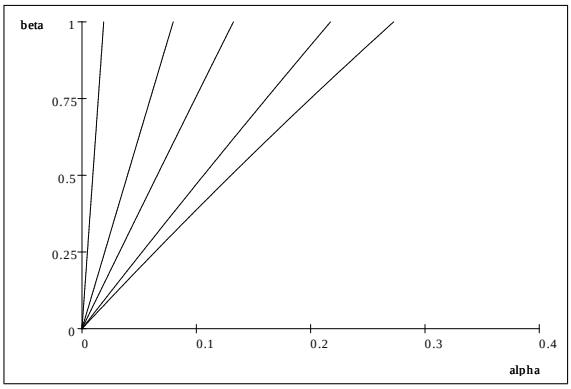
due to partial equilibrium effects, but production in firms in the open sectors will. A change in trade costs will, through partial equilibrium effects, increase production in firms in the open, unionised sector. See (3.15) .More production gives higher employment level, and this leaves less workers in the competitive sector. In the open, competitive sector, firms will also produce more, driving labour demand up further. The extra labour demand will give a higher competitive wage.

Now we will move on to the competitive wage with union wage equalisation.

$$-\frac{d\lambda_E w_E^c}{d\lambda_E t} = \alpha \frac{(n+2)(n+1)}{(n+2-\beta)(2n+\alpha+1)} - \beta \frac{1}{2(n+2-\beta)}.$$

With union wage equalisation, the competitive wage can both decrease and increase under globalisation. The explanation lies in the general equilibrium effects. The Naylor model concept that we used to derive the partial equilibrium could not find this result, as general equilibrium effects are ignored, and the competitive wage is assumed to be exogenous.

It is evident from the derivative $-\frac{d\lambda_E w_E^c}{d\lambda_E t}$, that direction of the effect will depend on the size of β and α.



The graph shows the values of α and β, where globalisation have no effect on the competitive wage for different values of n. From left to right when $n = 50$, $n = 10$, $n = 5$, $n = 2$ and $n = 1$. To the right of the graph globalisation has a positive effect on wage. When n increases, the union wages will close in on the competitive wages, and the area where the general equilibrium effect is negative will shrink.

If α is large, and β is small, the wage increases with globalisation. The reasoning is the same as in the Kreickemeier-Meland model. This always

applies as long as the open sector is larger than 27% of the economy, $\left(\alpha > \frac{3}{11}\right)$, no matter the size of the degree of unionisation, β. (See appendix A.5.1)

If α is small, and β is large, globalisation decreases the wage. As this is new to the model, it is consequently more intriguing. While a lower t still affects the competitive wage positively trough partial equilibrium effects, the general equilibrium effect is so strong that it overrules the positive partial equilibrium effect.

The general equilibrium effect is caused by changes in quanta produced in each sector, as this determines the amount labour demanded. An adjustment of trade costs increases labour demand in some sectors, while it decreases labour demand in others. The bigger the sector is, the more the effect on this particular sector will influence the economy.

So, what does it mean that α is small, and β is large? A small α means that the open sector is small, and a large β means that a big proportion of both open and shielded sectors are unionised.

Lower t will, as mentioned, give higher wages in open unionised sectors when production costs sink, see (3.10) . New to union wage equalisation is that firms in the shielded, unionised sector have the same wages, and now firms in *both* unionised sectors will wish fewer workers. This will push labour out into the non-union markets, and cause the competitive wage to drop.

When the shielded sector is sufficiently big, the positive effect on the competitive wage from higher labour demand in the open sector will be overruled by the negative effect from lower labour demand in the shielded sector. The net effect will be more workers in the competitive sectors, and lower wage.

As the number of firms increase, the market closes in on perfect competition, the union wage closes in on competitive wage. This will make the general equilibrium effects weaker, and a smaller proportion of the values for β and α will impose a higher competitive wage. The graph illustrates this point clearly.

6.1 Globalisation and welfare

By inserting the un-centered price variances (5.1) and (5.2) into the utility function (2.8), we can look at what effect globalisation has on welfare. There is no general solution that applies for all levels of trade costs, but we can find unique solution for all levels of trade costs that we allow in this model. See appendix (A.4.2) for trade costs levels.

$$-\frac{dU}{d\lambda t}|_{0<\lambda t<\lambda_E t_E^*} = -\frac{1}{2b}\frac{-d\lambda\sigma^2}{d\lambda t}|_{0<\lambda t<\lambda_E t_E^*} < 0$$

We find that globalisation will give lower consumer welfare. (See appendix A.5.2). This result was derived by Kreickemeier and Meland (2010).

$$-\frac{dU_E}{d\lambda_E t}|_{0<\lambda t<\lambda_E t_E^*} = -\frac{1}{2b}\frac{-d\sigma_E^2\lambda_E}{d\lambda_E t}|_{0<\lambda t<\lambda_E t_E^*} < 0$$

The outcome is the same under union wage equalisation. (See appendix A.5.3).

Compared to what we would realistically assume, the outcome in both regimes is the opposite of what we would expect from globalisation. Apparently, in this model, globalisation will make the un-centered variance of prices increase, and give lower welfare. Like with welfare and un-centered variance of prices, the intuition is distorted by ignoring the effect through λ. Higher price variance would give higher welfare. The reason for the lower welfare lies somewhere else, in the general equilibrium effect embedded in λ. By looking at what happens with the prices in (4.8), we can find the explanation.

First, let us consider the open sector. Globalisation will give the firms in the open sectors less production costs and less market power, production will increase, and prices will decrease.

In the shielded sector the opposite will happen. In the shielded sector, globalisation will mean higher wages, and thus, prices will increase. This does not necessarily apply for the non-unionised sector under union wage equalisation. Globalisation will influence them only through general equilibrium effects, and as shown above, the competitive wage can go in both directions depending on the size of the different sectors. This ambiguous effect is an interesting implication of union wage equalisation, but, it is not large enough to influence the final result

In short, globalisation makes the highest prices (shielded sector) higher (with the one exception), and the lowest prices (open sector) lower. This means more variance in prices, which *ceteris paribus* gives higher welfare. But, another effect through λ is so strong that it drowns out this positive effect. Like we found in the welfare argumentation, the higher price variance influences the marginal utility of income negatively. When taking this effect into account, we detect that the lower welfare from globalisation must be caused by an increase in the difference between prices and income ($a\mu - Ib$).

Chapter 7

Problems

There are three main concerns that should be mentioned when combining UGOLE and union wage equalisation. The first has to do with the structure of the unions we have to use in UGOLE, and how the common union wage decided upon. The second is tied to the UGOLE model in partial equilibrium, and the third is tied to UGOLE in general equilibrium.

7.1 The centralisation argument

So, we have found that union wage equalisation in UGOLE will give higher competitive wage and higher welfare. This sounds like the exact result that Aukrust and Lindbeck was trying to achieve. Unfortunately in UGOLE, this way of implementing solidaristic wages has one major flaw. The theory was that by making unionisation more centralised, national implications of wage setting should be taken into consideration to a much bigger extent. This has not happened, the wage is still determined, though identically, by an continuum of small unions in the open sector. Even though the new union wage does end up between the two former union wages, this is a result of general equilibrium adjustments, and not of regards for both unions' interests. A likely assumption would be that a wage set under cooperation between the two union types would, in partial equilibrium, be higher than the open union wage. How it would end up compared to the union wage equalisation wage we have derived here is hard to predict.

When using the UGOLE framework, it is impossible to assume one large union that will set the wage based on how it will influence more than one

market. This model is based on the assumption that all agents are small in the economy, and will ignore the general equilibrium effects of their behaviour, thus take the competitive wage as given. Therefore, it is impossible to solve a model where we assume a union that will operate with the best interest of both sectors in mind. Even though the outcome might not be perfect, something seems to have gone right. The new union wage does lie in between the two previous union wages. This is because of an adjusted competitive wage, and not because of more centralised wage bargaining. Despite that the union incentives in UGOLE are not spot on, they still leave us with an opportunity to evaluate the welfare effect of wages more in the direction of solidaristic wage setting than the starting point, so there is no reason to render the analysis worthless.

An argument that works in favour of our approach, is one of Moene's[1] points presented in the introduction. According to him, the union in the open sector would have to set the base for the wage negotiations, otherwise the export industry would suffer. If implementing solidaristic wage setting, in practise means letting the union in the opens sector set the wage, and then demand that the shielded sector follow suit, this is in accordance with union wage equalisation in UGOLE.

7.2 Capital flight

A drastic simplification in this model is that we assume identical countries, and no capital flight. The competitive wage is determined by labour demand, while any competition between workers is assumed nonexistent. In order to minimise costs, firms would choose the cheapest accessible production. An important implication of globalisation therefore would be that firms in unionised sectors would, if trade costs are sufficiently low, move production or part of the production abroad. This would create competition between workers. In order to avoid losing their jobs, they would accept lower wages. Even though union wage equalisation did in fact explain how globalisation in some cases would induce lower competitive wages, this result was due to shifts in labour demand within the different sectors, in cases where the higher union wage from lower production costs forced more workers into the non-unionised sector.

[1] Moene (2007)

Naylor's result, and the result found here, when union wage equalisation was not adopted, is that wages across all sectors increase when trade costs sink. An intuitively likely consequence of this will be that as firms will have higher costs, they would be inclined to look for cheaper solutions. As mentioned in the introduction, it has been demonstrated by Lommerud, Meland and Sørgard (2003) that capital flight can in fact be caused by unionisation. Their finding is that at some point, even though lower trade costs make export more profitable, if the union wage gets high enough, the foreign competition will be so strong that firms will prefer to move all production abroad.

7.3 Unemployment

We have used a framework where no unemployment is assumed. This is especially problematic because when we implement union wage equalisation, this most certainly should affect the employment level. In addition, historically, the employment level was an important argument in favour of solidaristic wage setting.

Assuming unemployment in UGOLE is fully possible, but unemployment also means that we would need to implement some form of support for the unemployed, e.g. a tax (that would affect production, and give efficiency loss), and this is problematic. In one respect, this posts no big problem. One of our important results is that welfare increases with union wage equalisation. Union wage equalisation also yields a higher competitive wage. When this wage increases it is because of higher aggregate labour demand. This would mean, if we had allowed for it, lower unemployment, and less of the efficiency distorting tax. It is a likely conclusion that this would increase welfare further.

On the matter of globalisation and welfare on the other hand, it is hard to predict how unemployment would affect the outcome. Globalisation will increase the union wage in the Kreickemeier-Meland model, and unemployment would sink. This should increase welfare, and thus the effect would go in the opposite direction of what we found. Under union wage equalisation, the effect from globalisation on the competitive wage is unambiguous, and globalisation can both increase and decrease the unemployment.

Chapter 8

Concluding remarks

In this thesis, we have tested the welfare implications of solidaristic wage setting. In addition, we have used the results to evaluate how union wage equalisation will affect the implications of globalisation. What distinguishes our approach compared to other investigations of solidaristic wage setting is that we have used a fairly new model that can encompass both strategic behaviour and general equilibrium, namely UGOLE. We have used a version of this model developed by Kreickemeier and Meland. In their framework, the economy is divided into four sectors, one open and one closed part, and within each of these there is a unionised and a non-unionised part. This framework demonstrates how oligopolistic competition will lead to reciprocal dumping and thus higher union wages in the shielded sector than in the open sector. This is one of the main arguments for imposing solidaristic wage setting.

The UGOLE setup allows us to distinguish between two different effects that influence the endogenous factors in the economy, partial and general equilibrium effects. What separates UGOLE from other general equilibrium models, is that the partial equilibrium effects spring from markets with oligopolistic competition. Each firm is small in the economy, and we assume them to consider the competitive wage as exogenous. They will optimise behaviour according to partial equilibrium conditions. General equilibrium effects will arise when the unions adjust wages and this leads the firm to change their number of employees. This will change the size of the workforce in the competitive sectors, and thus change the competitive wage. Changes in the competitive wage will create changes in all other prices and wages, this is the general equilibrium effect. When we have oligopolistic competition in the partial markets, the model can demonstrate the effect of different

degrees of market power by changing the number of firms in the market. In other monopoly models, the firm behaviour could be adjusted by considering a change in demand elasticity. This entails changing the consumer utility, and a change in this is an unlikely assumption.

Because we have chosen a path almost parallel to Kreickemeier and Meland (2011), our results have to be viewed in the light of theirs. We implemented solidaristic wages in this framework by forcing the union in the shielded sector to offer the optimal union wage for the open sector. We found that union wage equalisation leads to a union wage situated between the two Kreickemeier-Meland union wages and that the wage in the competitive sectors rose. Compared to their results, ours indicate that the aggregate welfare level increases with an solidaristic wage structure. This is in line with the ideology behind this kind of wage setting, but in the mechanics within UGOLE, the result is more unexpected. More equalised wages lead to more equal prices. In accordance with classic theory, this gives the consumers less opportunity to substitute towards the cheaper goods, thus making them worse off. However, it turns out that the general equilibrium effect of the wage compression will increase the income relative to prices. The unexpected result is that the change in wages and prices works to such an extent that it will drown out the effect of the price variance, and the aggregate utility will be higher under union wage equalisation.

We also found, like in Kreickemeier and Meland, that globalisation will give a lower level of welfare. Globalisation will increase production in the open sector relative to production in the shielded sector, thus creating larger price dispersion between the two, and higher variance of prices. This alone would give higher welfare, but globalisation will also trigger a general equilibrium effect that gives lower income relative to price level. The general equilibrium effect is larger than the partial equilibrium effect on price variance, and this is why globalisation creates a lower level of welfare.

When looking at how union wage equalisation will influence globalisation, we found one result that stood out compared to the Kreickemeier-Meland model. Without union wage equalisation, globalisation will increase production and labour demand. More labour in the unionised sectors gives less labour and higher wages in the competitive sector. Under union wage equalisation, the outcome is no longer unambiguous. In this case, the union in the shielded sector has a wage that increases with globalisation, but firms in the union have no reason, (due to partial equilibrium effects), to increase production. If this sector is big enough, the aggregate labour demand will

decrease, thus making the competitive wage decrease.

The biggest objection against UGOLE as an instrument for evaluating solidaristic wage setting, is that the union does not act on behalf of the economy as a whole, as would be plausible to assume. This is a problem because the common union wage will not be derived from the best interest of the entire economy, but only the interests of the unionised, open sector. When using UGOLE, it is impossible to fit the ideology of solidaristic wage setting into the model in a more adequate way, because, by definition, no agents in the economy will comprehend their influence on general equilibrium effects. Still, we have argued that even though we can not derive the centrally decided optimal wage, we have found, and evaluated the effect of a wage more in accordance with solidaristic wage setting. An additional argument in favour of this way of implementing solidaristic wage setting is that in order for the open sector to maintain a competitive export industry, they should set the standard for the common union wage.

A second objection, this time against UGOLE as developed so far, is that it does not take into account capital flight. If countries are not identical, globalisation would give incentives to move production to places were wages are lower, this would likely create a wage competition amongst workers.

And the last main objection; it is hard to allow for unemployment in this version of UGOLE. This is problematic because it might have given us different answers when we look at the effect of union wage equalisation on globalisation.

Further research We have analysed the welfare effects from union wage equalisation on one representative individual. This enables us to look at aggregate welfare effects. But, income will be different according to whether the individuals are capital owners or workers, and if they are workers; what sector they work in. Union wage equalisation will give the workers in the shielded, unionised sector lower wage, while the rest will receive higher wages. In addition, globalisation will influence the capital owner's income as firm profits will change. The impact of union wage equalisation and globalisation on the individual welfare varies with sector size and trade cost level, and further investigations on this individual welfare level would give some interesting, new insights.

Appendix A

Appendix

A.1

A.1.1 Deriving the indirect utility

Simplification of the indirect utility of the representative consumer is found by solving (2.4) for $x(z)$ and by inserting it into (2.2).

$$\begin{aligned} U &= \int_0^1 \left(ax\left(z\right) - \frac{1}{2} bx\left(z\right)^2 \right) dz, \\ &= \int_0^1 \left(a\frac{a-\lambda p\left(z\right)}{b} - \frac{1}{2} b \left(\frac{a-\lambda p\left(z\right)}{b} \right)^2 \right) dz = \int_0^1 \left(\frac{a^2 - \lambda^2 \left(p\left(z\right)\right)^2}{2b} \right) dz, \\ &= \frac{a^2 - \lambda^2 \left(\int_0^1 \left(p\left(z\right)\right)^2 dz \right)}{2b}. \end{aligned}$$

To simplify, we rename the integral of squared prices σ^2. The expression becomes

$$U = \frac{a^2 - \lambda^2 \sigma^2}{2b}.$$

A.2

A.2.1 Deriving the highest level of trade cost that gives an equilibrium in the model

Before going into the details, we will briefly go through the relationship between union wage in the open sector and the trade cost level. Unions whish high employment in the unionised firms, and a union wage that is high compared to the competitive wage. We see from (3.1) that rents are high when the union wage is high, or when employment is high, and of course when both are high, but that is not an option in this model.

When trade costs are low, a low union wage is the best option. This will induce high employment in the firms. The union will be better off because the high level of employment will make up for the low wage. When trade costs increase, production, and thus employment in the firms, sink, and the union will reply by slightly lowering the union wage. When the trade costs reach a certain level, employment in the firm will sink to the extent that the union will be better off by changing strategy. The new strategy is to stop holding the wage low to induce exports, instead raising the wage by a substantial amount, which would cause the firms to stop exporting, but may still be better in terms of union rent. As in Naylor (1999), there will be no equilibrium in pure strategies when there exists one-sided incentives to deviate from the 'double exports' equilibrium wage.

We will now will derive this threshold level of trade costs. There is more than one way to do this; we will use the method in Bastos and Kreickemeier (2009).

To get the notation in place: The union in open sector can choose between two strategies, a high-wage strategy, that yields utility rent level Ω_t^H, and a low wage strategy that yields utility rent level Ω_t^L. We assume symmetrical countries, thus the competitive wage is the same in both countries. When trade costs reach a certain level that we will call λt^*, the high wage strategy and the low wage strategy yields the same level of union rents. To find this trade cost level, we need to start by finding the union-rent levels.

High wage strategy

The union will choose a high wage strategy that gives the highest possible level of union rents when there is no export. The union whishes to optimise

wage when employment equals (3.5). As there is no export, $y_2 = 0$. The optimisation problem becomes

$$\Omega_t^H = \lambda(w^H - w^c)ny_1.$$

where λw^H denotes the wage in the high wage strategy. Optimising the equation yields

$$\lambda w^H = \frac{a + n\lambda\left(w^* + t\right) + \lambda w^c\left(n+1\right)}{2\left(n+1\right)}.$$

We find that this wage depends on the union wage in the foreign country. This is because if the union wage in the foreign country chooses a higher wage level, there will be less imports into the domestic market. This will increase the production, and employment in the domestic firms, and the union will implement a slightly higher union wage. Some of the additional employment will disappear, but not all, and this way the union can achieve a higher union wage and higher employment in the firms. This will give the union more union rents.

By inserting w^H into the union utility, we get the union rent level the union accomplished by the high wage strategy.

$$\Omega_t^H = \frac{\left(a + n\lambda\left(w^* + \lambda t\right) - w^c\lambda\left(n+1\right)\right)^2 n}{4\left(n+1\right)\left(2n+1\right)b}.$$

Low wage strategy

The low wage strategy is found by optimising union wage when there is export. We have assumed that λt is under the level where we can find an equilibrium, and that the union in the open sector in this model has chosen the low wage strategy. The optimal wage in this case is (3.8). Inserting this into the union utility, (3.1) when $l\left(z\right) = y_1\left(z\right) + y_2\left(z\right)$from (3.5), gives us the union rent obtained by the low wage strategy.

$$\Omega_t^L = n\frac{\left(\lambda\left(t - 2nw^*\right) + 2\lambda w^c\left(n+1\right) - 2a\right)^2}{8\left(n+1\right)\left(2n+1\right)b}.$$

How much rents the domestic union obtains from inducing trade, depends on whether or not firms in the other country will trade. We need to find the foreign union wage where both strategies give the domestic union the same

level of rents. This is obtained by setting $\Omega^L = \Omega^H$. We solve for λw^*. This gives us two solutions

$$\begin{aligned}(i):&\\ \lambda w^* &= \frac{-a+\lambda\left(t+w^c\right)(n+1)+\lambda t\frac{1}{2}\sqrt{2}\left(2n+1\right)}{n},\\ \frac{d}{d\lambda t}\lambda w^* &= \frac{\sqrt{2}+n2\left(\sqrt{2}+1\right)+2}{2n}>0\end{aligned}$$

$$\begin{aligned}(ii):&\\ \lambda w^* &= \frac{-a+\lambda\left(t+w^c\right)(n+1)-\lambda t\frac{1}{2}\sqrt{2}\left(2n+1\right)}{n},\\ \frac{d}{d\lambda t}\lambda w^* &= \frac{-\left(\sqrt{2}-1\right)(2n+1)+1}{2n}<0\end{aligned}$$

A lower λt makes exports more favourable, whilst lower λw^* makes export less favourable. To make the domestic union indifferent at this exact level of λw^*, $\frac{d}{d\lambda t}\lambda w^*$ must be negative. This occurs in (ii).

The foreign union wage (switching wage) that makes the domestic union indifferent to whether the firms exports is

$$\lambda w^* = \frac{-a+\lambda\left(t+w^c\right)(n+1)+\lambda t\frac{1}{2}\sqrt{2}\left(2n+1\right)}{n}.$$

The switching wage is increasing in trade costs. The optimal union wage under trade, (3.9), is decreasing in λt. The threshold level where the union is indifferent between diverging from inducing trade, and inducing trade is where these two wages are equal. $\lambda w_t^u = \lambda w^*$ yields

$$\lambda t^* = 4\frac{\left(a-\lambda w^c\right)(n+1)}{2n^2+7n+4+2\sqrt{2}n^2+5\sqrt{2}n+2\sqrt{2}}.$$

A.2.2 Deriving the highest level of trade costs where firms export

The firms will engage in trade as long as exports yield profits. The lowest possible wage in the economy, is the wage in the competitive sectors. We

can obtain the trade cost level where firms will trade even at the competitive wage. The optimisation problem has already given us the optimal export level (3.6). Finding the trade cost level where firms are indifferent to exporting or not, is straight forward. It is given by the level of optimal production in the open sector where $y_2 = 0$. Assuming symmetry in export and wages, and inserting for the wage in this sector, λw^c, gives us the optimal export:

$$y_{2i}(z) = \frac{a - \lambda w^c - \lambda t(n+1)}{b(2n+1)} = 0,$$

and the level where $y_{2i}(z) = 0$ is

$$\lambda t^{**} = \frac{a - \lambda w^c}{(n+1)}.$$

A.3

A.3.1 Deriving the aggregate price levels, $\lambda\mu$ and $\lambda_E\mu_E$

The aggregate price level is found by splitting up the integral, and inserting for the different prices in the different sectors.

$$\begin{aligned}
\mu\lambda &= \int_0^1 \lambda p(z)\, dz \\
&= \alpha\beta\lambda p_t^u + \alpha(1-\beta)\lambda p_t^c + (1-\alpha)\beta\lambda p_s^u + (1-\alpha)(1-\beta)\lambda p_s^c \\
&= \alpha\beta\left(a - Lb\frac{4(n+1)^2}{K} + \lambda t\frac{n(n+1)(2-\beta)(1-\alpha)}{K}\right) \\
&+ \alpha(1-\beta)\left(a - Lb\frac{4(n+2)(n+1)}{K} + \lambda t\frac{n(n+2)(2-\beta)(1-\alpha)}{K}\right) \\
&+ (1-\alpha)\beta\left(a - Lb\frac{(n+2)(2n+1)}{K} - \lambda t\frac{\alpha(2+n-\beta)n}{K}\right) \\
&+ (1-\alpha)(1-\beta)\left(a - Lb\frac{2(n+2)(2n+1)}{K} - \lambda t\frac{\alpha 2(2+n-\beta)n}{K}\right) \\
&= a - Lb.
\end{aligned}$$

We use the same procedure to obtain the union wage equalisation aggregate price level.

$$
\begin{aligned}
\lambda_E \mu_E &= \int_0^1 \lambda_E p_E(z)\, dz \\
&= \alpha\beta\lambda_E p_{tE}^u + \alpha(1-\beta)\lambda_E p_{tE}^c \\
&+ (1-\alpha)\beta\lambda_E p_{sE}^u + (1-\alpha)(1-\beta)\lambda_E p_{sE}^c \\
&= \alpha\beta\left(a + \lambda_E t \frac{n(n+1)(1-\alpha)}{(2+n-\beta)(2n+\alpha+1)} - bL\frac{2(n+1)^2}{(2+n-\beta)(2n+\alpha+1)}\right) \\
&+ \alpha(1-\beta)\begin{pmatrix} a + \lambda_E t \frac{n(n+2)(1-\alpha)}{(2+n-\beta)(2n+\alpha+1)} \\ -bL\frac{2(n+2)(n+1)}{(2+n-\beta)(2n+\alpha+1)} \end{pmatrix} \\
&+ (1-\alpha)\beta\begin{pmatrix} a - \lambda_E t \frac{(2n\alpha(n+2)+(2n+1)(1-\beta)+\alpha(3-\beta))n}{2(n+1)(2+n-\beta)(2n+\alpha+1)} \\ -bL\frac{(2n+1)(n+1)}{(2+n-\beta)(2n+\alpha+1)} \end{pmatrix} \\
&+ (1-\alpha)(1-\beta)\begin{pmatrix} a - \lambda_E t \frac{n\left(2n^2\alpha-2n\beta+6n\alpha-\beta+4\alpha-\beta\alpha\right)}{2(n+1)(2+n-\beta)(2n+\alpha+1)} \\ -bL\frac{(2n+1)(n+2)}{(2+n-\beta)(2n+\alpha+1)} \end{pmatrix} \\
&= a - Lb.
\end{aligned}
$$

We find that both in both regimes, the aggregate price level at the margin depends only on a, b and L.

A.3.2 Ranking by size the union wages in the two regimes

Now we will compare the union wages in the Kreickemeier-Meland model, and under union wage compression. Like when we looked at competitive wages, we have to compare the real union wages. Simple subtraction is sufficient to

obtain the ranking.

$$\frac{w_s^u}{\mu} - \frac{w_E^u}{\mu_E} =$$

$$\tau \frac{\left(\frac{(2n\alpha(n+1))}{(2n+\alpha+1)} + (2-\beta)\right)\left((n+2)(2n+1)(1-\beta) + \alpha\left(n+2+\beta n(2n+3)\right)\right)}{2(n+2-\beta)K}$$
$$+ \frac{bL}{(a-bL)} \frac{(n+1)(2n+1)\left((n+2)(2n+1)(1-\beta) + \alpha\left(2\beta n^2 + n + 3n\beta + 2\right)\right)}{(n+2-\beta)(2n+\alpha+1)K}$$
$$> 0.$$

$$\frac{w_E^u}{\mu_E} - \frac{w_t^u}{\mu} =$$

$$\tau \frac{\left(2\alpha n(n+1) + 2n(2-\beta) + (\alpha+1)(2-\beta)\right)\beta(n+1)(2n+1)(1-\alpha)}{2(n+2-\beta)(2n+\alpha+1)K}$$
$$+ \frac{bL}{(a-bL)} \frac{(n+1)(2n+1)\beta(n+1)(2n+1)(1-\alpha)}{(n+2-\beta)(2n+\alpha+1)K}$$
$$> 0.$$

We find that the real union wage under union wage compression will end up between the two union wages in the Kreickemeier-Meland model:

$$\frac{w_t^u}{\mu} < \frac{w_E^u}{\mu_E} < \frac{w_s^u}{\mu}.$$

A.4

A.4.1 Deriving the un-centered variance of prices, σ^2 and σ_E^2

The second moments of prices are obtained by inserting the price functions into their respective sectors.

In the Kreickemeier-Meland model, the sector wise prices that add up to the un-centered variance of prices are

$$
\begin{aligned}
\lambda^2\sigma^2 &= \int_0^1 \left(\lambda p\left(z\right)\right)^2 dz \\
&= \alpha\beta\left(\lambda p_t^u\right)^2 + \alpha\left(1-\beta\right)\left(\lambda p_t^c\right)^2 + \left(1-\alpha\right)\beta\left(\lambda p_s^u\right)^2 + \left(\alpha-1\right)\left(\beta-1\right)\left(\lambda p_s^c\right)^2 \\
&= \alpha\beta\left(a - Lb\frac{4\left(n+1\right)^2}{K} + \lambda t\frac{n\left(n+1\right)\left(2-\beta\right)\left(1-\alpha\right)}{K}\right)^2 \\
&+ \alpha\left(1-\beta\right)\left(a - Lb\frac{4\left(n+2\right)\left(n+1\right)}{K} + \lambda t\frac{n\left(n+2\right)\left(2-\beta\right)\left(1-\alpha\right)}{K}\right)^2 \\
&+ \left(1-\alpha\right)\beta\left(a - Lb\frac{\left(n+2\right)\left(2n+1\right)}{K} - \lambda t\frac{\alpha\left(2+n-\beta\right)n}{K}\right)^2 \\
&+ \left(\alpha-1\right)\left(\beta-1\right)\left(a - Lb\frac{2\left(n+2\right)\left(2n+1\right)}{K} - \lambda t\frac{\alpha 2\left(2+n-\beta\right)n}{K}\right)^2,
\end{aligned}
$$

and this collapses into

$$
\begin{aligned}
\lambda^2\sigma^2 &= a\left(a-2bL\right) \\
&+ \frac{\alpha\left(\left(n+2\right)^2 - \beta\left(2n+3\right)\right)\left(t\lambda n\left(2-\beta\right)\left(1-\alpha\right) - bL4\left(n+1\right)\right)^2}{K^2} \\
&+ \frac{\left(1-\alpha\right)\left(4-3\beta\right)\left(bL\left(n+2\right)\left(2n+1\right) + \alpha tn\left(2+n-\beta\right)\right)^2}{K^2}.
\end{aligned}
$$

The first part represents the whole economy. In the two shielded sectors, the prices will behave similar enough for us to collapse them into the second part. The two open sectors will also behave fairly similar, and collapses into the third part.

Under union wage equalisation the sector wise prices that add up to the un-centered variance of prices are

$$
\begin{aligned}
\lambda_E^2\sigma_E^2 &= \int_0^1 \left(\lambda_E p_E\left(z\right)\right)^2 dz \\
&= \alpha\beta\left(\lambda_E p_{tE}^u\right)^2 + \alpha\left(1-\beta\right)\left(\lambda_E p_{tE}^c\right)^2 \\
&+ \left(1-\alpha\right)\beta\left(\lambda_E p_{sE}^u\right)^2 + \left(1-\alpha\right)\left(1-\beta\right)\left(\lambda_E p_{sE}^c\right)^2 \\
&= \alpha\beta\left(a + \lambda_E t\frac{n\left(n+1\right)\left(1-\alpha\right)}{\left(2+n-\beta\right)\left(2n+\alpha+1\right)} - bL\frac{2\left(n+1\right)^2}{\left(2+n-\beta\right)\left(2n+\alpha+1\right)}\right)^2 \\
&+ \alpha\left(1-\beta\right)\left(a + \lambda_E t\frac{n\left(n+2\right)\left(1-\alpha\right)}{\left(2+n-\beta\right)\left(2n+\alpha+1\right)} - bL\frac{2\left(n+2\right)\left(n+1\right)}{\left(2+n-\beta\right)\left(2n+\alpha+1\right)}\right)^2 \\
&+ \left(1-\alpha\right)\beta\left(\begin{array}{c} a - \lambda_E t\frac{(2n\alpha(n+2)+(2n+1)(1-\beta)+\alpha(3-\beta))n}{2(n+1)(2+n-\beta)(2n+\alpha+1)} \\ -bL\frac{(2n+1)(n+1)}{(2+n-\beta)(2n+\alpha+1)}\end{array}\right)^2 \\
&+ \left(\alpha-1\right)\left(\beta-1\right)\left(\begin{array}{c} a - \lambda_E t\frac{n(2n(n\alpha-\beta)+6n\alpha+4\alpha-\beta-\beta\alpha)}{2(n+1)(2+n-\beta)(2n+\alpha+1)} \\ -bL\frac{(2n+1)(n+2)}{(2+n-\beta)(2n+\alpha+1)}\end{array}\right)^2.
\end{aligned}
$$

This collapses into

$$
\begin{aligned}
\lambda_E^2\sigma_E^2 &= a\left(a-2bL\right) \\
&+ \alpha\frac{\left(2bL\left(n+1\right)-\lambda_E tn\left(1-\alpha\right)\right)^2\left(\left(n+2\right)^2-\beta\left(2n+3\right)\right)}{\left(2+n-\beta\right)^2\left(2n+\alpha+1\right)^2} \\
&+ \left(1-\alpha\right)\beta\frac{\frac{\left(\lambda_E t(2n\alpha(n+2)+(1-\beta)(2n+1)+\alpha(3-\beta))n+2bL(2n+1)(n+1)^2\right)^2}{4(n+1)^2}}{\left(2+n-\beta\right)^2\left(2n+\alpha+1\right)^2} \\
&+ \left(1-\alpha\right)\left(1-\beta\right)\frac{\frac{\left(\lambda_E tn(2n\alpha(n+3)-\beta(2n+1)-\alpha(\beta-4))+2bL(2n+1)(n+2)(n+1)\right)^2}{4(n+1)^2}}{\left(2+n-\beta\right)^2\left(2n+\alpha+1\right)^2}.
\end{aligned}
$$

here too, the first part represents the whole economy, and the components that represents the shielded sector collapses into the second part. Because we have imposed an "unnatural" wage into the open, unionised sector, the two open sectors can no longer be collapsed into one part. The third part represents the open, unionised sector, and the fourth part represents the open competitive sector.

A.4.2 Regime specific threshold levels of trade costs

We have found two partial equilibrium threshold level of trade costs, λt^* and λt^{**}. Because the expressions we obtained depend on the competitive wage, it will be different in the two regimes.

We start with the lowest threshold level λt^*, from (3.13). We find the levels in the two regimes by inserting for λw^c and $\lambda_E w_E^c$ from (4.2) and (4.4). Because these depend on trade costs, we need to solve for λt and $\lambda_E t_E$ again. This way, we obtain the union threshold trade cost in the Kreickemeier-Meland model,(λt^*), and with union wage equalisation ($\lambda_E t_E^*$):

$$\lambda t^* = \frac{8Lb\,(2+n)\,(2n+1)\,(n+1)^2}{n\left(\left(\sqrt{2}+1\right)\left(2n^2+3n+2\sqrt{2}\,(n+1)\right)K - 8\alpha\,(n+1)^2\,(n+2-\beta)\right)}, \tag{A.1}$$

$$\lambda_E t_E^* = \frac{4L\,(n^2+2n+1)\,b}{\left(1+\sqrt{2}\right)\left(2n\,(n-\beta)+(1+\alpha)\,(3n-\beta)+4\alpha+2\sqrt{2}\,(1-\alpha)\,(n+1)\right)n}.$$

If we compare the threshold levels we find that

$$\lambda t^* - \lambda_E t_E^* = \frac{\frac{Lb4\left(\sqrt{2}-1\right)\beta(1-\alpha)}{n\left(2\left(\sqrt{2}-1\right)(2-\beta)(1-\alpha)(n+1)+K\right)}\left(n\left(2n-1+2\sqrt{2}\right)+2\left(\sqrt{2}-1\right)\right)(n+1)^2}{\left(n\alpha\left(3-2\sqrt{2}\right)+2n\,(n-\beta)+2\alpha\left(2-\sqrt{2}\right)+3n-\beta\,(\alpha+1)+2\sqrt{2}\,(n+1)\right)} > 0.$$

These threshold levels spring from the actions of the unions in the open sector. The only factor that separates the union wage in the open sector in the two regimes, is the different competitive wage, (both use (3.9)) This union wage increases with the competitive wage. Because the competitive wage is higher under union wage equalisation, production is more costly. This implicates that the firms can bear a higher trade cost without union wage equalisation, and

$$\lambda_E t_E^* < \lambda t^*.$$

The second threshold level λt^{**}, is given by (3.14). Substituting for the competitive wages, λw^c and $\lambda_E w_E^c$ then solving for λt and $\lambda_E t_E$, reveals the

threshold trade cost where firms refrain from export in the Kreickemeier-Meland model (λt^{**}), and with union wage equalisation ($\lambda_E t_E^{**}$).

$$\begin{aligned}\lambda t^{**} &= 2\left(n+2\right)b\frac{L}{\left(\left(n+2\right)\left(2-\beta\right)+n\beta\alpha\right)n},\\ \lambda_E t_E^{**} &= 2\left(n+1\right)\left(n+2\right)b\frac{L}{\left(2n\left(n-\beta\right)+6n+4-\beta-\alpha\beta\right)n}.\end{aligned} \tag{A.2}$$

Where by the same reasoning as to why $\lambda_E t_E^* < \lambda t^*$, we find that.

$$\lambda t^{**} - \lambda_E t_E^{**} = \frac{bL2\left(1+n^2+n\right)\left(1-\alpha\right)\frac{\beta(n+2)}{(2n-n\beta+n\beta\alpha+4-2\beta)}}{n\left(2n^2+2n\left(3-\beta\right)+\left(4-\beta-\alpha\beta\right)\right)} > 0,$$

$$\lambda_E t_E^* < \lambda_E t_E^{**}.$$

The relationship between λt^* and λt_E^{**} is hard to determine, but otherwise, the relationship is as follows:

$$\begin{aligned}\lambda_E t_E^* < \lambda t^* < \lambda t^{**},\\ \lambda_E t_E^* < \lambda_E t_E^{**} < \lambda t^{**}.\end{aligned}$$

The absolute lowest threshold level occurs under union wage equalisation. We need to be sure that an equilibrium exists in both regimes. This means that whenever we compare the two, we need to assume $\lambda t < \lambda_E t_E^*$.

A.4.3 Proof that $U_E - U$ is concave in λt

In order to conclude if wage equalisation giver higher welfare, we start with $\frac{\partial^2}{\partial(\lambda t)^2}\left(U_E - U\right)$. According to the pervious presented argumentation, we assume $\lambda t = \lambda_E t_E$. We find that the difference is concave in trade cost, and thus, as long as the expression is positive in the corner solutions, we know that it will always be positive.

Inserting for $\lambda_E^2\sigma_E^2$ and $\lambda^2\sigma^2$ into (2.8) in the two different regimes yields

$$
\begin{aligned}
&\frac{\frac{d^2}{d(\lambda t)^2}\left(U_E - U\right)}{S_2} = \\
&-4\left(\alpha+1\right)\left(2-\beta\right)\left(14\alpha+1\right)\left(1-\beta\right) \\
&-12\alpha\left(\beta\alpha\left(3-\alpha\beta\right)+\beta^2\left(2-\beta\right)+2\alpha\left(2n^4-\alpha-1\right)+\beta^2\alpha\left(1-\beta\right)+3\alpha^2\beta\right) \\
&-4n\left(7\left(1-\beta\right)\left(2-\beta\right)+\alpha\left(3-2\beta\right)\left(7\beta^2+52-39\beta\right)+2\alpha^2\beta^2\left(11-3\beta\right)\right) \\
&-4n\alpha^2\left(1-\beta\right)\left(9\left(1-\beta\right)+16\left(1-\alpha\right)+\beta\alpha\left(9-2\beta\right)+37\right) \\
&-n^2\left(1-\beta\right)\left(\beta\alpha^3\left(31-16\beta\right)+146-54\alpha^3-73\beta\right) \\
&-n^2\left(\alpha\left(4\beta^2\left(77-23\beta\right)+\left(1-\beta\right)\left(1230-347\beta\right)\right)+\alpha^2\left(262-\beta\left(33\beta+89\right)+4\beta^3\right)\right) \\
&-2n^3\left(43\left(1-\beta\right)\left(2-\beta\right)+\alpha\left(152\beta^2+\left(1-\beta\right)\left(32\beta^2+603-46\beta\right)\right)\right) \\
&-2n^3\left(\alpha^2\beta\left(1-\beta\right)\left(81-4\beta\right)+\alpha^2\left(76-9\alpha\left(1-\beta\right)\right)+12\alpha^2\beta^3+4\alpha^3\beta\left(1-\beta\right)^2\right) \\
&-2n^4\left(22\left(1-\beta\right)\left(2-\beta\right)+\alpha\left(126-8\beta^3+\left(1-\beta\right)\left(201-64\beta\right)\right)\right) \\
&-2n^4\left(2\alpha^2\left(39\beta-25\beta^2+4\beta^3\right)+\alpha^2\left(\alpha\beta+2-\alpha\right)\right) \\
&-8n^5\left(\left(1-\beta\right)\left(2-\beta\right)+\alpha\left(\beta^2+24-13\beta\right)+\alpha^2\left(7\beta-2\beta^2+1\right)\right) \\
&-8\alpha n^6\left(\alpha\beta+3-\beta\right) \\
&<0
\end{aligned}
$$

where

$$S_2 = \frac{\frac{1}{4}n\beta\left(\left(2-\beta\left(1+\alpha\right)\right)+2\alpha+2n\left(2-\beta\right)+2n\alpha+2n^2\alpha\right)}{b\left(n+1\right)^2\left(2+n-\beta\right)^2\left(2n+1+\alpha\right)^2K^2} > 0.$$

We find that $\frac{\partial^2}{\partial(\lambda t)^2}\left(U_E - U\right)$ is strictly negative.

A.4.4 Proof that $U_E - U$ is positive when $\lambda t = 0$

One corner solution is $\lambda t = 0$. We find that when there are no trade costs, union wage equalisation yields higher welfare:

$$
\begin{aligned}
&\frac{(U_E - U)\,|_{\lambda t=0}}{S_3} = \\
&+ 8\,(2-\beta)\,(1+\alpha)\,(\alpha + (1-\beta)\,(4\alpha+1)) \\
&+ n4\,(1-\beta)\left(29 - 14\beta + 6\alpha\,(19-5\beta) + \alpha^2\,(53-4\beta)\right) \\
&+ n12\alpha\beta^2\,(3\alpha+4) \\
&+ n^2 2\,(1-\beta)\,(\alpha\,(384-50\beta) + 160 - 73\beta) \\
&+ n^2 2\left(58\alpha\beta^2 + \alpha^2\left(96 - 5\beta^2 - 57\beta\right)\right) \\
&+ n^3\,(1-\beta)\,(417 - 172\beta) \\
&+ n^3\left(2\alpha\left(285 - 245\beta + 34\beta^2\right) + \alpha^2\left(73 - 44\beta^2 + 39\beta\right)\right) \\
&+ n^4 2\,(1-\beta)\,(131 - 44\beta) \\
&+ n^4 2\left(\alpha\left(96 - 26\beta - 16\beta^2\right) + \alpha^2\left(5 + 21\beta - 8\beta^2\right)\right) \\
&+ n^5 4\left((1-\beta)\,(19-4\beta) + \alpha\left(6 + 9\beta - 4\beta^2\right) + 2\alpha^2\beta\right) \\
&+ n^6 8\,(1 - \beta\,(1-\alpha)) \\
&> 0.
\end{aligned}
$$

Where

$$
S_3 = \frac{bL^2 n\beta\,(2n+1)\,(1-\alpha)}{2\,(2+n-\beta)^2\,(2n+\alpha+1)^2\,K^2} > 0.
$$

We find that $(U_E - U)\,|_{\lambda t=0}$ is strictly positive.

A.4.5 Proof that $U_E - U$ is positive when $\lambda t = \lambda t_E^*$

The other corner solution is $\lambda t = \lambda t_E^*$. This is the highest possible level of trade costs where we can obtain an equilibrium under union wage equalisation. To make the expressions more tidy we will use λt_E^{**}. We can do this because we know that $U_E - U$ is concave in trade costs. Therefore, when we know that $(U_E - U)|_{\lambda t=0} > 0$, and can prove that $(U_E - U)|_{\lambda t=\lambda_E t_E^{**}} > 0$, we can conclude that $(U_E - U)|_{0>\lambda t>\lambda_E t_E^{**}} > 0$. Thus, because $0 > \lambda_E t_E^* > \lambda_E t_E^{**}$, we know that $(U_E - U)|_{\lambda t=\lambda_E t_E^*} > 0$

When we insert for $\lambda t_E^{**}$from $(A.2)$, we find.

$$
\begin{aligned}
&\frac{\left(U_E - U\right)|_{\lambda t=\lambda_E t_E^{**}}}{S_4} = \\
&+ \left(4\left(1-\beta\right)\left(3-\beta\right)\left(2\alpha+1\right) + 4\alpha^2\left(1-2\beta\right)\left(3-2\beta\right)\right) \\
&+ 2n\left(\begin{array}{c}\alpha^2\left(16-40\beta+17\beta^2\right)+2\left(1-\beta\right)\left(20-7\beta\right)\\ +\alpha\left(\left(1-\beta\right)\left(56-23\beta\right)\right)+\alpha\beta\end{array}\right) \\
&+ n^2\left(\begin{array}{c}\left(1-\beta\right)\left(203-73\beta\right)+2\alpha\left(32\beta^2-115\beta+91\right)\\ +\alpha^2\left(27-62\beta+15\beta^2\right)\end{array}\right) \\
&+ n^3\left(\begin{array}{c}\left(1-\beta\right)\left(245-86\beta\right)+\alpha^2\left(17\beta+9-6\beta^2\right)\\ +2\alpha\left(6\beta^2+63-50\beta\right)\end{array}\right) \\
&+ n^4\left(\begin{array}{c}\left(1-\beta\right)\left(\alpha^2+145-44\beta\right)+2\alpha\left(19-2\alpha\beta^2\right)\\ +2\beta\alpha\left(11-10\beta\right)\end{array}\right) \\
&+ n^5 4\left(2\left(1-\beta\right)\left(5-\beta\right)+\alpha\left(6\beta-2\beta^2+1\right)\right) \\
&+ n^6 4\left(\alpha\beta+1-\beta\right),
\end{aligned}
$$

where

$$S_4 = \frac{L^2 b\beta 2\left(1+n+n^2\right)\left(1-\alpha\right)}{\left(2n^2+2n\left(3-\beta\right)+4-\beta-\alpha\beta\right)^2 K^2} > 0.$$

The three first parts can be both positive and negative depending on α and β. The last four parts are strictly positive. The parts that are positive, are the ones where n has the the highest exponents. We need to show that the expression is positive for any value of $n\,\epsilon\,(1,\infty)$. By taking the derivative of more than the 2^{th} order the three first paragraphs will disappear, and we know the rest of the expression is positive. We call the rest of the expression G_1. To prove that G_1 is positive we have to use the fact that if an equation is increasing in one of its component, it is enough to prove that is is positive for the smallest value of that component. Corresponding reasoning yields if an equation is decreasing in a component. If neither of these conditions are fulfilled, we have no information about the index sign of the equation.

To evaluate G_1, we start with the 3^{th} derivative.

$$\frac{d^3}{dn^3}G_1 > 0,$$

Therefore, $\frac{d^2}{dn^2}G_1$ increases as n increases, and is always positive if $\frac{d^2}{dn^2}G_1|_{n=1} > 0$

$$\frac{d^2}{dn^2}G_1|_{n=1} = \\ 2\alpha\left(828+60\alpha-\beta\left(100\beta+27\alpha\beta+119\alpha+98\right)\right) \\ +54\left(1-\beta\right)\left(84-25\beta\right) \\ >0.$$

We know that $\frac{d^2}{dn^2}G_1$ is strictly positive. This means that $\frac{d}{dn}G_1$ increases as n increases, and is always positive if it is positive when $n=1$.

$$\frac{d}{dn}G_1|_{n=1} = \\ \alpha\left(117\alpha+30\beta^2\alpha+90\beta^2+\left(1026-\beta\left(684+157\alpha\right)\right)\right) \\ +81\left(1-\beta\right)\left(25-8\beta\right)>0.$$

$\frac{d}{dn}G_1|_{n=1}$ is positive. This implies that $\frac{d}{dn}G_1$ is strictly positive, and that G_1 increase as n increase. G_1 is always positive if it is positive when $n=1$.

$$G_1|_{n=1} = 3\left(\beta-3\right)\left(81\left(\beta-1\right)+2\alpha\left(17\beta-27\right)\right)+\alpha^2\left(81+55\beta^2-158\beta\right).$$

To prove that $G_1|_{n=1}$ is positive we need to take a few more steps. We have to start with the second derivative with respect to β.

$$\frac{d^2}{d\beta^2}\left(G_1|_{n=1}\right) = 486+110\alpha^2+204\alpha>0.$$

$\frac{d^2}{d\beta^2}\left(G_1|_{n=1}\right)$ is always positive, this means that $\frac{d}{d\beta}\left(G_1|_{n=1}\right)$ increases as β increases, and is always negative if it is negative when $\beta=1$

$$\frac{d}{d\beta}\left(G_1|_{n=1}\right)|_{\beta=1} = -486-264\alpha-48\alpha^2<0.$$

$\frac{d}{d\beta}\left(G_1|_{n=1}\right)$ is always negative, so $G_1|_{n=1}$ decreases as β increases. $G_1|_{n=1}$ is always positive if it is positive when $\beta=1$.

$$G_1|_{n=1,\beta=1} = 2\alpha\left(60-11\alpha\right)>0.$$

$G_1|_{n=1}$ is therefore always positive. At this point, we can conclude that $\left(U_E-U\right)|_{\lambda t=\lambda t_E^{**}}>0$.

A.4.6 Ranking of production level in all sectors in the Kreickemeier-Meland model

First we consider production in the two unions, from (3.15).

$$\begin{aligned} & y_t^u - y_s^u \\ & = \frac{L\left(2n^2+3n+2\right)}{Kn} - \lambda t \frac{\left(n\left(2+\alpha\beta-\beta-\alpha\right)+2-\beta\right)}{Kb}. \end{aligned}$$

There is no solution that applies for all values of λt. We can see that if λt is sufficiently small, production is always bigger in the open sector. In our model we have an upper limit for λt. If we can demonstrate that production in the open sector is bigger for this level of trade costs, we can conclude that production is always higher in the open sector. Because $\left(y_t^u - y_s^u\right)|_{\lambda t=\lambda t^{**}} > 0$ implies $\left(y_t^u - y_s^u\right)|_{\lambda t=\lambda t^{*}} > 0$, we can use λt^{**} from $(A.2)$ in appendix A.4.2.

$$\begin{aligned} & y_t^u - y_s^u|_{\lambda t=\lambda t^{**}} \\ & = \frac{L}{n\beta\alpha + (2-\beta)(n+2)} > 0. \end{aligned}$$

We find that production within the unions is always higher in the open sector, than in the shielded sector:

$$y_t^u > y_s^u.$$

Next, we compare production in the two competitive sectors.

$$\begin{aligned} & y_t^c - y_s^c \\ & = L\frac{2(n+2)}{Kn} - \lambda t \frac{(2-\beta)(n+2)+n\beta\alpha}{Kb}. \end{aligned}$$

By the same reasoning as production in the unionised sector, we insert for λt^{**} $(A.2)$.

$$y_t^c - y_s^c|_{\lambda t=\lambda t^{**}} = 0.$$

At this level of trade cost, production is equal. The result should come as no surprise, as this is the threshold where firms in the open sector start to export. Thus

$$y_t^c \gtrless y_s^c.$$

As we will only allow for a level of trade cost lower than λt^{**}, namely λt^{*}, production is always higher (or equal) in the open sector.

Now we can compare the highest production level of the competitive sectors and the lowest production level of the unionised sectors.

$$\begin{aligned} y_s^c - y_t^u &= L\frac{2}{K} + \lambda t \frac{(n\beta\alpha + (2-\beta)(n+\alpha+1))}{Kb} > 0, \\ y_s^c &> y_t^u. \end{aligned}$$

We find that production is always higher in the competitive sector. And sorted by production volume, the order of the sectors is

$$y_t^c \geqslant y_s^c > y_t^u > y_s^u.$$

A.4.7 Price changes due to union wage equalisation

Obtaining the changes in prices brought forward by union wage equalisation, is straight forward calculus. Once again, we assume $\lambda t = \lambda_E t_E$

$$\begin{aligned} \lambda p_s^u &> \lambda_E p_{sE}^u \\ \lambda p_s^c &< \lambda_E p_{sE}^c \\ \lambda p_t^c &< \lambda_E p_{tE}^c \\ \lambda p_t^u &< \lambda_E p_{tE}^u. \end{aligned}$$

Because

$$\begin{aligned} \frac{\lambda_E p_{sE}^u - \lambda p_s^u}{S_5} &= -n\frac{\lambda t\,(2n\alpha\,(1+n) + (2-\beta)\,(\alpha+2n+1)) + 2Lb\,(n+1)\,(2n+1)}{2\,(n+1)\,(2+n-\beta)\,(2n+\alpha+1)\,K} \\ &< 0, \end{aligned}$$

where

$$S_5 = ((n+2)\,(2n+1)\,(1-\beta) + \alpha\,(2+n)\,(2n\beta+1) - n\alpha\beta) > 0.$$

Further

$$\begin{aligned} \lambda_E p_{tE}^u - \lambda p_t^u &= n\beta\,(1-\alpha)\,(n+1)\,\frac{\lambda t\,(2-\beta) + \frac{(2Lb(2n+1)+2\lambda tn\alpha)(n+1)}{(2n+\alpha+1)}}{(2+n-\beta)\,K} \\ &> 0, \end{aligned}$$

$$\lambda_E p^c_{tE} - \lambda p^c_t = (n+2)\, n\beta\,(1-\alpha)\,\frac{\lambda t\,(2-\beta) + 2\,(n+1)\,\frac{(bL(2n+1)+n\lambda t\alpha)}{(2n+\alpha+1)}}{(2+n-\beta)\,K}$$
$$> 0$$

and

$$\lambda_E p^c_{sE} - \lambda p^c_s = n\beta\,(n+2)\,(2n+1)\,(1-\alpha)\,\frac{\lambda t\,(2-\beta) + \frac{2(n+1)(bL(2n+1)+n\lambda t\alpha)}{(2n+\alpha+1)}}{2\,(n+1)\,(2+n-\beta)\,K}$$
$$> 0.$$

A.5

A.5.1 The smallest α where $-\frac{\partial \lambda_E w^c_E}{\partial \lambda_E t} > 0$ under union wage equalisation

The relationship between the competitive wage under union wage compression and globalisation is

$$-\frac{\partial \lambda_E w^c_E}{\partial \lambda_E t} = \frac{2\alpha\,(n^2+3n+2) - \beta\,(2n+\alpha+1)}{2\,(n+2-\beta)\,(2n+\alpha+1)}.$$

We need to find the value for α where $-\frac{\partial \lambda w^c_E}{\partial \lambda t} > 0$. First we need general statements for β and n that enables us to eliminate them.

$$\frac{\partial}{\partial \beta}\left(-\frac{\partial \lambda_E w^c_E}{\partial \lambda_E t}\right) < 0.$$

If this is positive for $\beta = 1$, it is positive for all values of β. The difference in the numerator increases with n, so if it is positive for $n = 1$, it is positive for all values of n. This means that it is sufficient for a general statement that $-\frac{\partial \lambda_E w^c_E}{\partial \lambda_E t}$ increases when $n = \beta = 1$.

$$-\frac{\partial \lambda_E w^c_E}{\partial \lambda_E t}|_{\beta=1,n=1} = \frac{1}{4}\frac{11\alpha - 3}{3+\alpha} > 0$$
$$\text{when}$$
$$\alpha > \frac{3}{11}.$$

We find that as long as the open sector is larger than approximately 27%, the competitive wage under union wage compression will always increase with globalisation.

A.5.2 The effect of globalisation on utility in the Kreickemeier-Meland model

We find that

$$-\frac{dU}{d\lambda t}|_{0<\lambda t<\lambda t_E^*} < 0,$$

which demonstrates that globalisation has a negative effect on utility in the Kreickemeier-Meland model. The effect is found by inserting (5.1) into (2.8). Then take the derivative with respect to λt.

$$\begin{aligned}
-\frac{dU}{d\lambda t} = & \\
& + \lambda t n^2 \alpha (1-\alpha) \frac{n^2 (\beta^2 (1-\alpha) + \beta\alpha + 4(1-\beta)) + (4-3\beta)(2-\beta)^2}{K^2 b} \\
& + \lambda t n^2 \alpha (1-\alpha) \frac{2n(2-\beta)(\beta^2 + (1-\beta)(\beta\alpha+4))}{K^2 b} \\
& - Lbn\alpha (1-\alpha) \frac{n^2(1-\beta) + 16(n+1)(1-\beta)}{K^2 b} \\
& - Lbn\alpha (1-\alpha) \frac{3n^2 + 2\beta(n^3-2) + \beta^2(2n^2+5n+6)}{K^2 b}.
\end{aligned}$$

There is no general solution to if welfare sinks with globalisation. We find that if trade costs are sufficiently low, the expression will be negative, and welfare will decrease as the level of globalisation increases. In this model we have limited trade costs to $0 < \lambda t < \lambda_E t_E^*$, this means that as long as this expression is negative when $\lambda t = \lambda_E t_E^*$, it will always be negative. This will also apply to λt^{**} because $\lambda_E t_E^* < \lambda t^{**}$. Because λt^{**} this expression is more tidy, we will use this instead, inserting λt^{**} from $(A.2)$ yields

$$-\frac{dU}{d\lambda t}|_{\lambda t=\lambda t^{**}} = -\frac{Ln^2\alpha\beta(1-\alpha)(n+\beta)}{K(n(n+2)(2-\beta)+n\beta\alpha)} < 0.$$

We can conclude that globalisation always gives lower welfare.

A.5.3 The effect of globalisation on utility under union wage equalisation

We find that

$$-\frac{dU_E}{d\lambda_E t}|_{0<\lambda t<\lambda_E t_E^*} < 0,$$

which demonstrates that globalisation has a negative effect on utility also under union wage equalisation. We use the same procedure as above. The effect on utility from a change in λt_E is found by inserting (5.2) into (2.8), then take the derivative with respect to λt_E.

$$-\frac{\frac{d}{d\lambda_E t}U_E}{S_6} =$$

$$\begin{aligned}
&- L\frac{\left(2n^3\alpha + 2\alpha n\left(8 - 4\beta - \beta^2\right) + \beta\left(2n+1\right)^2\left(1-\beta\right)\right)}{\left(n+1\right)} \\
&- L\frac{\left(8\alpha - \alpha\beta^2 + \alpha\left(2n^2\left(5-2\beta\right) - 5\beta\right)\right)}{\left(n+1\right)} \\
&+ \lambda t n\frac{2\beta^2\alpha\left(2n+1\right)^2 + \alpha\left(4n^4 - 3\alpha\beta\right) + 3\alpha^2\beta^2 + 4\alpha n^2\left(13 - 9\beta\right) + 2\alpha\left(8 - 7\beta\right)}{2\left(n+1\right)^2 b} \\
&+ \lambda t n\frac{8\alpha n\left(\left(6-5\beta\right) + n^2\left(3-\beta\right)\right) + \beta\left(1-\beta\right)\left(1 + 4n\left(n+1-\alpha^2\right)\right)}{2\left(n+1\right)^2 b},
\end{aligned}$$

where

$$S_6 = \frac{\left(1-\alpha\right)n}{2\left(2+n-\beta\right)^2\left(2n+1+\alpha\right)^2}$$

By the same reasoning as before; if trade costs are sufficiently low, we insert for $\lambda_E t_E^*$ from $(A.1)$, found in appendix A.4.2.

$$
\begin{aligned}
-\frac{\frac{d}{dt\lambda}U_E|_{\lambda t=\lambda_E t_E^*}}{S_7} = & \\
& -2n^3\alpha\left(3-2\sqrt{2}\right) \\
& -n^2\left(2-\sqrt{2}\right)\left(2\beta\left(2+\sqrt{2}\right)(1-\beta)+\alpha\left(10-3\sqrt{2}-4\beta\right)\right) \\
& -2n\left(\beta(1-\beta)(2+\alpha)+\alpha\left(18-10\sqrt{2}-\beta\left(9-4\sqrt{2}\right)\right)\right) \\
& -\left(8\alpha\left(2-\sqrt{2}\right)+\beta(1-\beta)-\alpha\beta\left(9-4\sqrt{2}+\beta\right)\right).
\end{aligned}
$$

Where

$$
S_7 = \frac{L(1-\alpha)\frac{n}{(n+1)(2+n-\beta)(2n+1+\alpha)}}{2\left(2n(n-\beta)+(3n-\beta)(1+\alpha)+4\alpha+2\sqrt{2}(n+1)(1-\alpha)\right)} > 0.
$$

Everything but the last part is negative. Let us call the last part G_2.

$$
G_2 = -\left(8\alpha\left(2-\sqrt{2}\right)+\beta(1-\beta)-\alpha\beta\left(9-4\sqrt{2}+\beta\right)\right).
$$

We have to start with $\frac{d^2}{d\alpha d\beta}G_2$ to prove that G_2 is negative. We find that

$$
\frac{\partial^2}{\partial\alpha\partial\beta}G_2 = 2\beta+9-4\sqrt{2} > 0.
$$

Ergo, $\frac{d}{d\alpha}G_2$ increases as β increases. This means that if $\frac{d}{d\alpha}G_2$ is negative if $\beta = 1$, it is always negative.

$$
\frac{\partial}{\partial\alpha}G_2|_{\beta=1} = 4\sqrt{2}-6 < 0.
$$

G_2 decreases when α increases. If G_2 is negative in $\alpha = 0$, it is always negative.

$$
G_2|_{\alpha=0} = -\beta(1-\beta) < 0.
$$

We can conclude that G_2 is always negative.

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