Wage Policy in a Global World

Dissertation

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Meinen lieben Eltern.

Abstract

This thesis contains an extended literature review and three essays on the interaction of globalization and wage policy, employment, income distribution and welfare. A specific focus lies thereby on the role of trade unions as one major labor market institution. A brief introductory chapter motivates the general topic before an extended literature review highlights main findings from previous studies.

The first essay sets up a multi-sector general oligopolistic equilibrium trade model in which all firms face wage claims of firm-level unions. By accounting for productivity differences across industries, the model features income inequality along multiple lines, including inequality between firm owners and workers as well as within these two groups of agents, and involuntary unemployment. This setting is used to study the impact of trade liberalization on key macroeconomic performance measures. In particular, the study shows that a movement from autarky to free trade with a fully symmetric partner country lowers union wage claims and therefore stimulates employment and raises welfare. Whether firms can extract a larger share of rents in the open economy depends on the competitive environment in the product market. Furthermore, the distribution of profit income across firm owners remains unaffected, while the distribution of wage income becomes more equal when a country opens up to trade with a fully symmetric trading partner. It is also shown how country size differences and technological dissimilarity of trading partners affect the results from the analysis.

The second essay also builds upon the framework of general oligopolistic equilibrium with two countries that, however, differ in the centralization of union wage setting. Being interested in the consequences of openness, this study shows that, in the short-run, trade increases welfare and employment in both locations, and it raises income of capital owners as well as workers. In the long run, capital outflows from the country with the more centralized wage setting generate winners and losers and make the two countries more dissimilar in terms of unemployment and welfare. Decentralization of wage setting can successfully prevent capital outflow and the export of jobs.

The third and final essay is of an empirical nature and investigates the role of wages as a potential driving force for German export activity. In the past 15 years Germany has been characterized by a strong export activity while at the same time initiating structural reforms on the labor market. It is often argued that German firms and plants are particularly successful in exporting since they are very competitive internationally. By computing unit labor costs as a measure of international competitiveness based on OECD STAN data and the IAB establishment panel this study investigates the role of labor costs for the decision to export. The results show that (i) German plants' export intensity is positively correlated with competitiveness and (ii) that the relationship is spuriously driven by a non-industry specific common time trend. The study furthermore applies a corner solution model that allows to disentangle the total effect into its effects at the extensive and intensive margin of trade. Results indicate a positive and significant effect of competitiveness at both margins but the effect turns out insignificant before the introduction of the Euro.

Zusammenfassung

Diese Dissertation besteht aus einem ausführlichen Literaturüberblick und drei Aufsätzen zum Zusammenhang von Globalisierung und Lohnpolitik, Beschäftigung, Einkommensverteilung und Wohlfahrt. Ein besonderer Fokus liegt dabei auf der Rolle von Gewerkschaften als eine der wesentlichen Institutionen auf dem Arbeitsmarkt. Das einführende Kapitel motiviert die Auseinandersetzung mit diesen Themen, bevor ein ausführlicher Literaturüberblick zentrale Erkenntnisse aus früheren Studien zusammenfasst.

Der erste Aufsatz konstruiert ein Handelsmodell mit oligopolistischem Wettbewerb und einem Kontinuum an Sektoren im allgemeinen Gleichgewicht, in dem sich sämtliche Firmen Lohnforderungen von Firmengewerkschaften gegenüber sehen. Unter Berücksichtigung von sektorspezifischen Produktivitäten führt das Modell zu verschiedenen Formen von Einkommensungleichheit, darunter Ungleichheit innerhalb der Firmeneigentümer und Arbeiter, Ungleichheit zwischen beiden Einkommensgruppen und auch Arbeitslosigkeit. Es zeigt sich, dass ein Übergang von Autarkie zu Freihandel mit einem symmetrischen Handelspartner die Lohnforderungen der Gewerkschaften reduziert und damit positive Beschäftigungs- und Wohlfahrtseffekte hat. Ob sich Firmen nach Handelsöffnung einen größeren Teil der ökonomischen Rente sichern können ist abhängig von der Wettbewerbssituation auf dem Gütermarkt. Freihandel lässt die Einkommensverteilung innerhalb der Firmeneigentümer unverändert, wohingegen die Einkommensverteilung innerhalb der Arbeitnehmerschaft ungleicher wird. Abschließend wird gezeigt, inwiefern Länderasymmetrien in Form von unterschiedlichen Produktivitäten und unterschiedlicher Landesgröße die Resultate beeinflussen.

Der zweite Aufsatz baut ebenfalls auf dem Modellrahmen des oligopolistischen Wettbewerbs im allgemeinen Gleichgewicht auf. Im Gegensatz zum ersten Aufsatz unterscheiden sich jedoch beide Länder im Zentralisierungsgrad der gewerkschaftlichen Lohnverhandlungen. Die Studie zeigt, dass internationaler Handel kurzfristig in beiden Ländern zu positiven Wohlfahrts- und Beschäftigungseffekten führt und sowohl Firmeneigentümer als auch Arbeitnehmer Einkommenszuwächse verzeichnen können. In der langen Frist fließt jedoch Kapital aus dem Land mit dem zentralisierten Lohnverhandlungssystem zum Handelspartner. Diese Kapitalflüsse erzeugen Gewinner und Verlierer und lassen die beiden Länder hinsichtlich ihrer Wohlfahrt und Arbeitslosenzahl divergieren. Eine Entwicklung hin zu dezentraleren Lohnverhandlungen kann die Kapitalabflüsse und somit den Export von Arbeitsplätzen verhindern.

Der dritte und zugleich letzte Aufsatz ist empirischer Natur und untersucht die Rolle von Löhnen als Triebfeder der deutschen Exportaktivitäten. In den vergangenen 15 Jahren war Deutschland durch eine starke Exportaktivität und zeitlich einhergehenden strukturellen Reformen auf dem Arbeitsmarkt gekennzeichnet. Es wurde oft argumentiert, dass deutsche Firmen und Betriebe insbesondere aufgrund ihrer hohen internationalen Wettbewerbsfähigkeit viele Exporte tätigen. Unter Berechnung der Arbeitsstückkosten als Maß für internationale Wettbewerbsfähigkeit mittels OECD STAN Daten und dem IAB Betriebspanel untersucht diese Studie die Rolle von Arbeitskosten für die Entscheidung zu exportieren. Die Ergebnisse zeigen, dass (i) die Exportaktivität deutscher Betriebe positiv mit ihrer Wettbewerbsfähigkeit korreliert ist und (ii) der Zusammenhang in loser Form durch einen nicht-industriespezifischen Zeiteffekt getrieben scheint.

Acknowledgement

In the course of writing this doctoral thesis I was delighted to benefit heavily from interactions and conversations with many people. I would therefore like to take this opportunity to show them my appreciation.

First and foremost my greatest thanks goes to my supervisor Hartmut Egger. His passion for research, not only in the field of international economics and trade, was a big source of inspiration. His academic strength, intellectual ability and ongoing encouragement have been of invaluable help for my dissertation. I am particularly grateful to Mario Larch for not only kindly agreeing to become my second supervisor but also giving me good advice and helpful comments for my studies and to Bernhard Herz for chairing the dissertation committee.

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1 Introduction

Over the past few decades the consequences and challenges of ongoing international market integration have been one of *the* key issues in the public, political and scientific debate. The protests during the WTO meeting in Seattle in 1999 and on subsequent meetings of supranational bodies document a strong interest and emotional, opposing views on the question what the globalization process means to people. Proponents often point out that stronger competition, increasing specialization and larger scales of production offer an opportunity to improve everyone's standard of living. On the other hand, less enthusiastic observers point to the negative aspects of globalization, such as growing market power of multinational corporations, a slump in national sovereignty, an erosion of humanitarian rights, or a race-to-the-bottom in social standards. While all of theses issues are highly important and relevant themselves, due to the complexity of the subject it would be far beyond the scope of this doctoral thesis to tackle all of them. Rather, this thesis intends to focus on the interaction of globalization and wages since this is a dimension that has attracted particular interest in the public debate.

With regard to this issue, again, the world seems to be divided into two camps with opposing views. One camp argues that lower production costs and less regulations in other countries benefits foreign firms and allows them to outcompete domestic producers thereby harming local workers through job losses and/or a reduction of the wage bill. By contrast, the other camp highlights that freer trade leads to an expansion in the export activity which increases the international demand for domestic products and, thus, improves the well-being of firm-owners and workers due to higher output, more jobs and/or a higher wage bill. While these two controversial views are dominating the public debate for as long as globalization has become of general interest, the way the academic profession looks at the linkage between ongoing market integration, unemployment and income distribution has changed tremendously. For a surprisingly long time, the mainstream view of economists on the link between employment and trade was that unemployment is determined by macroeconomic variables such as growth and business cycles with trade having no impact (cf. Krugman, 1993; Mussa, 1993). By contrast, in the meantime a lot of research has been done to revisit the linkage. In that respect, the questions put forward by public commentators and politicians have been addressed in the academic literature. Will wages be set in Beijing (cf. Freeman, 1995)? Will good jobs disappear to countries with less regulated labor markets, with a 'great sucking sound' as the former US presidential candidate Ross Perot illustratively put it during his campaign? Or does an increase in product market integration lead to an erosion of trade union power meaning an end to decent pay and job security (cf. Rodrik, 1997)? It's those questions that I had in mind when I started to work on my thesis. The outcome of almost five years of research is presented in this book. It contains two theory chapters that introduce and apply a new theoretical vehicle for studying the impact of different forms of globalization on inequality, unemployment and welfare in unionized labor markets. In addition, the book covers a empirical section that sheds light on the role of (unit) labor costs as a crucial determinant of international competitiveness in the export activity of plants and firms by using micro-level data from the German Institute for Employment Research (IAB) in Nuremberg. In the course of writing, the topics of interest have been fueled by the latest developments in the World Economy. First, it turned out that the economic and financial crisis further increased inequality in income distribution (cf. Atkinson, Piketty, and Saez, 2011) which has put the issue of inequality in a globalized world on the very top of public concerns. Second, given the enormous differences in trade balances in major OECD countries, the question of labor market linkages in open economies was revisited and policy recommendations to coordinate wage policy were discussed. Last but not least, a heated debated sparked off whether German wage moderation has contributed to the strong export activity of German firms and plants at the expense of its trading partners, especially within the Eurozone.

The remainder of this book is organized as follows. Chapter 2 reviews important contributions on the issue of wage setting in open economies. The main focus is on theoretical work and the review aims at highlighting important findings on the effect of globalization on inequality, welfare and unemployment. The subsequent chapter 3 studies the impact of trade liberalization on key macroeconomic performance measures such as unemployment, income inequality and welfare in a world of unionized general oligopolistic equilibrium. It is a slightly modified version of a joint paper with my PhD supervisor, Hartmut Egger, which in the meantime has been published as Egger and Etzel (2012a).[1] Chapter 4 is also a joint work with Hartmut Egger and can be interpreted as extension to Egger and Etzel (2012b).[2] The analysis there builds upon the same framework as chapter 3 but it assumes two countries that differ in their wage bargaining regimes on the labor market. This setting is used to study labor market linkages in a globalized world. Chapter 5 is a joint work with two colleagues from the German Institute for Employment Research (IAB) in Nuremberg, namely Hans-Jörg Schmerer and Andreas Hauptmann which is forthcoming as Etzel, Hauptmann, and Schmerer (2013). This study looks at the role of wages as a potential driving force for German plants' export activity in a empirical exercise. The final chapter 6 concludes with a brief summary of the most important insights from this book.

[1] In addition to the published version, the chapter contains an extended appendix which presents all relevant calculations step-by-step.

[2] Additionally to the two circulating working paper versions, the title has changed slightly as well as some explanations on the related literature.

2 Literature Review

Given the vast amount of literature dealing with the issues of inequality and unemployment in open economies, this review cannot cover all theoretical models and empirical contributions. Instead, it tries to give a rich picture about the main contributions and concepts to summarize the key findings concerning these two topics. The lion share of the review will be on theoretical contributions while some stylized facts and empirical evidence is reported to give an idea of the importance of the theoretical insights.

2.1 Inter-industry trade models with a perfect labor market

The way the economic profession traditionally linked the concepts of inequality and international trade built upon the classic trade theory of comparative advantage. Distributive effects were analyzed either in models of the Heckscher-Ohlin type or in the specific factors model.[1] Of course, employment effects are ruled out by assumption when considering a perfect labor market.

Heckscher-Ohlin model. Consider a stylized economy with two commodities and two input factors, capital (K) and labor (L), which receive returns r and w, respectively. Both sectors are perfectly competitive and produce under linearly homogeneous technologies. Commodity 1 is produced relatively capital-intensive at all possible factor prices, i.e. there are no factor intensity reversals. The two factors of production are perfectly mobile between industries but not across countries. Therefore, each factor receives the same income independent of the industry in which it is employed, since otherwise it would always have an incentive to move to the high-income industry. Consumers have homothetic preferences and production is diversified by assumption. Consider country Home being relatively abundant in capital compared to country Foreign. Then, the key insight from the Heckscher-Ohlin model is that moving from autarky to free trade increases the relative price of the capital-intensive commodity in Home which induces the country to specialize in the production of this commodity because it has a comparative advantage in the production of this good. This leads to a reallocation of resources towards Home's capital-intensive industry. However, the labor-intensive sector foregoes too many workers relative to units of capital than the capital-intensive sector can absorb at given factor prices. Consequently, relative factor prices have to adjust as well. The return to capital increases relative to wages in order to clear the factor market. However, as the Stolper-Samuelson theorem shows, factor prices do not only change in relative terms but also in real terms. Opening up for trade leads to an increase in the real return to the factor that is relative abundant in a country and to a decrease in the real return to the other factor. Thus, in the example illustrated here, trade would increase

[1] Harrison, McLaren, and McMillan (2011) provide an excellent review on the linkage between international trade and the distribution of income. Parts of the subsequent overview are inspired by this review.

income inequality between capital owners and workers in Home, while the opposite would be true in Foreign.[2]

Specific-factors model. In contrast to the Heckscher-Ohlin world, in the specific-factors model at least one factor of production cannot move between industries, and trade liberalization only leads to a reallocation of the mobile factor. In the classic textbook example with three factors of production, in which capital and land are specifically used in the production of one commodity while labor is free to move between the two sectors, trade increases the real income of the factor that is specific to the exporting sector and lowers the real income of the factor being specific in use to the import-competing sector. The effect on the mobile factor, labor, is ambiguous.

Empirical evidence. While both theories provide workhorse models of international trade theory to study the impact of trade on inequality there is little empirical evidence supporting the respective hypotheses. While Feenstra (2000) documents a severe widening in the income gap between blue- and white collar workers in the US in the period from 1982 to 1994 and suggests that trade has had some impact on this development, his analysis questions the explanations following the Heckscher-Ohlin framework especially for the following two reasons: (i) wages of the high-skilled workers will only increase if there has been a rise in prices of the goods that use skilled labor intensively, and, (ii) even if goods prices had changed, then there occurs a reallocation of the factors of production such that the production process becomes less skill-intensive since the use of skilled labor has become relatively more expensive. Both effects are not to be found in the data but even contradicted, which led economists to argue that skill-biased technological change is the more important factor to explain the development of growing income inequality (cf. Freeman, 1995, 1998).

Putting the focus on developing countries, Goldberg and Pavcnik (2004, 2007) show that international trade indeed led to distributional changes in these countries but not in the predicted way. Showing that international trade did not make less skilled workers better off relative to skilled workers, their empirical evidence stands in stark contrast to the theoretical predictions. These findings tempted Davis and Mishra (2007) to conclude that "Stolper-Samuelson is dead" and that it would not only be false but even dangerous to base predictions about distributive effects of ongoing market integration of developing countries on the traditional Heckscher-Ohlin trade theory. Instead, they argue that the Stolper-Samuelson theorem only holds in special circumstances, including the assumptions that all countries produce all goods and that imported and locally produced goods are close substitutes.

Extensions. There are, however, important extensions to the traditional models of comparative advantage that lead to significant qualifications of the orginal statements. For instance, Feenstra and Hanson (1996) developed a two-country framework of offshoring in which firms located in developed countries are able to shift some stages of the production process abroad. The two countries differ in the relative supply of skilled and unskilled workers such that cost mini-

[2] Replacing capital with human capital, one can use the insight to postulate a link between trade and wage inequality.

mization determines a cutoff stage, such that firms in the developed countries shift all production stages with a skill intensity below the cutoff abroad, while keeping all production stages with a skill intensity above the cutoff at home. Further market integration is modeled as an easier foreign investment of capital and leads to a relocation of production stages. The skill-abundant country shifts more tasks to the skill-scarce country. Due to the ranking of tasks in their skill intensities, the relative demand for skilled workers increases in both countries and this implies that the skill premium rises in both locations. Hence, in contrast to the Stolper-Samuelson theorem, this framework predicts an increase of inequality in both countries and is therefore in line with the observed empirical evidence from the above mentioned studies.

2.2 Inter-industry trade models with labor market frictions

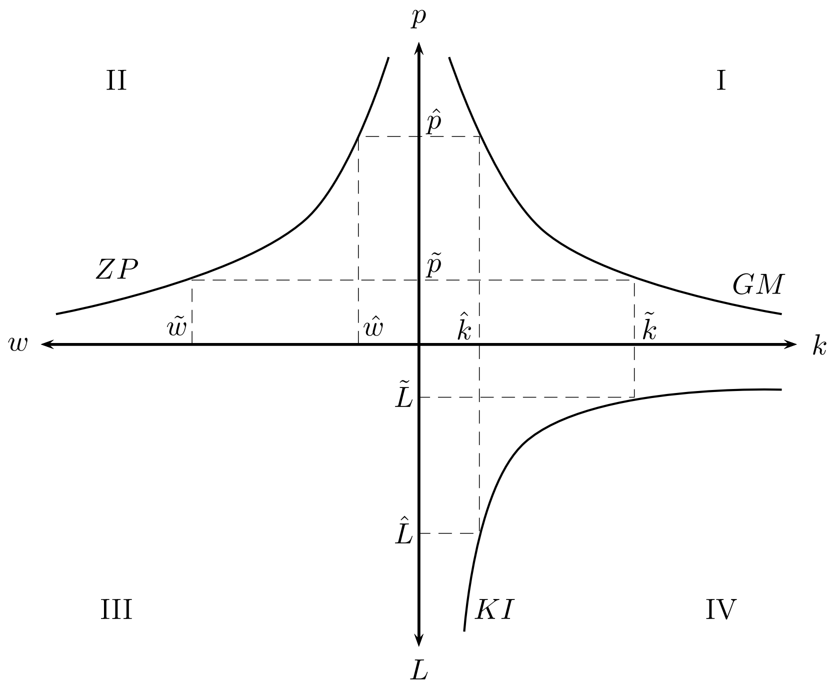
As indicated earlier, considering a frictionless labor market, the traditional trade models are not suited to address the question of employment effects of trade liberalization. Interestingly, while this issue has been at the centre of the public and political debate, the majority of the economic profession considered unemployment for a long time to be mainly a macroeconomic phenomenon with trade, if any, only having a minor impact (cf. Krugman, 1993; Mussa, 1993).

Minimum wage. The pioneering work on involuntary unemployment in open economies dates back to Brecher (1974). He has introduced a binding minimum wage into an otherwise standard Heckscher-Ohlin world as outlined in the previous section. The minimum wage fixes the return to labor in terms of good 2, which serves as numeraire, and, of course, it must be higher than the market clearing wage in order to be binding. Following Davis (1998) and Kreickemeier (2008), figure 2.1 illustrates the equilibrium in the closed economy with and without a minimum wage. The following discussion follows closely the discussion in Kreickemeier (2008).

In the first quadrant, the GM locus represents all combinations of the relative price, p, and economy-wide capital intensity, k, that are compatible with a goods market equilibrium. Hereby, economy-wide capital intensity is defined as the relative capital usage in production and thus equals total capital input divided by total labor input: K/L. GM is downward sloping since an increase in capital intensity rises the relative output in the capital-intensive sector which, with homothetic preferences, requires a decrease in the relative goods price to restore equilibrium.[3] The second quadrant shows the ZP locus that represents all combinations of the relative price and the wage rate that are compatible with zero profits under full diversification. The underlying Stolper-Samuelson theorem explains the downward slope. An increase in the relative price of the capital-intensive commodity reduces the wage rate. Finally, the KI locus in the fourth quadrant simply illustrates the definition of economy-wide capital intensity graphically. For a given capital stock, economy-wide capital intensity shrinks in aggregate labor input L. The standard Heckscher-Ohlin model can be easily explained with the help of figure 2.1. The determination of the equilibrium starts counter-clockwise in the fourth quadrant. The exogenous endowment in labor, $\hat{L}$, will be fully employed together with the given stock in capital, which determines the

[3]This mechanism is unambigously true when considering a closed economy. In the case of an open economy, one has to distinguish two scenarios. If the country under consideration is large, then the downward sloping GM loci remains. If, however, the country were small, then the GM loci would become horizontal.

Figure 2.1: The one-country equilibrium with and without a minimum wage



Source: Kreickemeier (2008)

aggregate capital intensity, $\hat{k}$. This furthermore directy implies the goods market clearing price ($\hat{p}$) and the equilibrium wage rate ($\hat{w}$). Opening up for trade shifts the GM locus north-east which implies for the given factor endowment a rise in the relative goods price and a decrease in the wage rate, as has been discussed above.

The implementation of a binding wage floor changes the analysis systematically. In such a scenario, the equilibrium is determined clockwise beginning from quadrant II. The exogenously specified minimum wage $\tilde{w}$ increases costs in both sectors, but, relative more so in the labor-intensive sector. Hence, the higher wage can only be compatible with zero profits if the relative price of the capital-intensive commodity sinks to $\tilde{p}$. Since consumers then want to buy more of the capital-intensive good, goods market clearing can only be restored if the relative supply of this good rises. This requires a higher capital-intensity, $\tilde{k}$. Since endowment of capital is fix, the only way to accomplish this is to adjust the amount of labor used in the production. Therefore, in the end, aggregate employment will fall from $\hat{L}$ to $\tilde{L}$. The Brecher framework contains two important features. First, as long as we assume diversified production, the minimum wage fixes the relative prices of the commodities in the economy.[4] As a consequence, the minimum wage ties down all relevant world market prices via factor price equalization in the open economy.[5] Second, as can be neatly seen in figure 2.1, the setting allows to talk about both, the *level* of unemployment, as well as the *rate* of unemployment. The given labor endowment of an economy

[4] Oslington (2002) considers the case in which an economy is forced to stop production in the labor-intensive sector.

[5] Thereby, the implementation of the minimum wage demolishes the source of gains from trade as goods prices do not adjust.

is a non-binding constraint and variations of it directly translate into changes in the number of unemployed workers. Both features make the framework highly tractable and allow to study employment effects of international trade.

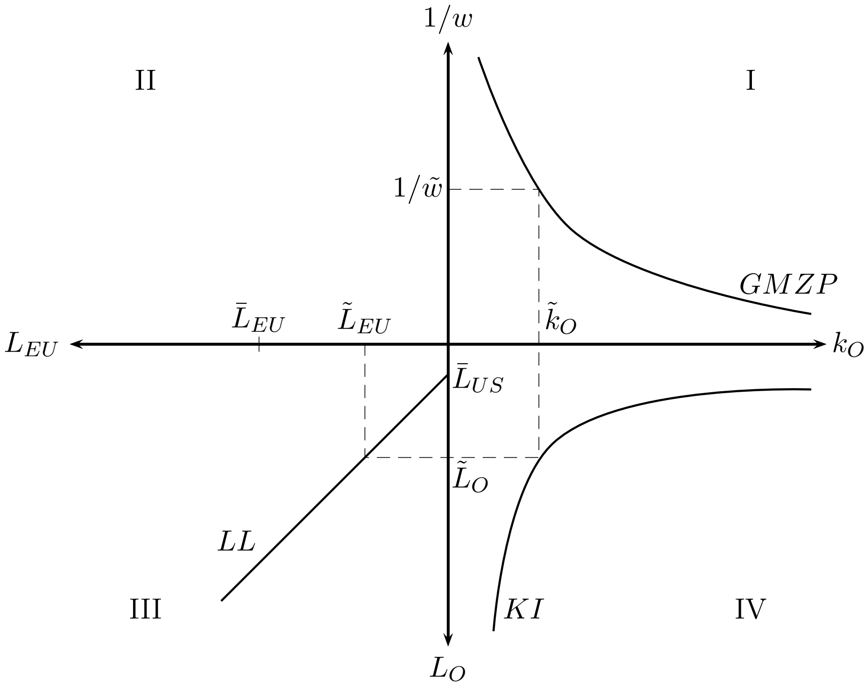
While not directly addressed in Brecher (1974), the setting furthermore allows to investigate labor market linkages in open economies. Against the background of distinctively different institutions and outcomes on the labor market in the US and Europe, the question of potential spillover effects of unilateral policy reforms on the labor market has inspired passionate discussions. In a very prominent contribution, Davis (1998) addresses the issue using the setup of Brecher (1974). He considers a world in which one country (Europe) imposes a binding minimum wage floor while the other country (US) maintains a flexible wage. Using the so-called integrated equilibrium,[6] the study identifies conditions under which free trade in commodities alone is sufficient to attain the same equilibrium as would occur if the two countries would constitute one combined closed economy with perfect mobility in goods and factors. One central assumption for this result is the absence of trade costs which implies factor price equalization in diversified equilibrium. Then, the crucial question that arises is, whether diversification is consistent with the existence of a minimum wage in one location. It is consistent if the world unemployment rate is the same as in the integrated equilibrium. Since unemployment can not occur in flexible-wage US, this directly implies that Europe has to carry the whole burden of unemployment. This is the key feature of the model and has two main implications. First, low-skilled workers in the US benefit from a higher minimum wage in Europe, and, second, any macroeconomic shock will be completely absorbed by the minimum wage European labor market, implying that US workers are insulated from exogenous shocks if Europe introduces a binding minimum wage.

To illustrate this and from the background of China's rise in the world economy, Davis (1998) extends the analysis by a third country. Thereby, he considers Home (OECD) to consist of two countries (Europe and US) that are completely identical except of their labor market regimes, freely trade with each other and now open up for trade with a third country, China, which is a net exporter of the labor-intensive commodity. The trade effects are illustrated in figure 2.2, which is a modified version of figure 2.1.

Quadrant I hosts the GMZP locus that represents all combinations of $1/w$ and the aggregate capital intensity of the OECD that are compatible with zero profit conditions in both sectors and goods market clearing. The fourth quadrant again illustrates the definition of capital intensity with the slight modification that it now represents the combined OECD economy. Finally, the third quadrant illustrates the LL locus, the distribution of employment across the US and Europe. We see that imposing a minimum wage in Europe (EU), implies an aggregate capital intensity k_O and aggregate OECD-wide employment at the level L_O. It can be split up into employment in the flexible-wage US ($\bar{L}_{US}$) and rigid-wage EU ($\tilde{L}_{EU}$) and reveals that the burden of unemployment is solely carried by the EU itself. Moving to free trade with labor-abundant China shifts the GMZP locus outwards, which means that for the fixed European minimum wage, the capital-intensity in the OECD has to increase. Given the exogenous capital stock this can only

[6] The concept of an integrated equilibrium originates from Samuelson (1949) and was further developed by Dixit and Norman (1980). As Davis and Weinstein (2000) conclude: "The central idea is that a world with imperfect mobility of productive factors across regions or countries may replicate the essential equilibrium of a fully integrated economy, provided that goods are perfectly mobile."

Figure 2.2: The two-country equilibrium with a minimum wage



Source: Kreickemeier (2008)

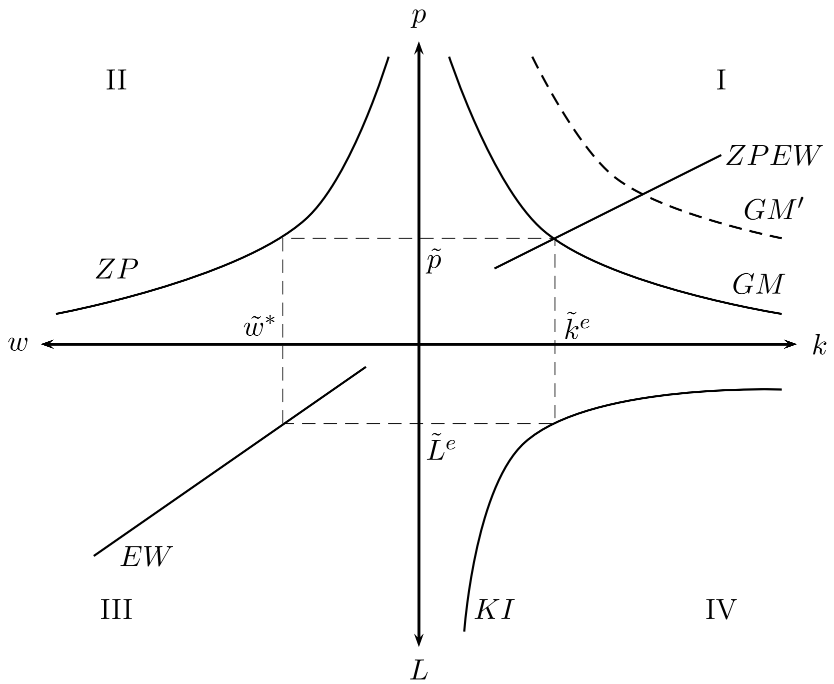
be achieved by reducing aggregate employment in the OECD and is completely absorbed by a one-to-one increase in European unemployment. This is the prominent and heavily discussed "insulation result" from above.[7]

Efficiency wage. In the face of its strong implications, it is no surprise that the work by Davis (1998) has evoked a lot of controversy. Aside of the already mentioned qualifications from Oslington (2002) and Meckl (2006), an important contribution regarding the predictions on labor market linkages in open economies comes from Kreickemeier and Nelson (2006). Instead of a minimum wage they introduce an efficiency wage model into the otherwise standard Heckscher-Ohlin world. Kreickemeier (2008) explains the main mechanism informally with the help of figure 2.3 and demonstrates the new effects compared to the minimum wage model described above. The crucial difference is the introduction of an upward sloping EW (efficiency wage) curve in the third quadrant. Workers can influence the effort level they are providing on the job. The better are the outside opportunities of workers the higher is the wage a firm has to pay in order

[7]Of course, the inferred implications are very controversial and have therefore received a lot of attention. One important qualification comes from Meckl (2006). He relies on the same framework, including factor price equalization, but accounts for differences in productivities within and between different skill groups of labor. This assumption generates differences in individual demand for education and thereby endogenizes the relative labor supply. If workers are paid according to their individual productivity, the effective wage (the firms' costs per unit of effective labor input) is then separated from the hourly wage (the wage per physical unit of labor). Since the latter is the only wage that can be fixed by legislation, an exogenously imposed wage floor does then not tie down all prices for goods and factors all over the world as in Davis (1998). Instead, this setting preserves key findings from a standard Heckscher-Ohlin world and extends them to unemployment effects and endogenous adjustment of relative skill supplies.

to motivate a worker to supply the requested effort level, which is assumed to be exogenous and normalized to one.[8] Hence, if unemployment is low and, thus, ceteris paribus workers are scarce, then firms are willing to pay a higher wage. This intuition explains the upward sloping EW curve. The EW curve can also be used to implement a relation between the relative price of the commodities and aggregate capital intensity, resulting in an upward sloping ZPEW locus in the first quadrant that represents all combinations of p and k that are compatible with the zero profit condition and the efficiency wage curve. From quadrant III we know that a higher employment level increases the wage rate. This reduces the relative price of the capital-intensive commodity as is illustrated in quadrant II. At the same time, for a given stock of capital a reduction in unemployment reduces capital intensity. Both effects together explain the upward sloping ZPEW curve in quadrant I. The intersection of the ZPEW curve with the GM curve determines the equilibrium values of the economy.[9]

Figure 2.3: The equilibrium with an efficiency wage



Source: Kreickemeier (2008)

We are now able to look at the trade effects. For convenience, we stick to the assumption that the country under consideration is capital-abundant and therefore a net supplier of the capital-intensive good. As we already know, opening up for trade therefore shifts the GM locus outwards. This leads to a new equilibrium (see figure 2.3) which is characterized by both, lower wages and higher unemployment. Two important comparisons can be drawn. First, the outcome can be easily contrasted to a standard Heckscher-Ohlin model with fully flexible wages as

[8]This can be constructed by a fair wage model as in Kreickemeier and Nelson (2006).

[9]In stark contrast to the minimum wage model, the wage rate and thus the relative price of commodities is endogenous. Furthermore, an increase in labor endowment shifts out the EW curve, affects the equilibrium and does not increase unemployment one-to-one.

described above. In that case, for the given endowment of capital and labor, the vertical difference between the GM and GM' curve determines by how much the wage rate has to decrease to restore equilibrium. Comparing this equilibrium with the one that is determined by the intersection of ZPEW with GM' it becomes apparent that the wage decrease is less pronounced in case of efficiency wages. This could lead one to argue that this kind of labor market imperfection prevents the increase in income inequality to be as severe as in the case of a frictionless economy. However, one has to keep in mind, that trade rises unemployment when accounting for the distortion on the labor market. Therefore, the total effect on inequality compared to the perfect Heckscher-Ohlin world is not clear. Second, comparing the scenario of an efficiency wage to a country that has imposed a minimum wage, a couple of interesting features can be noticed. First of all, we see that the wage rate and accordingly the commodity prices are no longer tied down but determined endogenously. It follows that the increase in unemployment is less pronounced since part of the adjustment occurs through a decrease in the wage rate. Furthermore, considering efficiency wages, the traditional source of welfare gains is still present: goods prices adjust as in the traditional Heckscher-Ohlin world. Whether this is still enough to increase welfare depends on the counteracting employment effect. In other words, it is not clear that opening up for trade leads to welfare losses as predicted by the minimum wage model. Instead, the welfare effects of trade in the efficiency wage model depend on the relative size of the traditional gains of trade and the newly introduced employment effects.

To qualify Davis' insulation result, one can also consider a three-country world, but with a less-pronounced asymmetry between the two OECD countries US and Europe. In this setting, unemployment exists in both countries due to the presence of efficiency wages in both locations. The constraint is however country-specific and therefore the unemployment rate differs between the US and Europe. By stark contrast to the minimum wage model, considering efficiency wages in both countries, employment is now endogenous in both locations. Therefore, the US economy is no longer shielded against macroeconomic shocks (like a trade liberalization with China) but also suffers from a reduction in employment and lower wages.

Search and matching. The books by Davidson and Matusz (2004, 2010) provide a comprehensive picture of their own work as well as major other contributions in the field. Most of their studies rely on the introduction of labor market frictions in form of search-and-matching unemployment along the lines of Mortensen and Pissarides (1994). A baseline model is presented in Davidson and Matusz (2004). They construct a simple model with homogeneous workers as the only input factor. Workers need to decide whether they want to work in the low-wage sector (sector 1) that offers many job opportunities or in the high-wage sector (sector 2) where vacancies are scarce. Employment in the first sector can be found immediately whereas job search takes time in sector 2. The production technology is different in both sectors. Diminishing returns to labor are present in the low-wage sector, while a linear production technology is assumed in the high-wage sector. Workers maximize their lifetime utility and thereby compare expected lifetime income in the two sectors. As jobs in sector 1 can be found immediately, workers in that sector are never unemployed. By contrast, in the high-wage sector, jobs are created at some rate e and destroyed at some rate b. These two job-turnover rates are the crucial variables and determine expected lifetime income in the second sector (V_E). Of course, in a steady-state equilibrium expected lifetime income of being unemployed (V_U) has to equal expected lifetime income when working in the low-wage sector (V_1), since otherwise either an unemployed would choose to take a job in the low-wage sector or a worker from the low-wage sector would quit his job to find a better paid job in the other sector. Finally, to close the model the number of employed workers that lose their jobs has to equal the number of searching unemployed that find a new job.

Using the concepts of relative supply and relative demand, the simple model shows that the autarky equilibrium price is solely determined by the turnover rates, b and e. It is then straightforward to show how they influence the trade pattern. To make this point clear, consider two countries that are completely identical except of their labor market frictions. A country then has a comparative advantage in the production of the search sector if (i) it has the more efficient search technology (higher e) and/or (ii) it has the more durable search sector (lower b). The intution for this is easy to understand. If it becomes more difficult to find a job in sector 2, then a worker is only willing to look for a job if the output price and thus his return is increasing as well. Therefore, a country with a higher probability to find a new job, i.e. a more efficient search technology, will have a lower autarky price for the second commoditiy and, thus, be the net exporter of the search commodity. The same logic inversely applies to the breakup rate, b. Unfortunately, the real world is not always as simple as theory. It may be the case that a country has a generally less dynamic labor market (i.e. low values for both turnover rates) than its trading partner. Hence, there exist two opposing forces and the comparative advantage in the search sector depends on the relative strength of these forces. Having derived the structure of the trade patterns let us turn towards the employment effects of trade. In fact, given the structure of the model unemployment occurs only through workers that are seeking a job in sector two. Hence, the level and the rate of unemployment severly depends on the size of this sector. The bigger is the full-employment sector one, the lower is unemployment. Hence, when trade leads to an increase in the price of the second commodity, this sets an incentive for more workers to search for employment in this sector which leads to higher wages and rises unemployment. In sum, one can therefore conclude that unemployment goes up in the country with the comparative advantage in the search sector, since production of the search commodity increases while the opposite is true in the other country.

It turns out that the propositions of the simplified model are robust when considering more realistic assumptions like in Davidson, Martin, and Matusz (1999), who endogenized the turnover rate, introduced capital as second input factor and assume search frictions in both sectors. While not changing the predictions regarding the trade pattern and unemployment, the introduction of a second input factor is a necessary ingredient to revisit the predictions of the classic Stolper-Samuelson theorem regarding the distributive effects of trade liberalization.[10] They use a general equilibrium model of international trade with two countries, that both consist of two sectors and two types of agents (workers and entrepreneurs). Both agents are endowed with one unit of input (labor and capital) that can be supplied in the production process. At each instant, labor (capital) is either employed (active) or unemployed (idle). Furthermore, both input factors are nationally fully mobile and, hence, will choose a sector to search for a job (rental) opportunity. The production of one unit of output requires one unit of each input, which implies that an un-

[10] A similar approach is taken in Davidson, Martin, and Matusz (1988) and Hosios (1990).

employed worker looks for an entrepreneur with idle capital. Such a match will then be created and will last until an exogenous shock forces the partners to separate. The break-up rate is assumed to be country- and sector-specific thereby allowing the duration of a match to vary across countries and sectors. Furthermore, it is also assumed that it is harder to create a match in one sector. For instance, if the labor-intensity is high in one sector, then it becomes more difficult for an unemployed worker to find an employment, whereas, on the other hand, it becomes easier for idle capital to find a match. The countries being equal in all other respects, the structure of the labor market is the sole source of comparative advantage and determines the pattern of trade, similar to the previously described benchmark model. Beyond the analysis of the trade pattern, the framework is also used to analyze the impact of trade on the returns to workers and entrepreneurs. In that respect, the study severely distinguishes between searching and employed factors. As searching factors are perfectly mobile, they respond immediately to changes in world prices. Thereby, they act in the same manner as proposed by the Stolper-Samuelson theorem, i.e. the real return to the unemployed factor used intensively in the expanding sector rises while the real return to the unemployed factor used intensively in the shrinking sector decreases. While this result has already been derived by Hosios (1990), the new finding from the analysis by Davidson, Martin, and Matusz (1999) consists in the effects for employed factors. It turns out that the impact of trade on the employed factors is ambiguous and determined by Stolper-Samuelson and Ricardo-Viner forces. Four scenarios can be distinguished: (i) A factor being employed and used intensively in the exporting industry will gain from trade; (ii) a factor employed and used intensively in the importing sector will lose from trade; (iii) a factor employed in the exporting industry but used intensively in the importing industry gains from the Ricardo-Viner force of being matched in the expanding industry but loses due to Stolper-Samuelson forces; (iv) finally, a factor employed in the importing industry but used intensively in the exporting industry gains from Stolper-Samuelson forces but loses due the the Ricardo-Viner force. In sum, the total impact of trade on the real return of employed factors is therefore ambiguous.

Trade Unions. A different approach to implement unemployment into the traditional trade theory was taken by Brecher and Long (1989). They consider a standard trade model with two commodities, fixed endowment of two inputs (capital and labor), constant-returns-to-scale technology and perfect competition in the goods market. Home is considered as a large open economy in which an economy-wide trade union sets wages unilaterally (monopoly union model) to maximize rents. While the resulting unemployment is hence voluntary from the perspective of the union, it is involuntary from the perspective of each individual worker. This setting then allows to determine an equilibrium with consistent combinations of employment and wages. Assuming a world equilibrium with diversification, the world price determines the real wage, and, thereby, a level of employment in Home that is consistent with the clearing of world goods markets. A higher real wage set by unions corresponds to a fall in the relative price of the capital-intensive good according to the Stolper-Samuelson theorem. Consequently, applying the Rybcyznski theorem, this implies a smaller level of employment in the large open economy of Home.

2.3 Intra-industry trade models with monopolistic competition

While the models discussed in the previous sections have helped to increase our understanding of how trade integration may affect the distribution of income and unemployment, the availability of new data provoked a series of new questions and challenges. Concerning the trade pattern itself, studies by Grubel and Lloyd (1971) showed that the majority of international trade occurs within one and the same industry between industrialized countries. Since this type of trade is not captured in the traditional theories it required some theoretical explanation. The seminal contribution came from Krugman (1979, 1980) who constructed a model of monopolistic competition, in which homogeneous firms produce a differentiated good under increasing returns to scale and consumers have love-of-variety preferences. In this setting, trade liberalization may force some firms to drop out of the market due to the increase in international competition but increases the total amount of available varieties which is welfare-enhancing.[11]

While the Nobel-price awarded approach by Krugman was a milestone in explaining intra-industry trade and has been applied extensively in the field of international economics, it has had a relatively small impact concerning the questions of unemployment and inequality. For instance, Davis (1998) discusses the robustness of his results when considering a Krugman-type trade model. He shows that an increase in the European minimum wage would imply an efficiency loss and reduce aggregate goods demand which would force firms from both countries to exit the market. Furthermore, however, the cost increase would render European firms to move to lower-cost US which is beneficial for US workers so that the key insights from the baseline model remain unaffected by considering a model variant with intra-industry trade between monopolistically competitive firms. A further notable exception comes from Matusz (1996) who introduces shirking à la Shapiro-Stiglitz into a Krugman-type model to show that trade rises employment in both countries. In contrast to efficiency wages in the Heckscher-Ohlin world, trade increases the variety of available intermediates which implies an increase in the division of labor. This leads to higher productivity and therefore higher real wages. As a consequence, the efficiency-wage constraint is relaxed and, hence, employment increases.

The research frontier was shifted again by new stylized facts in the 1990s. With respect to the trade pattern, Bernard and Jensen (1997) have documented that exporting firms are distinctively different from pure domestic firms and share a number of key characteristics: they are larger, more productive and pay higher wages than their domestic counterparts.[12] This finding was a big challenge since in the Krugman-model firms are considered to be homogeneous. The seminal work that presented a clear theoretical answer to this puzzle stems from Melitz (2003). He has introduced heterogeneous firms à la Hopenhayn (1992) into the international trade literature. His seminal work extends the monopolistic competition framework by Krugman (1979, 1980) by allowing for firm heterogeneity due to firm-specific productivity levels. The following discussion and presentation of the model is closely linked to the summary in Harrison, McLaren, and McMillan (2011). In the Melitz-world consumers have constant elasticity of substitution

[11] This mechanism is only present in the original Krugman (1979) paper. In Krugman (1980), the only variable of adjustment is the number of goods consumed, leaving the number of active firms constant.

[12] Similar results were documented for other countries like Taiwan (cf. Aw and Hwang, 1995) and Germany (cf. Bernard and Wagner, 1997). An excellent survey on this topic is provided by Bernard, Jensen, Redding, and Schott (2011).

preferences over a continuum of potential commodities. In general, anyone can start up a new firm if he/she is able to cover a fixed cost f_e for developing a new product. Once the fixed cost is paid, firms can start production, facing a decreasing returns to scale technology. Output q in each period, in which the firm is active, is given by

$$q = (l - f)\phi \tag{2.1}$$

where l, f is total and fixed labor input, respectively, and ϕ is the marginal product of labor. While the fixed cost of prodution is the same for all producers, ϕ is firm-specific and determined in a lottery, in which potential entrants can participate by paying the initial fixed cost f_e (in units of labor). Since the outcome of the lottery is random, some entrants have to realize that their productivity is not sufficiently high for breaking even given the fixed production cost f and, thus, have to exit the market. The autarky equilibrium is therefore determined by two key values. On the one hand, the number of firms that enter the market by paying the fixed cost of the "lottery ticket", f_e, and cutoff productivity ϕ_a^* that allows them to break-even and stay in the market. The "zero cutoff profit" condition requires that variable (operating) profits of a firm with the cutoff productivity ϕ_a^* have exactly to equal the fixed cost f. This implies that any firm with a lower realization of productivity, i.e. with $\phi < \phi_a^*$, will remain inactive and any firm with a higher realization of productivity, i.e. with $\phi > \phi_a^*$ will not only stay in the market but even make positive profits. Melitz (2003) considers a model in which firms have an infinite time horizon and face a common exogenous probability of exit. In a steady-state equilibrium, potential entrants - who are uncertain about the outcome of the productivity lottery - must be indifferent between entering and not entering the lottery. This requires that the expected present value of profits has to equal the market lottery fixed costs, f_e, so that ex-ante profits of (potential) entrants are equal to zero. This is a standard free entry condition.

In the open economy, there exist $n + 1$ identical countries, i.e. there are no sources of comparative advantage. Any firm can export to any country in the world by incurring a fixed cost of exporting f_x. Furthermore, exporting firms also have to pay "iceberg" trade costs, which means that a share of the output melts away in transit to the foreign countries. The fixed cost of exporting implies that it is not reasonable to export only a small amount of the commodity. As a consequence, only high-productive firms are able to start penetrating foreign markets. The open-economy equilibrium is therefore characterized by three values: the number of exporting firms that enter into the foreign market, a cutoff productivity ϕ^* that allows to stay in the market after facing the high-productive foreign competitors, and a cutoff productivity ϕ_x^* that allows firms to break-even when penetrating the foreign market. Provided that the fixed cost of exporting is sufficiently high, the model implies $\phi_x^* > \phi^*$. In this case, any firm with $\phi < \phi^*$ will drop out of the market whereas firms with $\phi > \phi_x^*$ will start exporting and any firm with a productivity level between those two cutoffs will just produce for the domestic market. Since exporting generates additional labor demand, the least productive firm under autarky can no longer survive in the open economy, then as a key result the model generates $\phi^* > \phi_a^*$ which implies that active firms in the open economy are on average more productive than active firms under autarky. While this selection effect and the increase in productivity give rise to a new channel for welfare gains of trade, the model *per se* has nothing to contribute to income distribution and/or unemployment since it assumes a perfect labor market. While the model does not provide a discussion on these topics, it can serve as a point of departure to study trade effects for income distribution and/or unemployment. In the following I will present different prominent approaches that have addressed these issues.

Efficiency wage. One prominent approach comes from Egger and Kreickemeier (2009). Like Kreickemeier and Nelson (2006) they propose the idea that workers care about fair wages along the lines of Akerlof and Yellen (1990), i.e. the effort level of workers depends on the perceived fairness of their wages. A key assumption of Egger and Kreickemeier (2009) is that workers who are employed in more productive and, thus, more profitable firms feel entitled to higher wages. This assumption generates wage inequality of homogeneous workers who are employed by heterogeneous firms. To be more specific, a fair remuneration from the perspective of workers must be at least as high as the reference wage

$$\hat{w}(\phi) = \phi^{\theta}[(1-U)\bar{w}]^{1-\theta} \tag{2.2}$$

with $\hat{w}$ for the reference wage, U for aggregate unemployment and θ for a parameter that indicates how important the firm's productivity is to the worker's evaluation of the fair wage. As in Melitz (2003), ϕ is firm-specific productivity and $\bar{w}$ labels the average wage of employed production workers. The term $[(1-U)\bar{w}]$ expresses the average income of the economy, taking into account that part of the workforce is unemployed and in the absence of unemployment benefits has zero income. A high value of θ indicates that a worker in a high-productive firm feels entitled to a high wage, regardless of the outside economic environment. This implies that wage inequality increases in θ. An effort function relates effort provision to the wage the worker receives relative to the reference wage. Workers that receive at least the reference wage supply full effort which is normalized to one whereas workers that get paid a wage lower than the reference wage will reduce the effort proportionally. Therefore, no firm has an incentive to pay a lower wage than the reference wage. In principle, it would be possible that firms have to pay more than the fair reference wage. But this is only possible if unemployment is zero. Focussing on parameter configurations which lead to involuntary unemployment in equilibrium, it is clear that firms in this model pay exactly the reference wage. This is the case we focus on in the subsequent discussion, implying that the wage payment depends endogenously on unemployment and the average wage. The key innovation relative to other contributions to the fair-wage literature is that the wage is now firm-specific due to the differences in the firm-level productivity. As in the basic Melitz-framework, the autarky equilibrium is characterized by two variables: a productivity cutoff and a number of entrepreneurs entering the market.

When opening up for trade, the basic mechanism is still at work. Again, marginal firms are forced to exit the market, while firms at the other end of the productivity distribution start exporting. However, considering fair wages as a source of labor market imperfection adds some new features to the analysis of trade effects. First, unemployment rises. On the one hand, trade increases aggregate output and therefore increases the demand for labor which reduces unemployment. On the other hand, though, trade leads to an increase in productivity which lowers the demand for workers for any given level of output. It is the second effect that is stronger and therefore trade leads to an increase in unemployment. Second, since firms in the open economy are more productive on average, the average real wage of employed workers increases. And, last but not least, when measuring wage income inequality as the ratio of the average wage for employed workers to the lowest wage for employed workers, $\bar{w}/\hat{w}(\phi^*)$, trade leads to rising wage income inequality. This result may seem at odds with the intuition given that the average real wage increases and low-productivity firms are squeezed out of the market. The forces at work are however easy to understand. First of all, the mere truncation of a distribution does not necessarily lower inequality, and especially not in the assumed case of a Pareto distribution. Therefore, the drop-out of low-productivity firms does not reduce wage income inequality. Furthermore, the wage that is paid by two firms is a function of the firm's productivity levels and not their realized profits. Hence, comparing two firms, this ratio ceteris paribus does not change after opening up for trade. The key mechanism is therefore in the reallocation of ressources that is due to trade. In order to penetrate foreign markets, high-productivity firms increase their output which forces them to hire more workers. Of course, the opposite happens in firms that are squeezed out of the market. This implies that the share of workers with a job in high-productivity firms increases and this is instrumental for an increase in $\bar{w}$. In other words, the higher employment share of high-productivity firms relative to low-productivity firms is responsible for the rise in wage inequality. Of course, when additionally accounting for the increased number of unemployed workers with zero wage, the increase of the gap in wage income of ex-ante homogeneous worker becomes even more pronounced.

A related approach of introducing labor market imperfections in the model of heterogeneous firms is presented by Davis and Harrigan (2011). They also introduce labor market frictions in the form of efficiency wages but in a substantially different form. They follow the idea by Shapiro and Stiglitz (1984) that workers can shirk on the job and need to be restrained from doing so by the threat to get fired if they are caught shirking. In the dynamic textbook variant of the so-called shirking model, all firms were identical and had the same exogenous probability to monitor and catch a shirker in each time period. In equilibrium, each firm therefore pays exactly the lowest wage that prevents workers to shirk given the monitoring ability of the firm. Building upon the Melitz-framework with heterogenous firms, in Davis and Harrigan (2011) firms do not only differ in their marginal product of labor, ϕ, but also in the probability m to detect shirking of their employees. This assumption gives rise to firm-specific wage rates since the lowest wage any firm is willing to pay depends on the firm-specific ability to monitor its workforce. Hence, firms that are good at catching shirking workers (i.e. firms with a high m) will pay lower wages than firms that are bad in monitoring. Jobs at firms with low detection probability are labeled as "good jobs" since the wage is high. Trade liberalization forces low-productivity firms and firms with a small probability to detect shirking to exit the market. This however implies, that free trade may destroy "good jobs", i.e. high-wage jobs, if these jobs are associated with high labor costs. More specifically, if m and ϕ are not strongly negatively correlated, the firms with the low wages tend to be those with the small marginal costs, which are therefore the bigger ones, and the ones that export. However, such an outcome seems at oods with empirical evidence which documents that exporters are more productive, larger and pay higher wages.

Search and matching. Another strand of the literature has introduced search frictions into the Melitz framework for studying the impact of intra-industry trade with heterogeneous firms on employment and income distribution. The most prominent contribution doing so is by Helpman, Itskhoki, and Redding (2010). In their model, workers search for a job and find employment with a probability that depends on the tightness of the labor market, i.e. the ratio of job searchers and open vacancies. Workers are assumed to have an idiosyncratic match quality for any employer. Better matches increase the productivity on the job, and hence, any firm tries to hire workers that constitute good matches. Since neither firms nor job seekers are informed about the match-specific quality of applicants prior to recruitment, firms systematically screen all of their applicants to identify whether the quality is above a certain threshold level, which itself is endogenous and depends on the screening intensity. Workers above this threshold level will be hired and start wage-bargaining with the employer. Workers below the required minimum match quality do not receive a job offer and get unemployed with zero income. In equilibrium, more productive firms set a higher threshold for the match quality, and thus invest more into the screening/recruitment process. This follows from the assumption that it is costly to set a higher threshold-level and, hence, only more productive firms can afford to pay these (fixed) costs. Therefore, a worker that passes the test at a high-productivity firm will be highly productive at that employer. This provides a positive link between a firm's baseline productivity and the surplus of employment with the latter being divided between firms and workers in a Nash bargain. At the end, although the underlying mechanism is substantially different to Egger and Kreickemeier (2009), this setup also implies that workers in larger, more productive firms receive a higher wage than workers employed in small, low-productive firms. Opening up for trade furthermore intensifies these effects. High-productivity firms have the opportunity to export and therefore screen even more extensively. Marginal firms that survive the foreign competition but do not export themselves have lower incentives to screen and therefore will pay lower wages. This leads to an increase in wage inequality due to trade liberalization. With respect to unemployment, the model predicts a lower employment level in the open economy. High-productivity firms do produce more due to the export activity but they also become more picky in hiring new workers, which, together with the drop-out of some domestic firms rises unemployment.

Felbermayr, Prat, and Schmerer (2011a) also introduce search unemployment à la Pissarides into the Melitz setup but do not consider idiosyncratic match quality nor screening activity of the employer to reveal the firm-specific productivity of an applicant. Instead, they allow for individual or collective bargaining. The well-known selection effect forces firms to exit the market and thereby decreases the cost of vacancy posting relative to the productivity of the average firm. Consequently, the cost reduction increases the ratio of job openings to unemployed workers which results in a decrease of unemployment. In contrast to Helpman, Itskhoki, and Redding (2010) wages do not depend on the individual productivity of a firm but on aggregate productivity. Hence, this setup does not give rise to wage inequality but leaves all workers with the same return despite being employed at firms with different productivity levels.

A similar form of labor market imperfection in a trade model with heterogeneous firms is considered by Helpman and Itskhoki (2010). In stark contrast to the other two papers though, they construct a setup with two sectors, one of which produces homogenous goods under perfect competition while the other produces differentiated goods under monopolistic competition with heterogeneous firms. Common to both sectors is the exposure to search and matching frictions in the labor market and wage bargaining which leads to equilibrium unemployment. The world consists of two countries that are identical in all respects except of the labor market institution. The matching efficiency and costs for posting vacancies can be different across sectors in the two locations. While trade generates welfare gains for both countries, the impact on unemployment is ambiguous and depends on the severeness of the labor market frictions in the two sectors. If the differentiated-goods sector is characterized by low (high) labor market frictions, trade raises (lowers) the rate of unemployment.

Trade Unions. Another approach to implement wage inequality is by Montagna and Nocco (2013). They develop a model along the lines of Melitz and Ottaviano (2008) with heterogeneous firms and firm- and market-specific markups in which wages are set via bargaining between firms and unions. While collective bargaining was already considered in the previously discussed work by Felbermayr, Prat, and Schmerer (2011a), that study could not address the issue of wage inequality due to an iso-elastic demand structure. This becomes different when relying on the setup by Melitz and Ottaviano (2008). The Melitz-Ottaviano framework uses different preferences that generate linear demand. This modification still generates the predictions of the standard Melitz framework but additionally adds two interesting features: (i) trade affects the toughness of competition and (ii) trade affects the average mark-ups. Enriched with the idea of firm-level collective bargaining, this setting gives rise to firm-specific wages and is used to study how unionization and trade liberalization affect intra-industry selection and thereby wage inequality. Considering endogenous markups, however, the rent that accrues to workers via union activity does not only depend on the productivity of a firm but also on the firm-specific market power. As more efficient firms have a stronger market power, unions can extract a bigger part of the economic rents than in less efficient firms. The imposed market power is furthermore market-specific due to market segmentation. Therefore, an exporting firm has two independent profit-centres, one for the domestic and one for the foreign sales. Switching towards a system with wage bargaining at level of the profit-centres instead of the firm-level discriminates wages according to the activities of the firm. A union is willing to moderate wages to improve the firm's competitiveness on the export market. This implies that opening up for trade can influence within-group wage inequality along two dimensions. On the one hand, it affects the competitive selection across firms, and, on the other hand, it changes wages within firms between the two profit centres.[13]

Union activity has also been addressed in a trade model with heterogeneous firms by Eckel and Egger (2009). Their focus is however on the incentives of firms to invest abroad for improving their bargaining position when negotiating wages with unions. This improvement is reached

[13] Relying on the same framework but focusing on a closed economy, Braun (2011) investigates how different degrees of centralization in wage bargaining affect productivity and firm performance. He shows that the wage bargaining regime implies a trade-off between product variety and average productivity. More centralized bargaining forces low-productivity firms to exit the market, reduces the number of available varieties while increasing average productivity. Less-centralized bargaining, by contrast, allows less-productive firms to survive in the market at the expense of a lower average productivity.

because multinational firms in this setup shift production abroad in case of disagreement in the wage bargaining with a local union. This improves the outside opportunity of firms vis-à-vis unions and reduces the wage payments. If labor markets are not unionized or wages are monopolistically set by unions, the firm decision to penetrate the foreign market via exports or foreign direct investment depends on the proximity-concentration trade-off. If, however, firms and unions negotiate about wages, then multinational firms are able to realize a wage discount due to the possibility to shift production abroad in case of disagreement. Unions fear the loss of jobs and are willing to agree on lower wages. As a consequence, in that case, trade liberalization further improves the bargaining position of firms since it becomes cheaper to reimport the foreign production into the domestic market.

Minimum wage. The question of potential spillover effects of unilateral policy reforms has already been discussed in this section when presenting the minimum wage model by Davis (1998) which predicted that bad labor market institutions in the foreign country can be beneficial for the domestic economy. However, since empirical evidence for this hypothesis has been missing and new theories of international trade have been developed, Egger, Egger, and Markusen (2012) have readdressed the question of labor market linkages in open economies. The innovation of the study is the introduction of a minimum wage into a trade model with heterogeneous firms. To be more precise, the paper assumes a model with firms producing and supplying differentiated goods under monopolistic competition along the lines of Ethier (1982) and Markusen (1989). The production of intermediate goods requires labor as the only input factor while the intermediate goods are aggregated into a homogeneous final good. Furthermore, following Melitz (2003), it is assumed that the producers in the intermediate sector have firm-specific productivities. Both, production of intermediate goods and heterogeneous firms give rise to two channels for gains from trade. First, the positive external scale effect by having access to a greater variety of intermediate inputs and, second, due to the selection effect of only the productive firms surviving the competition from abroad. It turns out that the second effect (selection effect) is crucial for the analysis of the impact of trade liberalization on a minimum wage economy. To highlight this second effect, the study sets trade costs equal to zero. Furthermore, the countries under consideration are assumed to be completely symmetric except of the level of the minimum wage. Opening up for trade then establishes a link between domestic and foreign marginal costs of production in the sector of intermediate goods. If firms in this sector would be homogeneous as in Krugman (1980) the minimum wage could only be binding in one economy whereas full employment would occur in the other one. If, for instance Home has a higher binding minimum wage than Foreign, then Home firms could not compete with its Foreign competitors and therefore had to exit the market whereas new intermediate goods producers would enter in Foreign due to lower production costs. At the end of this adjustment process all workers in Foreign would be employed and wages would have increased to the level of the minimum wage in Home, just like in the original work by Davis (1998) as long as still some firms are active in Home.[14] However, things become crucially different when assuming heterogeneous firms due to productivity differences. In that case, opening up for trade still equalizes the marginal costs of production

[14] In fact, a brief analysis of a minimum wage in a Krugman (1980)-type trade model has already been presented by Davis (1998).

but only of the marginal firms in both locations. This implies that countries can still have different binding minimum wages as long as these differences are compensated by difference in the productivities of the marginal firms. Taking the example from above, a higher minimum wage in Home leads to an efficiency loss and thereby lowers aggregate world demand for intermediate goods. Ceteris paribus, such a shock hits both economies and firms from both locations will exit the market. As before, there is a second, counteracting effect. Since the unilateral policy reform is conducted in Home, firms relocate from Home to Foreign. However, contrary to a model with homogeneous firms, this second effect is not as strong because the relocation of firms implies that the productivity of the marginal firm in Foreign shrinks while the productivity of the marginal firm in Home increases. This adjustment process is the key innovation relative to the previous literature. As a result, an increase in the minimum wage in one country may lower employment in both countries. To put it in a more general perspective, the analysis using such a framework predicts that bad labor market institutions in one country may also hurt the trading partner which stands in stark contrast to the predictions of the work by Davis (1998).

Empirical evidence. All of the papers mentioned above address the question of distributive and/or employment effects of international trade and can be linked with empirical evidence from the literature. While the theoretical predictions concerning the employment effects of trade are mixed, there seems to be an unambiguous trend in the empirical evidence. Independent from each other, Felbermayr, Prat, and Schmerer (2011b) and Dutt, Mitra, and Ranjan (2009) document a negative relationship between trade openness and unemployment. For instance, using OECD data Felbermayr, Prat, and Schmerer (2011b) report for their benchmark specification that a ten percentage points increase in openness leads to a reduction in aggregate unemployment by about three quarters of one percentage point. With respect to the linkage between openness and inequality studies by Katz and Autor (1999), Barth and Lucifora (2006) and Autor, Katz, and Kearney (2008) showed that a special form of inequality, within-group inequality, has become very important and risen tremendously. Before the work by Melitz (2003) there was no theoretical argument why and how trade liberalization could contribute to the increase in this special form of inequality.[15] The presented contributions then became even more convincing, however, when further empirical evidence by Hildreth and Oswald (1997) and Winter-Ebmer and Zweimuller (1999) showed that firm-specific factors are highly relevant for explaining wage inequality. Another study by Bernard and Jensen (1997) revealed that the large rise in average skilled wage premia stems from intra-industry shifts instead of inter-industry shifts or within-plant shifts. Amiti and Davis (2012) provide some confirmation for the findings from the theoretical papers by Egger and Kreickemeier (2009) and Helpman, Itskhoki, and Redding (2010) by showing that trade liberalization increases the wages for workers employed in most productive firms and lowers the wages for firms that are only serving domestic consumers. Finally, focusing on the impact of spillover effects of unilateral policy reforms on the labor market for the trading partner, a study by Felbermayr, Larch, and Lechthaler (2013) document empirical support for the predictions by Egger, Egger, and Markusen (2012) and Helpman and Itskhoki (2010). They show that a reduction in the domestic distortion in the labor market is beneficial for both countries even

[15] Instead the literature put the emphasis on technological progress and organizational change (cf. Galor and Moav, 2000; Aghion et al., 2002; and Egger and Grossmann, 2005).

more so, the more they are trading with each other.

2.4 Intra-industry trade models with oligopolistic competition

The fear of an increase in the income gap between workers and firm owners ranks prominently in the public perception about globalization. One strand of literature that is particularly well suited to tackle this issue is the literature on unionized oligopoly in an international context. Oligopolistic competition gives rise to pure rents in the form of firm profits. The generated economic rents can be shared between a firm and its workforce via unions. Originally, the literature concerning rent-sharing in an unionized oligopoly was based on work by Brander (1981) and Brander and Krugman (1983), who were the first to study intra-industry trade between oligopolistic competitors. The baseline model considers an economy with two sectors and labor as the only input factor. One sector is perfectly competitive, whereas in autarky only one monopoly firm is active in the other sector. Considering market segmentation and abstracting from the possibility of new entrants to the market, the profit-maximizing monopoly firm is charging a mark-up on the price, generating positive profits and producing less than would be socially optimal. Moving from autarky to free trade with a symmetric country, implies a switch from monopoly to duopoly. The increase in competition stimulates production, lowers consumer prices and creates a new source for welfare gains from trade.[16]

Despite its intuitive appeal, the approach of oligopolistic competition to explain intra-industry trade has not received as much attention as the approach of monopolistic competition following Krugman (1979, 1980) for homogeneous firms and Melitz (2003) for heterogeneous firms. One potential drawback is that due to the choice of quasi-linear preferences changes in aggregate income exhibit no feedback effects on the imperfectly competitive goods market or labor. Therefore, Neary (2010) calls this only half a theory of trade since it neglects the general equilibrium feedback effects which are typical and a central piece of theories on international trade. Due to this drawback, the literature on unionized oligopoly is also not well suited to investigate aggregate labor market effects of trade such as adjustments in unemployment. This has changed with a recent paper by Neary (2003, 2009) who designed a tractable model of general oligopolistic equilibrium (GOLE). Before presenting the details of this more sophisticated framework, I will first present important insights from partial equilibrium settings with oligopolistic competition in the goods market and imperfect labor markets, distinguishing between models that consider symmetric countries and models that allow countries to differ in their labor market institutions. Hereby, the focus will be on union wage setting as the prevailing source of labor market imperfection.

Partial equilibrium with asymmetric countries. Brander and Spencer (1988) were the first to use an intra-industry trade model of oligopolistic competition to study the effects of unionization. They use a simple oligopolistic model along the lines of Brander and Krugman (1983) to analyze the effects of unionization on international markets. Union activity is modeled in the form of a right-to-manage setting, i.e. firms and unions bargain over wages while the firms

[16] The basic model excludes any form of trade costs. Relaxing this assumption by considering iceberg transportation costs, one finds that they need to be sufficiently low for welfare gains to exist.

remain the right to manage the level of employment. Their study shows that rising bargaining power of labor reduces output and welfare and they shed light on how the presence of unions may influence the optimal strategic trade policy. Mezzetti and Dinopoulos (1991) extend the analysis by Brander and Spencer (1988) and qualify the result of a reduction in output and welfare. They consider a model with efficient bargaining, i.e. firms and unions bargain over wages and employment, and argue that if a union is employment-oriented instead of wage-oriented, then a rise in its bargaining power increases both output and welfare. An employment-oriented union renders the domestic firm more aggressive in the Cournot game on the product market which induces a shift in the economic rents from the foreign to the domestic firm. Furthermore, their study also emphasizes the ability to shift production abroad in case of disagreement in wage bargaining. This improves the fallback profit of the multinational firm and, thus, leads to a lower negotiated wage, similar to Eckel and Egger (2009).

Partial Equilibrium with symmetric countries. Huizinga (1993) and Sørensen (1993) show independent from each other that in a symmetric two-country model with unionized labor markets in both countries, the wage under free trade is lower than in autarky. When opening up for trade, competition on the product market increases which exerts a disciplining effect on the wage claims by unions and thus reduces wages. Naylor (1998, 1999) uses the same framework as Huizinga (1993) and Sørensen (1993) and looks at the complementary question how small changes in trade barriers impact the union wage setting. He shows that in a situation of restricted trade, a further reduction in trade barriers increases wages. Finally, Munch and Skaksen (2002) allow for and distinguish between fixed and variable trade costs. Their study shows that the wage effect of international trade in this kind of unionized oligopoly setting is sensitive as to which of the trade costs are lowered. Thereby, their study is able to explain the different results in the beforementioned contributions and nests them in a unified framework.

An innovative contribution comes from Zhao (1995) who develops a unionized international oligopoly framework to study foreign intra-industry investment, similar to Mezzetti and Dinopoulos (1991). However, in extension to their study, he considers a framework with two symmetric countries and shows that cross-hauling foreign direct investment causes the negotiated wage to decrease and that the existence of labor unions provides an incentive for firms to invest abroad in order to improve their position in the bargain with local unions. In contrast to Eckel and Egger (2009), the study abstracts from any form of trade and investment costs which implies that exporting is never a profitable alternative compared to FDI activity.

General equilibrium. A new interest in unionized oligopoly was initiated by the seminal work by Neary (2009). He developed a model of oligopolistic competition in general equilibrium. Earlier approaches to modelling such a framework have been problematic for a number of reasons. One important obstacle was to make sure, that no agent in the economy has enough market power to influence aggregate variables. The approach by Neary avoids this problem in a very neat and simple way. It assumes a continuum of industries with an exogenous number of firms in each sector competing under Cournot competition. This implies that firms have market power within their own industry, but are small on the aggregate and therefore cannot influence aggregate variables. In this model trade does not only increase competition but also labor demand. For a given labor endowment this leads to an increase in wages. Positive welfare effects only occur if countries are asymmetric and/or productivities are industry-specific but not in a featureless economy of full symmetry.

Bastos and Kreickemeier (2009) were the first to apply this setup for studying the linkage between international trade and union wage-setting behavior. They extend the GOLE framework by considering union activity in a subset of industries, while the firms in the residual sectors pay the competitive wage rate. A movement from autarky to free trade doubles the number of competitors in each industry, which ceteris paribus lowers profits and, thus, wage claims of unions by means of a standard rent-sharing mechanism. Furthermore, the mass of consumers doubles as well. This renders both consumer and labor demand more elastic and further reduces union wage claims. In sum, wages decline and employment in unionized firms increases when a country opens up to trade. This finding is well in line with previous work on international trade in partial equilibrium unionized oligopoly models (see Huizinga, 1993; Sørensen, 1993) – although there is an additional general equilibrium effect in the GOLE setting, as consumer demand adjusts in response to income changes. However, aside from this consumer demand channel, there arises an additional general equilibrium effect due to adjustments in the labor market. If all unionized firms increase their employment level, economy-wide labor demand is stimulated. In a model with labor market clearing, this induces a change in the competitive wage, which must increase in order to restore the labor market equilibrium. The surge in the competitive wage then leads to an increase in the union wage claim and, as pointed out by Bastos and Kreickemeier (2009), this second-round adjustment may be strong enough to dominate the partial equilibrium impact effect, so that the union wage rate can actually increase relative to its autarky level.

2.5 Summary and own contribution

While the theoretical work on heterogenous firms can help shedding light on the increasing importance of firm-specific factors in the determination of wage inequality, these approaches are less suited to explain why industry-specific factors have become a less important determinant of inequality (cf. Faggio, Salvanes, and Van Reenen, 2010). On the other hand, partial equilibrium models with oligopolistic competition and unionized labor markets as well as GOLE models with union activity in only a subset of sectors cannot explain changes in unemployment. Therefore, the first essay (chapter 3) constructs a model of oligopolistic competition in general equilibrium à la Neary (2009) with sector-specific productivities and a unionized labor market. The study shows that globalization in the form of free trade between symmetric countries lowers the wage claims of unions and reduces unemployment as well as intra-group inequality of workers.

Furthermore, labor market institutions differ substantially between countries. The literature has addressed many different forms of imperfections in the labor market. However, the role of union activity as a source of competitive advantage has not been systematically investigated in previous contributions. The second essay (chapter 4) develops a framework that is suited to examine the impact of differences in the wage bargaining regime for explaining differences in macroeconomic performance measures like employment and welfare as well as group-specific well-being. Moreover, it sheds light on the question of how different forms of globalization may change these performance measures due to the prevailing differences in wage setting regimes.

Finally, while the literature has shown that exporting firms are distinctively different from non-exporting ones and that only the most productive firms start exporting, there is relatively little empirical knowledge on the underlying determinants for the selection into exporting. Following the idea by Harrigan and Reshef (2011) we investigate the role of unit labor costs as a driving force for the export activity of German plants. Our estimations provide supportive evidence for the idea that labor costs are an important measure of competitiveness and that there exists a positive correlation between competitiveness and export activity. This correlation is shown to be stronger at the extensive than at the intensive margin.

3 The Impact of Trade on Employment, Welfare, and Income Distribution in Unionized General Oligopolistic Equilibrium

3.1 Introduction

The distributional effects of international trade are of major concern to the general public and policy makers alike. The common fear is that market integration improves the outside opportunities of firm owners, and hence limits the possibility of workers to skim a fair share of the rents arising from economic activity (OECD, 2007). This issue has been prominently discussed in a large literature on union wage setting in an international oligopoly (see, e.g., Mezzetti and Dinopoulos, 1991; Naylor, 1998; Lommerud, Meland, and Sørgard, 2003). However, by focussing on rent sharing at the firm or industry level in a partial equilibrium environment, this literature is not well equipped for analyzing the implications of trade on the economy-wide distribution of profit and wage income, an issue that is of primary interest for policy makers who are concerned about the impact of trade on inequality and social justice (Bernanke, 2007; OECD, 2007). Furthermore, by considering a competitive outside sector that absorbs all workers who do not find a job in unionized industries, existing studies in this literature ignore a key channel through which trade affects inequality, namely changes in the unemployment rate. When being interested in a comprehensive picture of inequality, this seems to be a major shortcoming, since even in countries that offer generous unemployment compensation those who do not find a job are at the lower tail of the income distribution, so that changes in the unemployment rate have serious distributional consequences.[1]

It is the aim of this paper to provide a detailed discussion of how opening up to trade affects rent sharing and thereby the economy-wide distribution of profit and wage income as well as involuntary unemployment. A prerequisite for studying these effects is a model in which firms can make pure profits in equilibrium, and considering a unionized oligopoly seems promising in this respect as it relates the results to a well-established literature on rent sharing in an international trade context. On the other hand, the model should allow for economy-wide effects, and hence we have to embed the unionized oligopoly into a general equilibrium framework.

[1] Since getting unemployed is usually associated with a significant social decline it is not surprising that the risk of job loss is the main concern of workers, regarding the labor market implications of trade liberalization (see Scheve and Slaughter, 2001). In view of such observations, Davidson, Martin, and Matusz (1999, p. 272) claim that "trade economists should begin to seriously consider environments in which unemployment is carefully modeled."

Neary's (2009) general oligopolistic equilibrium (GOLE) model seems to be a suitable framework for this purpose. With a continuum of industries, a small and exogenous number of symmetric firms within each sector, Cournot competition between these firms, and labor as the only factor of production, it captures in a theoretically convincing way the intuitively appealing idea that firms are large and have market power in their own industry, but at the same time are small in the aggregate (and thus can rationally ignore their impact on economy-wide variables), without relying on the common approach of introducing a competitive outside sector that rules out, by construction, any general equilibrium feedback effects of labor market adjustments. Assuming in the GOLE model that industries differ in their technology and that all producers are confronted with wage claims of firm-level unions, we get a tractable theoretical framework, in which the interaction of industry-specific factors and rent sharing between firms and unions generate income inequality along multiple lines.[2] In particular, the resulting framework features inter-group inequality between firm owners and workers as well as intra-group inequality within these two groups of agents, and, of course, involuntary unemployment.[3]

After introducing the main model ingredients, characterizing the closed economy equilibrium and shedding light on the role of unemployment compensation for aggregate employment, welfare and income distribution, we study in detail the consequences of a country's movement from autarky to free trade. To keep the analysis simple, we first look at trade between two fully symmetric countries, while the role of country asymmetries is addressed in an extension to this benchmark scenario. Thereby, we consider two forms of asymmetry, namely size and Ricardian technology differences. With respect to the role of country size differences, there is a presumption from previous work that trade effects are less pronounced in larger economies. We analyze whether such insights extend to a model in which both product and labor markets are imperfectly competitive. With respect to the role of Ricardian technology differences, we know from previous research that in an otherwise identical model with perfectly competitive goods and labor markets, trade leads to full specialization in the production of the two economies (see Dornbusch, Fischer, and Samuelson, 1977). This is no longer true if consumers are served by quantity-setting oligopolistically competitive producers. In this case, we can expect co-existence of domestic and foreign producers over a large subset of industries and, as pointed out by Neary (2009), either country's production even remains fully diversified in the open economy if the prevailing technology differences are not too large. This is the case we are focussing on in our paper, and we analyze within this full diversification framework how the insights from the benchmark model of identical countries have to be modified when allowing for technological dissimilarity.

[2] There is clear supportive evidence for the idea that this interaction is indeed a key determinant of income inequality. For instance, see Dickens and Katz (1987), Krueger and Summers (1988), Katz and Summers (1989), and Grey (1993). More recent evidence is provided by Du Caju, Katay, Lamo, Nicolitsas, and Poelhekke (2010). Using the European Structure of Earning Survey, an internationally harmonized matched employer-employee data set, these authors document the existence and persistence of inter-industry wage differentials in European industries, and they conclude that these differentials are consistent with rent sharing.

[3] Our model is not the first one that introduces labor unions into a GOLE model along the lines of Neary (2009). Bastos and Kreickemeier (2009) use such a framework to show that general equilibrium feedback effects through labor market adjustments are important and that accounting for these feedback effects can change the impact of trade on wages in unionized industries in a qualitative way. However, Bastos and Kreickemeier (2009) assume that unions are only active in a subset of industries, so that involuntary unemployment does not materialize in their setting. Furthermore, they do not address the role of rent sharing for the economy-wide distribution of income, an issue that is in the center of this paper's interest.

As a first result of our analysis we find that trade exerts a union-disciplining effect and thus reduces union wage claims, similar to a partial equilibrium setting (see Huizinga, 1993; Sørensen, 1993). The fall in union wage claims provides an employment stimulus which lowers involuntary unemployment and raises welfare. In the case of fully symmetric trading partners or countries that only differ in their market size, all firms are equally exposed to foreign competition despite prevailing differences in labor productivity across sectors, and the welfare stimulus arises from a proportional increase in output and thus consumption of all industrial goods. With Ricardian technology differences, the positive welfare effect is reinforced as countries (partially) specialize their production according to the law of comparative advantage, while employment declines in response to the relocation of economic activity. For high degrees of technological dissimilarity, this second-round employment reducing effect can be more pronounced than the initial employment stimulus of trade between symmetric countries, so that trade may aggravate the unemployment problem. However, this is not possible if technology differences are sufficiently small, so that trade between industrialized economies can be expected to have a positive employment effect – a result that seems to be well in line with empirical evidence (see Dutt, Mitra, and Ranjan, 2009; Felbermayr, Prat, and Schmerer, 2011a).

With respect to the outcome of rent sharing, we find that the average worker may gain or lose relative to the average firm owner, with the respective result depending crucially on the market power of producers. To be more specific, we show that, on average, firm owners gain relative to production workers if the market power of firms within their own industry is large. For instance, if the autarky equilibrium is characterized by a monopolistic or a duopolistic sectoral market structure, the ratio of average profits to average wages (the profit-wage ratio, in short) definitely goes up in the benchmark case of fully symmetric countries. Furthermore, we find that an increase in the profit-wage ratio is more likely if a country opens up for trade with a smaller trading partner, whereas Ricardian technology differences do not exert a clearcut effect on the profit-wage ratio. Aside from looking at the impact of trade on aggregate measures of rent sharing between firm owners and workers, we also study its impact on the distribution of income within these two groups of agents. In this respect, we show that the distribution of profit income across firm owners does not change in response to trade liberalization if the two countries are fully symmetric or only differ in size. The reason is that all firms are equally exposed to foreign competition and thus experience a proportional output increase in this case. Things are different if countries are technologically dissimilar. In particular, under the plausible assumption that countries have a comparative advantage in their high-productivity industries, they experience a more than proportional expansion of output and thus start exporting in those sectors, in which profits have already been high under autarky. This raises income inequality among firm owners.[4]

[4]That access to trade can have a significant impact on the distribution of profits has also been highlighted by a recent literature on heterogeneous firms (see Melitz, 2003, and consecutive work on the matter). This literature assumes that firms within the same industry differ in productivity and it emphasizes that due to this heterogeneity only the most productive firms within an industry start exporting in the open economy, while the least productive ones cease production in face of foreign competition. These two forms of selection effects provide a relocation of economic activity from less productive to more productive firms, so that inequality of profit income increases even if trade occurs between two fully symmetric countries. In contrast, our results point to a surge in profit income inequality that arises due to a relocation of economic activity between industries if trading partners differ in their technology. Hence, the insights from our analysis are complementary to those from the literature on heterogeneous firms in a Melitz (2003)-type framework.

Regarding the impact of trade on income inequality among production workers, we can distinguish two principle sources of influence, namely changes in the wage differential and changes in the relative employment across industries. If countries are fully symmetric or only differ in their size, a movement from autarky to free trade does not affect the composition of workers across industries. However, it lowers the wage differential between sectors with differing productivity levels and therefore renders the distribution of wage income more equal in the open economy. Things are more complicated if we allow for technological dissimilarity of countries. While we are not able to identify a clearcut effect of technological dissimilarity on the distribution of wage income, insights from numerical simulation exercises indicate that if technological differences of countries are sufficiently pronounced trade does not necessarily lead to lower wage inequality. These results upon the impact of trade on the distribution of labor income contribute to a relatively new literature that addresses the consequences of trade for intra-group wage inequality (see, for instance, Egger and Kreickemeier, 2009; Egger and Meland, 2011; Helpman, Itskhoki, and Redding, 2010; Davis and Harrigan, 2011). Existing studies to this literature point to self-selection of the most-productive firms into export status (and exit of the least productive ones) as a key rationale for explaining observations from both sides of the Atlantic that intra-group wage inequality not only accounts for a substantial part of overall wage inequality but also has significantly increased in recent years (see Katz and Autor, 1999; Barth and Lucifora, 2006; Autor, Katz, and Kearney, 2008).

This selection mechanism is well in line with two empirical regularities, namely the relevance of firm-specific factors for explaining wage inequality (see, for instance, Hildreth and Oswald, 1997; Winter-Ebmer and Zweimuller, 1999) and the observation that exporters are more productive and pay higher wages than non-exporters (see Schank, Schnabel, and Wagner, 2007a, and the literature cited there). However, by focussing on the differential impact that trade exerts on heterogeneous firms within an industry, existing models in this literature are not capable to explain the decline in the relevance of industry-specific factors for individual wage payments over the last few decades (Faggio, Salvanes, and Van Reenen, 2010). A rationale for the latter observation can be inferred from our analysis, which shows that given productivity differences between industries have a smaller impact on sectoral wage payments in an open economy if trade occurs between two countries that are not too different with respect to their production technologies. This suggests that the respective decline in the relevance of industry-specific factors for the wage distribution can at least be partially explained by the significant decline in trade costs over the same period. We can thus conclude that our results upon the impact of trade on intra-group inequality among production workers are complementary to those from the literature on heterogeneous firms within an industry and may therefore be helpful for drawing a comprehensive picture about the channels through which distributional effects of trade can materialize.

The remainder of the paper is organized as follows. Section 3.2 describes the main model ingredients and sets up the theoretical framework. Section 3.3 characterizes the autarky equilibrium and provides insights on how changes in unemployment compensation affect the outcome in the closed economy. Section 3.4 considers trade between two fully symmetric countries and shows how the opening up to trade affects aggregate employment, welfare, the rent sharing between firm owners and workers as well as the distribution of income within these two groups of agents.

In Section 3.5 we consider trade between two asymmetric countries. The last section concludes with a brief summary of the most important results.[5]

3.2 The model set-up

We conduct our analysis in a general oligopolistic equilibrium (GOLE) framework, in which firms are small enough to rationally ignore their influence on aggregate variables, while they are large in their own industry, and hence engage in strategic interaction with their competitors. Production and consumption are modeled along the lines of Neary (2009), who presents a workhorse model of the GOLE theory. However, we deviate from the baseline model by accounting for labor market imperfections due to the presence of labor unions (see Bastos and Kreickemeier, 2009). Furthermore, we distinguish between two types of agents: firm owners who receive profit income and workers who receive wage income if employed and unemployment benefits, otherwise. Details on our modeling strategy are outlined in Subsections 3.2.1-3.2.3.

3.2.1 Preferences and consumer demand

Preferences of the representative consumer are given by an additively separable utility function over a continuum of different goods, with the sub-utility function for each of these goods being quadratic. Denoting consumption of good z by $x(z)$, utility can be written as[6]

$$U[\{x(z)\}] = \int_0^1 \left[ax(z) - \frac{1}{2}bx(z)^2\right] dz. \tag{3.1}$$

The budget constraint of the representative consumer is given by

$$\int_0^1 p(z)x(z)dz \leq I, \tag{3.2}$$

where $p(z)$ denotes the price of good z, and I is aggregate income. Maximizing utility (3.1) subject to a binding budget constraint (3.2) gives the inverse demand function for good z:

$$p(z) = \frac{1}{\lambda}[a - bx(z)], \tag{3.3}$$

where λ represents the Lagrangian multiplier of the respective optimization problem. The Lagrangian multiplier equals the marginal utility of income, which in this model is a function of the first and the second moment of prices,

$$\mu_1^p \equiv \int_0^1 p(z)dz \quad \text{and} \quad \mu_2^p \equiv \int_0^1 p(z)^2 dz, \tag{3.4}$$

[5] In the interest of readability we do not present derivation details in the main text, but relegate them to the appendix.

[6] As discussed in detail in Neary (2009), the preferences underlying the utility function in (3.1) are quasi-homothetic. This allows us to apply the concept of a representative consumer to aggregate consumer demand of heterogeneous agents.

respectively, as well as aggregate income, I. Solving Eq. (3.3) for $x(z)$ and substituting the resulting expression into (3.2), we can reformulate the binding budget constraint to obtain

$$\lambda[\{p(z)\}, I] = \frac{a\mu_1^p - bI}{\mu_2^p}. \tag{3.5}$$

Furthermore, substituting $x(z)$ into (3.1), we can determine indirect utility, which, ignoring constants, can be expressed as $\tilde{U} = -\lambda^2\mu_2^p$.[7]

3.2.2 Technology and production

We associate each good z with a separate production sector and, therefore, consider a large number – or more precisely a continuum – of industries. Firms in all industries use labor to produce a homogeneous output and compete in quantities with the other firms in their industry. Output is linear in the labor input: $y = l/\alpha(z)$, with $\alpha(z)$ denoting the labor input coefficient in industry z. We abstract from investment costs for establishing the production facility and consider an exogenous number of firms, n, which is the same in each industry.

Since the number of competitors within each industry is finite (or small), firms anticipate that they can influence industry-level variables, whereas they rationally take aggregate, economy-wide variables as given. As a consequence, they treat λ parametrically and therefore face linear demand functions, according to (3.3). However, λ is endogenous for the economy as a whole. In what follows, we choose the representative consumer's marginal utility as numéraire and set λ equal to one. This choice of numéraire has become standard in the GOLE literature, as it proves particularly useful from a modeling point of view. However, it implies that income variables in our setting, such as profits and wages, have to be interpreted as real profits or wages *at the margin* and that changes of these variables do not have direct implications for utility (see Neary, 2009).

Considering product market clearing, $\sum_{i=1}^n y_i = x(z)$, and accounting for demand function (3.3), we can then write profits of firm j in sector z as

$$\pi_j = \left[a - b\sum_{i=1}^{n} y_i - c_j(z)\right] y_j, \tag{3.6}$$

where $c_j(z) = \alpha(z)w_j$ denotes unit production costs. Throughout our analysis we focus on the case of positive supply of all firms and, therefore, restrict our attention to parameter configurations that lead to $a > c_j(z)$ for all j and z. Without loss of generality, we assume that industries are ranked such that $\alpha(z)$ is increasing in z.

[7]Notably, the analysis in this subsection builds upon two assumptions: (i) non-satiation and (ii) participation regarding each agent's consumption of any good z. This requires inter alia a positive income level of all agents and sufficiently small price differences between all goods, which in our model can be established by sufficiently small differences in labor productivity. We assume that the relevant parameter constraints are fulfilled, and hence only focus on interior solutions throughout our analysis.

3.2.3 Labor market and factor endowment

Regarding the determination of factor return w_j, we abandon the assumption of a perfectly competitive labor market as in Neary (2009) and assume that each industry is populated by n firm-level unions, which unilaterally set wages, while firms keep the right-to-manage employment and choose $l_j = \alpha(z)y_j$ to maximize profits (3.6) conditional on w_j.[8] The objective function of the labor union is given by[9]

$$V_j = (w_j - \bar{w})l_j, \tag{3.7}$$

with $\bar{w}$ denoting exogenous and constant unemployment benefits, which are financed by a proportional income tax that applies the same tax rate to all types of income, including wages, profits, and unemployment benefits (see Davidson and Matusz, 2006, for a similar assumption). This tax is a lump-sum instrument and does neither distort the firm's profit-maximizing output choice (see above), nor does it influence the outcome of union wage setting. Hence, the wage chosen by the union does not depend on whether the union objective is formulated in pre-tax or after-tax notation, and it is therefore meaningful to choose pre-tax notation in order to save on parameters. Due to our choice of numéraire, the assumption of a constant $\bar{w}$ implies that unemployment compensation is continuously adjusted by policy makers to keep it constant relative to the inverse of the representative consumer's marginal utility of income, λ^{-1}. This assumption is useful for analytical tractability and has the nice implication that nominal unemployment benefits are increasing in aggregate income, which is well in line with empirical evidence. To complete the characterization of the labor market in our model, we finally assume that the country is populated by L identical workers, each of them endowed with one unit of labor.

3.3 Equilibrium in the closed economy

The equilibrium outcome is determined by the solution of a two-stage problem with unions setting wages at stage one, and firms deciding upon output (employment) and purchases taking place at stage two. In Subsection 3.3.1, we solve the two-stage problem through backward induction and determine firm-level and industry-level variables. In Subsection 3.3.2 we solve for the general equilibrium and characterize economy-wide variables.

3.3.1 Solving for firm-level and industry-level variables

At stage 2, firms choose profit-maximizing output (employment) levels. With firms anticipating that all their competitors in industry z are identical and set the same output level, $y_i = y_k$

[8] In a previous version of this manuscript, we have considered a slightly more general framework with wage negotiations between firms and unions. However, since our main results do not hinge on the relative bargaining strength of firms and unions, we decided to stick to the more parsimonious model in which unions have all the bargaining power and therefore set wages unilaterally.

[9] Eq. (3.7) can either be interpreted as a Stone-Geary objective function, with unions simply maximizing rents and workers being perfectly mobile across firms and industries (see Bastos and Kreickemeier, 2009), or it can be interpreted as a utilitarian objective function, with union membership being predetermined. In the latter case, it is commonly assumed that workers are assigned in a way such that each union has some unemployed members and at the same time can prevent outsiders from being hired by the firm before its unemployed members get a job (see Alesina and Perotti, 1997; Blanchard and Giavazzi, 2003). Furthermore, the assignment can be such that expected labor income of individual workers is the same in all unions. For an overview on different objective functions, see Oswald (1985).

$\forall i, k \neq j$, the solution to the profit-maximization problem of firm j is given by

$$y_j = \frac{a + (n-1)\alpha(z)w_i - n\alpha(z)w_j}{b(n+1)}, \quad l_j = \frac{\alpha(z)\left[a + (n-1)\alpha(z)w_i - n\alpha(z)w_j\right]}{b(n+1)}, \tag{3.8}$$

according to (3.6), and, as mentioned above, both of these variables are independent of the common tax rate, as proportional income taxation is non-distortionary in our setting. To solve the wage-setting problem of union j, we substitute l_j from (3.8) in (3.7) and maximize the respective expression. Furthermore, considering symmetry, i.e. $w_j = w_i$, in the first-order condition $dV_j/dw_j = 0$, we obtain[10]

$$w_j = \frac{a + n\alpha(z)\bar{w}}{\alpha(z)(n+1)} \equiv w(z) \tag{3.9}$$

for the pre-tax wage income of workers in industry z. While all firms within a single industry use the same technology and thus pay identical wages, it follows from (3.9) that sectors with higher labor productivity, i.e. a lower $\alpha(z)$, pay higher wages. This is intuitive, because firms in more productive sectors realize higher profits, all other things equal, and unionized labor participates in these higher profits due to a rent-sharing mechanism.[11]

The relative wage paid in two industries z_1, z_2, with $\alpha(z_1) > \alpha(z_2)$ is given by

$$\frac{w(z_2)}{w(z_1)} = \frac{\alpha(z_1)\left[a + n\alpha(z_2)\bar{w}\right]}{\alpha(z_2)\left[a + n\alpha(z_1)\bar{w}\right]} \equiv \omega_{21}. \tag{3.10}$$

It is immediate that $\omega_{21} > 1$, because firms in sector z_2 use a more productive technology than firms in sector z_1. However, the sectoral wage differential, ω_{21}, is smaller than the prevailing productivity differential, due to the existence of unemployment compensation. Put differently, unemployment compensation leads to wage compression in our model. The impact of $\bar{w}$ on the wage differential in (3.10) is monotonic. A higher unemployment benefit raises the fallback income of workers. This leads to higher wage claims of unions, with the respective effect being stronger in sectors with lower productivity, according to (3.9). As a consequence, the wage differential ω_{21} shrinks if $\bar{w}$ goes up. Finally, income taxation does not exert an impact on the wage differential, as long as the same tax rate is applied to all factor returns.

Substituting the wage rate from (3.9) in (3.8), gives equilibrium output and employment levels:

$$y(z) \equiv \frac{n[a - \alpha(z)\bar{w}]}{b(n+1)^2}, \quad l(z) \equiv \frac{n\alpha(z)[a - \alpha(z)\bar{w}]}{b(n+1)^2}. \tag{3.11}$$

[10] Two remarks are in order here. First, rent sharing implies $w(z) > \bar{w}$ if firms have market power and, thus, make positive profits. In the limiting case of $n \to \infty$, the model approaches to one with perfect competition in the product market, with zero profits, and hence $w(z) = \bar{w}$ – provided the firms can hire the profit-maximizing amount of labor at $\bar{w}$. Second, substituting $w(z)$ from (3.9) into condition $a > c(z)$, it is immediate that $a > \alpha(1)\bar{w}$ is sufficient for an interior solution with a positive output level in all industries.

[11] There is indeed strong empirical support for the idea that more productive firms pay higher wages (see Hildreth and Oswald, 1997). This finding also survives if one controls for individual-specific factors, like education or experience. Furthermore, existing results suggest that a substantial part of the prevailing wage differential is still due to industry effects, even though the role of these effects has continuously declined in recent years (see Faggio, Salvanes, and Van Reenen, 2010). For instance, Blanchflower, Oswald, and Sanfey (1996, p. 241) conclude that "[c]hanges in industries' levels of prosperity have large effects upon workers' remuneration."

The equilibrium price level then follows from (3.3):

$$p(z) = \frac{(2n+1)a + n^2\alpha(z)\bar{w}}{(n+1)^2}. \tag{3.12}$$

Higher unemployment benefits, $\bar{w}$, lead to higher wage claims and thus lower output and employment at the firm level. This reduces competition in the goods market and leads to higher prices in all industries, according to (3.12). Comparing two firms with differing labor input coefficients (and thus two firms from different industries), we find that the firm with the higher input coefficient $\alpha(z)$ has higher production costs for a given wage rate, but at the same time pays lower wages, due to more moderate wage claims of unions. The first effect dominates in our setting, so that the firm with the higher $\alpha(z)$ faces higher unit production costs and thus a lower output level $y(z)$. Since within an industry all firms are symmetric, sectoral output is lower and prices are higher in less productive industries. This is in line with Neary (2009). However, the respective output and price differential across industries is smaller if labor markets are unionized. Regarding employment, we can again distinguish two counteracting effects of a higher $\alpha(z)$. On the one hand, it lowers output and thereby employment, $l(z)$, all other things equal. On the other hand, more labor is needed to produce a given level of output. In general, it is not clear which of the two counteracting effects dominates. To be more specific, we find that $dl(z)/d\alpha(z) >,=,< 0$ if $a >,=,< 2\alpha(z)\bar{w}$. Hence, comparing firms from two industries with differing labor input coefficients, $\alpha(z_1) > \alpha(z_2)$, we find that an outcome with a higher employment level in the more productive firm, i.e. $l(z_2) > l(z_1)$, is the more likely the higher is the level of unemployment benefits, $\bar{w}$. This is intuitive as higher unemployment compensation lowers the wage differential ω_{21}, according to (3.10), and therefore increases the output differential $y(z_2) - y(z_1)$, according to (3.11). Leaving the employment requirement for producing a given level of output unaffected, an increase in $\bar{w}$ therefore raises the employment differential $l(z_2) - l(z_1)$ in favor of the more productive firm.

In a final step, we can now substitute wage (3.9) for w_j and output (3.11) for y_j in (3.6), to determine equilibrium (pre-tax) profits $\pi(z)$. With linear demand, these profits are proportional to the square of output, $\pi(z) = by(z)^2$, so that it is immediate from our analysis above that profits are higher in more productive industries and decreasing in the level of unemployment benefits $\bar{w}$. Since all sectors are populated by the same exogenous number of producers, these insights also extend to industry-wide profits. This completes our discussion on firm- and industry-level variables.

3.3.2 Unemployment, welfare, and income distribution

With the insights from Subsection 3.3.1 at hand, we can now solve for the general equilibrium and characterize the economy-wide variables. Thereby, we need to keep in mind that the income tax introduced for financing unemployment benefits adjusts endogenously if we impose the common assumption of a balanced budget of the public sector. However, due to the lump-sum character of a proportional income tax, we do not need to analyze these adjustments in detail, as the respective changes in the tax rate do not feed back on the general equilibrium variables of interest: unemployment, welfare and income distribution.[12]

The mass of unemployed agents can be determined by adding up employment over all firms and subtracting the resulting expression from total labor endowment. This gives $uL = L - \int_0^1 nl(z)dz$, where u denotes the unemployment rate. Substituting for $l(z)$ from (3.11), we thus obtain

$$uL = L - \frac{n^2 \left(a\mu_1 - \bar{w}\mu_2\right)}{b(n+1)^2}, \tag{3.13}$$

with

$$\mu_1 = \int_0^1 \alpha(z)dz, \qquad \mu_2 = \int_0^1 \alpha(z)^2 dz \tag{3.14}$$

being the first and (uncentred) second moments of the technology distribution. From (3.13), we can deduce that total employment $(1-u)L$ is independent of labor supply, implying that aggregate unemployment uL increases one-for-one with L. Provided that L is sufficiently large, labor supply is thus a non-binding constraint in our setting. This is in line with Brecher's (1974) model on minimum wages in a traditional trade framework, and it is the case we are focussing on in the subsequent analysis. As noted in the last subsection, higher unemployment benefits lead to higher wage claims and to lower employment at the firm level. From (3.13), we see that this effect translates into lower aggregate labor demand and thus higher unemployment. This is intuitive and well in line with the existing literature on labor unions in general equilibrium models (see, for instance, Layard and Nickell, 1990).

A further aggregate variable of interest is welfare, which in a model with a representative consumer can be expressed by this consumer's indirect utility. Recollecting $\lambda = 1$ and ignoring costants, welfare can be written as $\tilde{U} = -\mu_2^p$. In view of (3.12), we obtain:

$$\tilde{U} = -\int_0^1 \left[\frac{(2n+1)a + n^2\alpha(z)\bar{w}}{(n+1)^2}\right]^2 dz. \tag{3.15}$$

It is immediate that $\tilde{U}$ depends negatively on unemployment benefits $\bar{w}$. However, as pointed out by a referee, one needs to be careful when discussing the welfare effects of changes in unemployment compensation in a model that lacks the main reason for introducing such a compensation: a public insurance against the income loss when getting unemployed in a world with risk averse agents.

The final aggregate variable of interest is income inequality which allows us to assess how the rents of production are distributed between firm owners and workers as well as within these two

[12] While a change in the income tax *per se* does not have a direct effect on *aggregate* welfare, it of course alters individual welfare, which depends on the net income of the respective agent. For that reason and in view of the fact that there is a continuum of income groups in our setting, it is cumbersome to determine individual welfare changes in the comparative-static experiments studied below. We therefore infer insights upon how agents from different income groups are affected in our comparative-static experiments from looking at the relative change in these agents' income, instead of comparing their welfare levels. This has the advantage of easier analytical tractability and, in addition, allows us to compare the results from our analysis with findings from other theoretical or empirical work on the matter. In particular, empirical studies provide evidence on the evolution of income inequality, while, lacking detailed information on preferences, they do not offer insights on how the welfare of individual agents adjusts over time. On the other hand, by focussing on relative income changes, we cannot determine whether aggregate welfare increases are associated with gains of all agents or involve losses of a subgroup of them. This should be kept in mind, when interpreting our results.

groups of agents from an economy-wide point of view. Thereby, we have to be careful when deciding upon how to measure inequality. Due to our choice of numéraire, it is not meaningful to study absolute differences in income levels, as they only allow insights into real income inequality at the margin – without direct implications for utility (see Neary, 2009). However, we can look at relative income measures, as they do not depend on the choice of numéraire and have the additional attractive feature of being unaffected by changes in the proportional income tax. Put differently, looking at changes in the relative return of certain income groups provides insights on how these groups' real income has changed in relative terms, despite choosing utility as numéraire in our analysis.

To get an idea about how production rents are distributed between firm owners and workers, we can look at the ratio of average profits to average wages, which is given by

$$\xi = \frac{n^2}{b(n+1)^3} \frac{\left[a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right]\left[a\mu_1 - \bar{w}\mu_2\right]}{a^2 + (n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2}. \tag{3.16}$$

This ratio approaches zero if firms have no market power, i.e. in the limiting case of $n \to \infty$. With perfect competition firms make zero profits, while the common wage rate equals the unemployment compensation, $\bar{w}$. Otherwise, ξ is strictly positive and it may exceed one if both the unemployment compensation and the number of competitors are not too high. This is the empirically relevant case and the one we are focussing on in the subsequent analysis. A higher $\bar{w}$ raises union wage claims and lowers profits, implying that the profit-wage ratio in (3.16) falls if unemployment compensation becomes more generous.

For a comprehensive picture of income inequality, we additionally account for the cross-sectoral distribution of profits and the personal income distribution of workers, as two measures of intra-group income inequality. With a continuous distribution of profit and wage income, it is a necessary first step to find an adequate summary statistics. The two most commonly used metrics in this respect are the Gini index and the Theil index. Both of these indices share one important property: they are based on the Lorenz curve. Hence, instead of choosing one particular index, we can directly look at the Lorenz curve in the subsequent analysis.[13]

We start with analyzing the Lorenz curve for profit income, which is given by

$$\mathfrak{I}(\bar{z}) \equiv \frac{a^2\bar{z} - 2a\bar{w}\int_{1-\bar{z}}^{1}\alpha(z)dz + \bar{w}^2\int_{1-\bar{z}}^{1}\alpha(z)^2 dz}{a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2} \tag{3.17}$$

and depicted in Figure 3.1. It ranks sectors according to their profit income and measures the share of profits that is attributable to industries $z \geq 1 - \bar{z}$, which are the $\bar{z}$ industries with the lowest rank in the profit distribution. A higher $\bar{w}$ lowers $\mathfrak{I}(\bar{z})$ for any given $\bar{z} \in (0,1)$, and thus raises cross-sectoral profit inequality. Higher unemployment benefits induce higher wage claims, according to (3.9), which reduces profits in any sector. However, with firms differing in productivity, the negative profit effect is not equally strong in all industries. As outlined above, unemployment benefits lead to wage compression, so that the increase in union wage claims as well as the decline in profits are more pronounced in industries with low productivity, i.e. a high $\alpha(z)$. This makes the cross-sectoral profit distribution more unequal.

[13]Details on how the inequality measures in this subsection are determined and a formal discussion of their

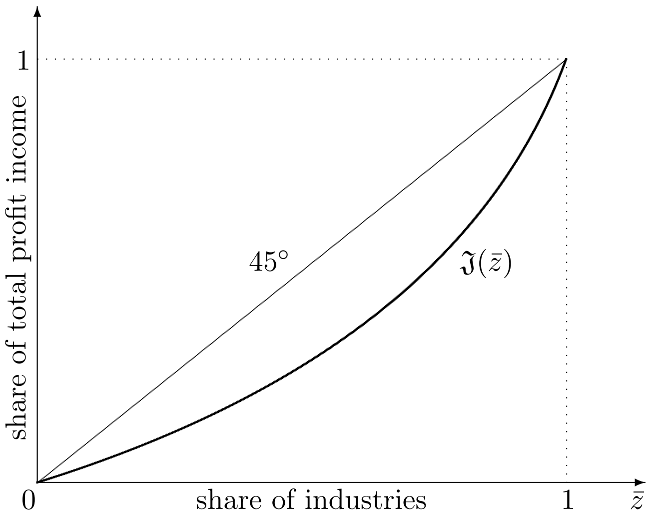


Figure 3.1: The Lorenz curve for profit income

The Lorenz curve for wage income is slightly more complicated than the one for profit income and characterized by the following two equations:

$$\mathfrak{L}(\bar{z}) \equiv \frac{a^2\bar{z} + (n-1)a\bar{w}\int_{1-\bar{z}}^{1}\alpha(z)dz - n\bar{w}^2\int_{1-\bar{z}}^{1}\alpha(z)^2dz}{a^2 + (n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2} \tag{3.18}$$

and

$$\rho(\bar{z}) \equiv \frac{a\int_{1-\bar{z}}^{1}\alpha(z)dz - \bar{w}\int_{1-\bar{z}}^{1}\alpha(z)^2dz}{a\mu_1 - \bar{w}\mu_2}, \tag{3.19}$$

where the former equation determines the share of wage income that accrues to workers in industries $z \geq 1-\bar{z}$, while the latter equation determines the share of production workers employed in industries $z \geq 1-\bar{z}$: $\bar{\rho} \equiv \rho(\bar{z})$. Substituting $\rho^{-1}(\bar{\rho})$ from (3.19) for $\bar{z}$ in (3.18), gives the Lorenz curve for labor income $\mathfrak{M}(\bar{\rho}) \equiv \mathfrak{L}(\bar{z}(\bar{\rho}))$, which is depicted in Figure 3.2. If firms differ in their productivity level, the existence of labor unions leads to cross-sectoral wage inequality among ex ante identical workers. In this case, unemployment compensation becomes a crucial determinant of the wage distribution and an increase in $\bar{w}$ affects the Lorenz curve through two different channels of influence. On the one hand, higher unemployment benefits lead to higher wage payments in all sectors, with the respective increase being more pronounced in less productive industries (see Eqs. (3.9) and (3.10)). This lowers the cross-sectoral wage differential, and hence renders the wage distribution more equal. On the other hand, the higher labor costs lead to a decline of employment in all sectors, with the relative employment between two industries increasing in favor of the more productive one. This increases the cross-sectoral wage inequality ceteris paribus. Unfortunately, we are not able to determine the total impact of a higher $\bar{w}$ on the distribution of wage income for arbitrary levels of unemployment benefits. However, in the appendix we show that slightly increasing a small $\bar{w}$ unambiguously lowers wage

properties are deferred to the appendix.

income inequality.[14] This completes our discussion of the closed economy.

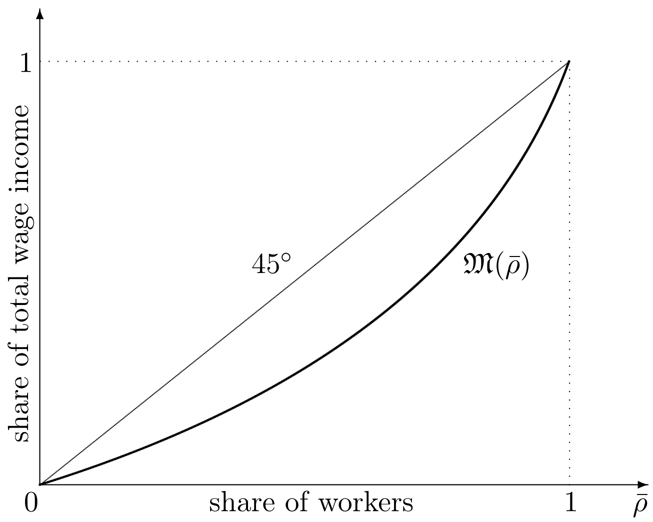


Figure 3.2: The Lorenz curve for wage income

3.4 Trade between two fully symmetric countries

In this section, we consider trade between two countries, whose economies are as described in Section 3.2. We abstract from any trade impediments and assume that goods markets are fully integrated, while labor markets remain internationally segmented and workers are immobile between countries. Furthermore, we assume that the two countries under consideration are fully symmetric in all respects and defer a discussion of country asymmetries to Section 3.5.

In the open economy, aggregate demand for output of sector z can be determined by maximizing utility of the representative *world* consumer subject to his/her budget constraint. This gives inverse demand for good z:

$$p(z) = \frac{1}{\lambda}\left[a - \frac{b}{2}x(z)\right], \tag{3.3'}$$

where $x(z)$ now refers to global consumption of good z. Comparing the latter with (3.3), we see that consumer demand is more elastic in the open economy than under autarky. With this insight at hand, we can now study the open economy equilibrium. Again, we start our analysis with the characterization of firm- and industry-level variables and compare our findings for the trade regime with the respective results under autarky.

[14] In order to see whether this result holds more generally, we have conducted a set of numerical simulation exercises for different specifications of $\alpha(z)$, including $\alpha(z) = e^z$ and $\alpha(z) = 1 + z^\gamma$, $\gamma \in \{0.5, 1, 2\}$. These simulation exercises indicate that, at least for the considered specifications, the inequality reducing effect of an increase in $\bar{w}$ extends to larger levels of unemployment benefits.

3.4.1 Firm-level and industry-level variables in the open economy

Solving the maximization problem of firm-level unions gives wage rate

$$w^t(z) = \frac{a + 2n\alpha(z)\bar{w}}{\alpha(z)(2n+1)}. \tag{3.9'}$$

Comparing (3.9′) with (3.9), it is immediate that $w^t(z) < w^a(z)$, where superscripts t and a are introduced in order to distinguish between $t$rade and $a$utarky variables, respectively. There are three effects that can be distinguished. First, the number of competitors as well as the mass of consumers doubles when a country starts trading with a symmetric partner economy. In line with textbook oligopoly models, we can thus conclude that for given wages the opening up to trade leads to higher output and higher labor demand at the firm level. All other things equal, this provides an incentive for unions to set higher wages. Second, the increased competition in the goods market lowers profits, and hence wage claims of unions by means of a standard rent-sharing argument. Third, labor demand is more elastic in the open economy. This affects the trade-off between higher wages and higher employment in union objective (3.7) and implies that a given increase in union wage claims causes a stronger negative employment effect than in the closed economy. All other things equal, this reduces the incentives of unions to set excessive wages. In sum, the latter two effects dominate the former one, so that trade liberalization disciplines unions and leads to more moderate wage setting. However, this does not mean that unionized workers are worse off in the open economy. On the one hand, $w(z)$ measures real wages at the margin (see Neary, 2009), so that changes in these wages do not have direct welfare implications. On the other hand, $w(z)$ refers to pre-tax wages, so that a decline in $w(z)$ does not account for endogenous adjustments in the income tax rate, which gives rise to a general equilibrium feedback on net labor income in our model.

For both of these reasons, it is not meaningful to put too much emphasis on changes in levels, but rather one should infer insights on how trade affects union wage setting from changes in wage ratios. In this respect, we can note that the strength of the wage dampening effect is industry-specific and depends on the prevailing productivity level. For instance, the wage differential between two industries z_1 and z_2, with $\alpha(z_1) > \alpha(z_2)$ is given by

$$\omega_{21}^t = \frac{\alpha(z_1)\left[a + 2n\alpha(z_2)\bar{w}\right]}{\alpha(z_2)\left[a + 2n\alpha(z_1)\bar{w}\right]} \tag{3.10'}$$

in the open economy. Comparing the latter with the respective ratio in the closed economy, we get $\omega_{21}^t < \omega_{21}^a$, implying that the cross-sectoral wage differential shrinks if an economy opens up to trade. This is intuitive, as the existence of unemployment compensation causes wage compression, so that the decline in wages due to the opening up to trade is less pronounced in industries with low productivity. To substantiate this argument, it is worth noting that, in view of (3.10) and (3.10′), $\omega_{21}^t = \omega_{21}^a = \alpha(z_2)/\alpha(z_1)$ holds in the borderline case of $\bar{w} = 0$. From this, we can deduce that the social security system does not only determine the extent of income inequality but also affects the way in which relative factor returns respond to international trade.

Regarding output and employment in the open economy, we can calculate

$$y^t(z) = \frac{4n[a - \alpha(z)\bar{w}]}{b(2n+1)^2}, \quad l^t(z) \equiv \frac{4n\alpha(z)[a - \alpha(z)\bar{w}]}{b(2n+1)^2}. \tag{3.11$'$}$$

On the one hand, firms expand activity at given wages and, on the other hand, wages decline. Since both effects go into the same direction, it is immediate that firms operate at a larger scale in the open economy. Substituting $x(z) = 2ny^t(z)$ from (3.11′) in (3.3′), we can conclude that the price in the open economy is given by

$$p^t(z) = \frac{(4n+1)a + 4n^2\alpha(z)\bar{w}}{(2n+1)^2} \tag{3.12$'$}$$

and lower than under autarky. This confirms the key finding of Brander (1981) that trade exhibits a pro-competitive effect if an oligopolistic structure with firms competing in quantities prevails in the product market.

In a final step, we investigate the impact of trade on profit income. While changes in income levels *per se* do not exert direct welfare implications (see above), the comparison of (pre-tax) profits in autarky and free trade is still instructive as it highlights one important channel through which trade can alter the distribution of income in our setting. To be more specific, we will see in the next section that changes in profit income and changes in union wage-setting fully characterize the impact of trade on the profit-wage ratio. With linear demand, firm-level profits are proportional to the square of output, implying $\pi^a(z) = b\,[y^a(z)]^2$ and $\pi^t(z) = (b/2)\,[y^t(z)]^2$ for the closed and the open economy, respectively. Substituting the output levels from (3.11) and (3.11′), the following result is immediate. Firm-level profits are higher in the free trade equilibrium than under autarky if the number of competitors is sufficiently small.[15] There are two counteracting effects at work. On the one hand, there is stronger competition in the open economy, implying that firm-level profits shrink. For given wages, this effect is counteracted but not dominated by the increase in the number of consumers. On the other hand, unions set lower wages in the open economy, thereby providing an additional source for profit gains. It turns out that the second effect is stronger than the first one if the market power of firms is sufficiently large. Since the number of local producers stays constant in either economy, the respective firm-level profit effects translate one-to-one into industry-level profit effects.

3.4.2 Aggregate variables in the open economy

In this subsection, we close the general equilibrium model and characterize aggregate variables in the open economy. Thereby, we focus on unemployment, welfare and the three measures of inequality, while leaving a detailed discussion on the income tax rate open to the interested reader. The unemployment rate, is determined in analogy to the closed economy and, using $l^t(z)$

[15]Note first that $\pi^t(z) >,=,< \pi^a(z)$ is equivalent to $8/(2n+1)^4 >,=,< 1/(n+1)^4$, according to (3.11), (3.11′) and the respective expressions for firm level profits under autarky and free trade. Noting that $8(n+1)^4/(2n+1)^4 = 1$ has a unique solution in $\mathbb{R}^+$ at $\bar{n} \approx 2.14261$, with $8(n+1)^4/(2n+1)^4 >,=,< 1$ if $\bar{n} >,=,< n$, confirms the respective result in the text. Restricting n to integer values, we can thus conclude that firm owners are better off in the free trade equilibrium if either a monopolistic ($n = 1$) or a duopolistic ($n = 2$) market structure prevails in the autarky equilibrium. This result is akin to findings by Huizinga (1993) and Naylor (2002).

from (3.11′) instead of $l^a(z)$ from (3.11), it can be expressed as

$$u^t L = L - \frac{4n^2\left[a\mu_1 - \bar{w}\mu_2\right]}{b(2n+1)^2}. \tag{3.13′}$$

Intuitively, due to a positive employment stimulus at the firm level, the unemployment rate is lower under free trade than under autarky. This is in line with empirical evidence from cross-country studies (see Dutt, Mitra, and Ranjan, 2009; Felbermayr, Prat, and Schmerer, 2011b) but differs from recent theoretical insights from the heterogeneous firms literature. This literature emphasizes the selection effects of trade, which imply that those firms with the lowest productivity level leave the market while the most productive producers expand production and start exporting. In a model with labor market imperfection, this generates two counteracting effects on total employment. And total employment may actually shrink in response to trade with a fully symmetric trading partner, if the employment stimulus from exporting is dominated by the employment drop due to firm exit (see Egger and Kreickemeier, 2009). In our model, firms in a particular industry are homogeneous and all producers expand their production when a country moves from autarky to free trade with a fully symmetric trading partner, because access to international trade exerts a pro-competitive effect which lowers union wage claims and raises firm-level employment.

Changes in aggregate employment and output also exhibit an impact on welfare. Noting from above that welfare is measured by the representative consumer's indirect utility, $\tilde{U} = -\mu_2^p$, we obtain

$$\tilde{U}^t = -\int_0^1 \left[\frac{(4n+1)a + 4n^2\alpha(z)\bar{w}}{(2n+1)^2}\right]^2 dz \tag{3.15′}$$

according to (3.12′). Comparing $\tilde{U}^t$ and $\tilde{U}^a$, proves existence of gains from trade due to a fall in consumer prices, i.e. $p^t(z) < p^a(z)\ \forall z$. While this result is well in line with the positive welfare effects in Neary (2009), there remains a crucial difference between the mechanisms at work. With perfect labor markets, there are no gains from trade if (i) the two economies are identical in all respects and (ii) all industries utilize the same production technology. In such a *featureless* economy, international trade stimulates competition in the product market and, thus, shifts income from firm owners to workers, while it leaves aggregate output and welfare unaffected. In our framework, opening up to trade lowers union wage claims, and hence reduces involuntary unemployment. This increases output and lowers consumer prices, thereby providing a welfare stimulus even if all domestic and foreign industries make use of the same production technology.[16]

We summarize our findings upon the employment and welfare effects of trade in the following

[16] The welfare effects in this paper also differ from those in Bastos and Kreickemeier (2009), who – similar to us – consider union wage setting in a general oligopolistic equilibrium model. However, with unions being active only in a subset of industries, all workers find a job, implying that, by construction, aggregate employment effects cannot materialize in their setting. Nonetheless, there are gains from trade in the Bastos and Kreickemeier (2009) framework, even if countries are identical and all industries use the same technology. The reason is that if sectors differ in their labor market institutions, their wage costs and prices differ as well. In such a setting, the opening up to trade reduces the wage premium in unionized industries, so that the variance of consumer prices across sectors declines. This raises welfare even though aggregate output and employment stay constant in the Bastos and Kreickemeier (2009) framework.

proposition

Proposition 1 *A shift from autarky to free trade with a fully symmetric partner country stimulates aggregate employment and welfare.*

Of course, the insight that positive employment effects are an important channel through which gains from trade can materialize is not entirely new. In particular, in a setting in which labor market distortions are the only source of market imperfection, an employment stimulus brings an economy closer to its production possibility frontier with positive consequences for efficiency and welfare. This effect is well understood from the seminal work by Brecher (1974), and the respective insight has been extended to models that feature monopolistic competition and thus *almost efficient* product markets (see Matusz, 1996; Egger and Etzel, 2012a). However, in a setting with an oligopolistic market structure and union wage setting, there exists a non-trivial interplay of product and labor market imperfections, so that the welfare implications of higher employment are not immediate. In this respect, our analysis provides the novel insight that previous findings upon gains from trade due to an employment stimulus extend to general oligopolistic equilibrium models with Cournot competition in the product market and union wage setting in the labor market.

While a comparison of (3.15) and (3.15′) reveals that the economy as a whole is better off in the open than the closed economy, this does not mean that all individuals equally benefit from a movement towards free trade. In particular, trade changes rent sharing between firm owners and workers and thus inter-group inequality. To determine this effect, we can look at the profit-wage ratio, which in the open economy is given by

$$\xi^t = \frac{8n^2}{b(2n+1)^3} \frac{\left[a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right]\left[a\mu_1 - \bar{w}\mu_2\right]}{a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2}. \tag{3.16′}$$

Comparing Eqs. (3.16) and (3.16′), we can conclude that inter-group inequality is larger in the open than in the closed economy, i.e. $\xi^t > \xi^a$, if the number of competitors in either economy is small. As formally shown in the appendix, $n \leq 2$ is sufficient for an increase in inter-group inequality after trade liberalization. This is intuitive, as we already know from Subsection 3.4.1 that the opening up to trade lowers real wages at the margin, while it raises real profits at the margin if the market power of incumbent firms is large. On the contrary, if the number of competitors is sufficiently high, not only profit income but also inter-group inequality is reduced by a shift from autarky to free trade.

The following proposition summarizes our insights regarding the impact of trade on inter-group inequality.

Proposition 2 *A shift from autarky to trade with a fully symmetric partner country, does not provide a clearcut effect on inter-group inequality between firm owners and production workers. This effect depends on the market power of firms in the closed economy. If competition in the closed economy is strong (weak), firm owners will lose (gain) relative to production workers when a country opens up to trade.*

To the extent that firm owners are better educated than production workers, the insights from Proposition 2 contribute to the controversial debate upon the role of trade for explaining the surge in the US skill premium during the 1980s. Empirical evidence suggests that trade had just a minor impact (see Bound and Johnson, 1992; Katz and Murphy, 1992), and following the reasoning from traditional theory this can be explained by the relatively small extent of North-South trade in the respective period (Krugman, 2000). Our analysis offers an additional explanation: in a setting with intra-industry trade between two advanced countries, the outcome of rent-sharing between firm owners and workers may be biased towards the former group if trade barriers are abolished, even though the respective trade cost reduction may exert just a small stimulus on actual trade flows if the two countries are similar and the world market is fully integrated ex post. Hence, it is not the observed pattern of trade that matters for the skill premium, but rather the increase in competition when a country opens up for trade according to our analysis.

In a final step of our analysis, we now look at the impact of trade on the distribution of income within the group of firm owners and the group of production workers, respectively. As formally shown in the appendix, access to trade does not affect the Lorenz curve for profit income. To understand this invariance result, it is worth noting that with linear demand profits are proportional to the square of output (or employment), and hence we can infer insights regarding relative profit effects from insights upon relative employment effects. With respect to relative employment across industries, we can distinguish two effects of trade. On the one hand, firms in more productive industries produce at a less elastic segment of the labor demand curve than firms in industries with a high $\alpha(z)$. This implies that a proportional reduction in wages induces a less than proportional expansion of employment in industries with a small $\alpha(z)$. On the other hand, wages fall more than proportionally in high-productivity industries, according to Eq. (3.10′). This counteracts and exactly offsets the former effect, so that relative employment and output levels remain unaffected when a country moves from autarky to free trade (see Eqs. (3.11) and (3.11′)). However, with relative output remaining constant, relative profits do not change either, and hence the cross-sectoral profit distribution under autarky must be equal to the respective distribution under free trade.

Income inequality within the group of production workers is captured by the Lorenz curve for labor income. To determine the respective curve in the open economy, we proceed as under autarky and combine the Lorenz curve for cross-sectoral wage inequality, which is given by

$$\mathfrak{L}^t(\bar{z}) \equiv \frac{a^2\bar{z} + (2n-1)a\bar{w}\int_{1-\bar{z}}^{1}\alpha(z)dz - 2n\bar{w}^2\int_{1-\bar{z}}^{1}\alpha(z)dz}{a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2}, \tag{3.18′}$$

with the employment distribution across industries, which is characterized by the same $\rho(\bar{z})$ as in the closed economy, because – as noted above – relative employment between any two sectors remains unaffected when a country opens up to trade. Intuitively, since relative employment of any two industries stays constant, while the wage premium paid by more productive industries shrinks, according to (3.10′), intra-group wage inequality must fall when two fully symmetric countries move from autarky to free trade.

This concludes the formal discussion, and we summarize our insights regarding the impact of trade on intra-group inequality in the following proposition.

Proposition 3 *A shift from autarky to free trade with a fully symmetric partner country does not* *affect income inequality among firm owners, while it lowers income inequality among production workers.*

The results in Proposition 3 have to be interpreted with care. For instance, the finding that trade does not affect the distribution of income within the group of firm owners crucially depends on the proportional increase of firm-level output in all industries when a country moves from autarky to free trade. This invariance result is therefore an immediate implication of our assumption that the two countries are fully symmetric, which rules out a relocation of production across industries. Once we allow for country asymmetry, trade will alter relative employment of firms from different industries and thus the distribution of profit income. Whether this will lead to more or less inequality is analyzed in the next section. Furthermore, the finding that trade renders the distribution of labor income more equal should not be understood as a general claim that trade reduces labor income inequality, since our model closes several important channels through which trade can affect the distribution of wages. For instance, by assuming that all firms within a particular industry are identical, we abstract from distributional effects that materialize due to self-selection of just the best producers into export status (see Egger and Kreickemeier, 2009; Egger and Meland, 2011; Helpman, Itskhoki, and Redding, 2010) and thus ignore an important mechanism through which trade can increase wage inequality. However, our analysis points out that trade lowers the relevance of industry-specific factors for the remuneration of workers and therefore adds a new facet to the discussion upon the distributional effects of trade – one that seems to be well in line with the empirical observation that the role of industry-specific factors for explaining individual wage income has continuously declined over the last few decades (see Faggio, Salvanes, and Van Reenen, 2010), a period in which trade costs have fallen significantly.

3.5 Trade between two asymmetric countries

In the previous section, we have considered the impact of a country's movement from autarky to trade with a symmetric partner country on welfare, unemployment, and income distribution. We now analyze whether the main results from this analysis extend to the case of asymmetric economies. In principle, there can be many sources of asymmetry, and it is of course beyond the scope of a single paper to study all of them. However, we can at least look at two specific forms of asymmetry that feature prominently in the international economics literature, namely country size and technology differences. From existing work on international trade between otherwise identical economies, we have a presumption that the effects of trade are more pronounced in smaller countries, as these countries ceteris paribus get access to a relatively larger market when opening up for trade.[17] In our model, a simple way to study the role of foreign market size for the effects of trade liberalization, is by assuming that the economy under consideration opens up for trade vis-á-vis $k > 0$ identical trading partners (see Eckel and Neary, 2010, for a similar comparative static experiment). A small foreign market can then be associated with low levels of k (for instance, $k < 1$), while a large foreign market can be associated with high levels of k (for instance, $k > 1$). Insights upon the role of foreign market size can then be inferred from a

[17]Such an effect is, for instance, present in Krugman (1980), where consumers from smaller countries get access to more imported varieties and thus benefit disproportionately from trade with a large economy.

comparative-static analysis of changes in k. As shown in detail in a technical supplement, which is available from the authors upon request, country size has the expected effects in our model: The larger a country is relative to its trading partner, the smaller are the trade effects on the variables of interest. However, pure size differences do not change the results from Section 3.4 in a qualitative way.[18]

A second form of asymmetry we are interested in are Ricardian technology differences. Since such differences change some of our results in a qualitative and non-trivial way, it is worth discussing them in detail. To highlight the specific role of technology differences, we follow the approach in Neary (2009) and keep the two countries identical with respect to their labor endowments, L, the number of firms, n, and the first and (uncentred) second moments of their technology distributions, μ_1, μ_2. While this makes countries symmetric in key aggregate variables, it still allows for differences between the two economies in the labor input coefficients of at least some of their industries. To put it formally: Using an asterisk to refer to variables of the foreign economy, we assume $\alpha(z) \neq \alpha^*(z)$ for some z. With this asymmetry at hand, it is useful to specify the (uncentred) covariance of input coefficients

$$\gamma \equiv \int_0^1 \alpha(z)\alpha^*(z)dz. \tag{3.20}$$

Using the standard property that $\mu_2 + \mu_2^* \geq 2\gamma$, we have $\mu_2 \geq \gamma$, in view of our assumption that $\mu_2 = \mu_2^*$, and we can thus define $\delta \equiv \mu_2 - \gamma > 0$ as a measure of technological dissimilarity or the countries' comparative advantage (see Neary, 2009).[19] With the first and the second moment of the technology distribution being identical in the two economies, countries have *on average* a comparative advantage in those industries in which they have an absolute productivity advantage over the trading partner. In this respect, our technology assumptions are more restrictive than those imposed by Dornbusch, Fischer, and Samuelson (1977) in their seminal study on Ricardian technology differences in a traditional trade model with a continuum of industries. On the other hand, in view of the oligopolistic market structure, our model allows for co-existence of domestic and foreign firms over a broad range of industries. And there is even full diversification in the production of both economies if technology differences between the two countries are not too large. This is the case we are focussing on throughout our analysis.

Finally, to fix ideas we think of the two countries as ones that possess a comparative advantage in their respective high-productivity industries, and we capture this idea by assuming $d\alpha(z)/dz > 0$, $d\alpha^*(z)/dz < 0$. As will become clear below, this assumption does not influence the impact of trade on welfare, employment, and the distribution of income between firm owners and production workers, and it is therefore innocent in this respect. However, it implies that workers move towards high productivity industries when production is relocated according to the law of comparative advantage and therefore pre-determines to a certain extent the impact

[18] Of course, the effects of country size differences are not straightforward when considering inter-group inequality. With the effect of trade on this inequality measure being not clearcut in the benchmark scenario of fully symmetric countries, we cannot expect a clearcut result if countries differ in size. However, we can show that a positive impact on the profit-wage ratio is more likely if a country opens up for trade with a smaller trading partner.

[19] In the special case of $\alpha(z) = \alpha^*(z)$ in all industries z, we have $\delta = 0$ and the model degenerates to the benchmark scenario of *fully* symmetric economies in Section 3.4.

that technological dissimilarity exerts on the distribution of income within the groups of firm owners and production workers. While being aware of these implications, we think that associating industries in which a country possesses a comparative advantage, with industries that have a relatively high labor productivity is a good point of departure for modeling technological dissimilarity in our setting.

Equipped with these assumptions, we can now follow the analysis in Section 3.4 step by step in order to calculate the main variables of interest. Instead of presenting all formal details of this analysis, we focus on the main equations and discuss the consequences of allowing for technological dissimilarity in an intuitive way, while readers who are interested in the formal details of our analysis are referred to a technical supplement, which is available from the authors upon request. As a first variable of interest, we can calculate the union wage rate

$$w^t(z) = \frac{(4n+1)\left[a + 2n\alpha(z)\bar{w}\right] + 2n^2\left[\alpha^*(z) - \alpha(z)\right]}{\alpha(z)(2n+1)(4n+1)}. \tag{3.9''}$$

Comparing Eqs. (3.9′) and (3.9″), we can conclude that union wages in industry z are higher than in the benchmark model with identical countries if and only if labor productivity in this industry is higher than in the foreign economy. The reason for this outcome is that domestic firms have a larger market share if competing with less productive foreign producers and thus will end up with higher profits, ceteris paribus. Since workers participate in this profit gain due to union wage setting, it is clear that domestic wages in all industries with $\alpha^*(z) > \alpha(z)$ increase relative to the benchmark scenario in which all domestic and foreign firms of industry z share the same productivity. Of course, the opposite reasoning applies to industries in which domestic firms have a productivity disadvantage as compared to their foreign competitors, and, in view of our assumptions regarding the ranking of $\alpha(z)$ and $\alpha^*(z)$ across industries, we can therefore conclude that technological dissimilarity leads to a steeper wage profile across industries in our setting. Similarly, the relocation of economic activity from industries with low productivity to industries with high productivity lead to a steeper employment profile across industries, which can be confirmed by comparing firm-level employment

$$l^t(z) = \frac{4n\alpha(z)\left\{(4n+1)[a - \alpha(z)\bar{w}] + 2n^2\bar{w}[\alpha^*(z) - \alpha(z)]\right\}}{b(2n+1)^2(4n+1)} \tag{3.11''}$$

with the respective expression in Eq. (3.11′).

With these firm-level effects at hand, we can now look at the impact of technological dissimilarity on aggregate economic variables. The first of these variables is involuntary unemployment, which is now determined by

$$u^t L = L - \frac{4n^2\left[(4n+1)\left(a\mu_1 - \mu_2\bar{w}\right) - 2n^2\delta\bar{w}\right]}{b(2n+1)^2(4n+1)}. \tag{3.13''}$$

As pointed out above, technological dissimilarity of the two countries induces a relocation of employment according to the law of comparative advantage, and this effect turns out to be instrumental for a negative aggregate employment effect, as can be formally confirmed by comparing Eqs. (3.13′) and (3.13″). To understand this result, it is worth noting that a higher δ

raises profits in export-oriented industries and lowers profits in import-competing ones. Unions respond to these profit changes by raising their wage claims in the former and reducing them in the latter industries. However, the reduction of wage claims in import-competing industries is mitigated by the common unemployment benefit, implying that the labor market distortion becomes more pronounced if δ increases. We can also show that the employment-reducing effect of technological dissimilarity can in principle be strong enough to entirely eliminate the positive employment stimulus from a country's opening up to trade with a fully symmetric trading partner. Put differently, the finding of $u^t < u^a$ does not extend to arbitrarily high levels of δ. Hence, the model with technological dissimilarities seems better suited for capturing the concern of workers in industrialized countries that globalization increases the risk of job loss.

Welfare in the open economy is now given by

$$\tilde{U}^t = -\int_0^1 \left[\frac{(4n+1)a + 2n^2\bar{w}[\alpha(z) + \alpha^*(z)]}{(2n+1)^2}\right]^2 dz, \tag{3.15''}$$

and solving Eqs. (3.15′) and (3.15″), we can show that technological dissimilarity increases welfare by $U^t\big|_{\delta>0} - U^t\big|_{\delta=0} = 8n^4\bar{w}^2\delta/(2n+1)^4 > 0$. This implies that gains from trade are further increased when countries (partially) specialize their production pattern according to the law of comparative advantage, which is well in line with insights from traditional trade models that have pointed to the gains from comparative advantage as the main channel through which a country benefits from opening up to trade.

The following proposition summarizes the main insights regarding the role of technological dissimilarity for the impact of trade on welfare and employment.

Proposition 4 *Technological dissimilarity that is sufficiently small to leave both countries' production patterns fully diversified in the open economy increases the gains from trade and lowers the employment stimulus from trade relative to the benchmark scenario with two fully symmetric countries. Negative employment effects of trade cannot be ruled out for high levels of technological dissimilarity.*

To determine how technological dissimilarity affects the distribution of economic rents between firm owners and production workers, we can compare the profit-wage ratio for this scenario with the one from the benchmark case of fully symmetric countries.[20] This comparison does not provide a clearcut ranking of $\xi^t\big|_{\delta>0}$ and $\xi^t\big|_{\delta=0}$, because there are two counteracting effects of a higher degree of technological dissimilarity on the profit-wage ratio. On the one hand, higher levels of δ lead to a shift of economic activity from industries with relatively low profit margins to industries with relatively high ones, thereby triggering an increase in the average return to firm owners. On the other hand, wages are linked to profits by a rent-sharing mechanism, so that the average return to production workers also increases in response to a higher δ-level. Since it is in general not clear which of these two effects dominates, we can conclude that the total impact of a higher δ on ξ^t is ambiguous. Together with the insights from Section 3.4 regarding the impact of trade on the profit-wage ratio in the benchmark scenario with symmetric countries, we can

[20]Since the solutions for the three distributional measures give lengthy and complicated expressions, we decided against presenting them in the main text, and refer the interested reader to the technical supplement mentioned above.

therefore conclude that trade does not exert a clearcut effect on inter-group inequality, with the respective outcome crucially depending on the market power of incumbent producers and the degree of technological dissimilarity between the two economies.

To get insights on how a positive level of δ affects income inequality among firm owners, we can note from above that technological dissimilarity leads to a shift of economic activity towards sectors in which firms have a higher profit margin. As formally shown in the technical supplement to the analysis in this section, this induces an increase in profit income inequality as captured by $\mathfrak{J}^t(\bar{z})\big|_{\delta=0} > \mathfrak{J}^t(\bar{z})\big|_{\delta>0}$ for any possible $\bar{z} \in (0,1)$. Combining this insight with the finding from Section 3.4 that trade does not alter profit income inequality if the two countries are fully symmetric, we can conclude that the invariance is just a knife-edge result that changes if one accounts for technological dissimilarity of countries. In the latter case, we can expect trade to render the distribution of profit income less equal, which implies a downward shift of the respective Lorenz curve in Figure 3.1.

Regarding the impact of technological dissimilarity on the distribution of wage income, we can distinguish two effects. On the one hand, technological dissimilarity induces a relocation of workers towards high-wage industries, which lowers inequality ceteris paribus. This effect is captured by $\rho^t(\bar{z})\big|_{\delta>0} < \rho^t(\bar{z})\big|_{\delta=0}$. On the other hand, a larger share of labor income is realized in high-wage industries if countries differ in their technology, and this raises income inequality for a given allocation of workers. This effect is captured by $\mathfrak{L}^t(\bar{z})\big|_{\delta>0} < \mathfrak{L}^t(\bar{z})\big|_{\delta=0}$. Since the two effects counteract, we are not able to rank the Lorenz curve in the benchmark scenario and the one for technologically dissimilar countries, without imposing additional assumptions regarding the $\alpha(z)$ profile across industries. Furthermore, we have found a numerical example where opening up for trade between two technologically dissimilar countries does not lower labor income inequality according to the Lorenz criterion. Hence, there must be a counteracting effect on labor income inequality, which is not present when trade occurs between two fully symmetric countries, and we can expect that this counteracting effect, if it exists, is the stronger, the higher is δ. We therefore should be warned against simply transferring the results from Section 3.4 regarding the impact of trade on intra-group wage inequality to a North-South context, where technological dissimilarities can be substantial.

We summarize the main insights upon the consequences of technological dissimilarity for the distributional effects of trade in the following proposition.

Proposition 5 *Technological dissimilarity that is sufficiently small to leave both countries' production patterns fully diversified in the open economy increases profit income inequality relative to the benchmark scenario with two fully symmetric countries, provided that the two countries relocate production towards their high-productivity industries in the open economy. The impact of technological dissimilarity on the two other measures of income inequality are not clearcut in general.*

While technological dissimilarity does not change the distributional effects of trade in a clearcut way, there is still an important lesson to learn from our analysis above. By changing the way rents are shared between firm owners and workers, trade uncouples the distribution of profit income from the distribution of labor income and may thus trigger different distributional consequences for these two income groups. For instance, it is possible that trade raises inequality between firm owners, while, at the same time, it reduces inequality among production workers. The possibility of such differential effects must be taken into account by future empirical research that aims at estimating the impact of trade on intra-group inequality.

3.6 Concluding remarks

This paper presents a general oligopolistic equilibrium model with a unit mass of heterogeneous industries, a small number of identical quantity-setting firms in either sector and imperfect labor markets due to the existence of firm-level unions. In this framework, we investigate how a movement from autarky to free trade with a fully symmetric partner country affects the product and labor market outcome. In particular, we show that trade lowers the scope of unions for excessive wage claims, while firms increase their output levels in the open economy. Beyond that, we analyze how these adjustments at the firm level affect aggregate variables in the general equilibrium. Thereby, we show that an opening up to trade, by lowering union wage claims, raises economy-wide employment and welfare. Aside from this positive efficiency effect, access to international trade reduces income inequality among production workers, while it leaves income inequality among firm owners unaffected. Finally, the impact of trade on inter-group inequality between firm owners and production workers is not clearcut in general. On the one hand, product market competition is stimulated, while, on the other hand, unions lower their wage claims in the open economy. Which of these two counteracting effects dominates depends on the degree of product market competition. More specifically, we show that inter-group inequality increases in response to trade liberalization if not more than two domestic firms are active in either industry.

In order to see to what extent the results from our analysis hinge on the assumption of two fully symmetric trading partners, we consider two forms of country asymmetries in an extension to our benchmark model. As a first source of asymmetry, we consider country size differences. In this respect, our model leads to the expected result that a smaller economy experiences larger effects from trade, as it gets access to a larger foreign market than an otherwise identical economy of larger size. However, pure country size differences do not affect the main results from our analysis in a qualitative way. As a second source of asymmetry, we consider Ricardian technology differences between the two trading partners, and we show that these differences may affect the results from our analysis in a qualitative way. To be more specific, by relocating production according to the law of comparative advantage, technologically dissimilar economies face an additional channel through which gains from trade materialize, implying that the welfare stimulus of trade identified in the setting with fully symmetric trading partners is reinforced if countries differ in their technology. However, the relocation of economic activity towards a country's comparative advantage industries lowers aggregate employment and this effect may be sufficiently strong to induce a total negative employment effect of trade if the technological dissimilarity is sufficiently pronounced. Finally, if countries relocate production towards their high-productivity industries, technological dissimilarity fosters income inequality among firm owners, while its impact on inter-group inequality between firm owners and workers and intra-group inequality among production workers turns out to be not clearcut in general. However, the distributional effects of trade between two technologically dissimilar countries indicate that trade uncouples the distribution of profits from the distribution of wages even though union wage setting leads to rent sharing in our setting.

In the working paper version of this manuscript, we have extended the benchmark model in two further dimensions in order to check robustness of our results. In a first extension, we have given up the assumption of constant unemployment benefits and considered benefits that are proportional to the average wage rate as an alternative compensation scheme and, in a second one, we have looked at industry-level instead firm-level unions. Since these modifications do not affect the main results from our analysis in a significant way, we decided against presenting them in this paper. Another possible extension that may be worthwhile to consider in future research is the analysis of marginal trade liberalization. While there are of course different possibilities to model partial trade liberalization in our setting, assuming that just a subset of industries opens up for free trade would be a particularly attractive option from the perspective of analytical tractability. In a benchmark model without productivity differences across industries, it is immediate that profit and wage inequality vanish in the closed as well as the open economy with full trade liberalization. However, there is inequality in both of these dimensions for intermediate levels of trade liberalization, implying that an increase in the share of open sectors exerts a non-monotonic impact on intra-group inequality in this baseline scenario. Things are more complicated in a sophisticated model variant that allows for productivity differences across industries. In this case, the impact of marginal trade liberalization crucially depends on which sectors are newly exposed to international trade and no general result can be derived without an additional assumption regarding the sector ranking in the time line of globalization. Deriving more detailed results in this respect as well as extending the model in other possible directions is beyond the scope of this paper but may be a worthwhile task for future research.

3.7 Appendix

Derivation details for Eq. (3.8)

Maximizing the profits in (3.6) for output y_j gives the first-order condition

$$\frac{\partial \pi_j}{\partial y_j} = a - b\sum_{i \neq j}^{n} y_i - c_j(z) - 2by_j = 0. \tag{3.21}$$

Solving for y_j, we further obtain the best response function of firm j to output decisions of all other producers:

$$y_j = \frac{a - b\sum_{i \neq j} y_i - c_j(z)}{2b}. \tag{3.22}$$

In a similar vein, we can determine the the best response function of firm $k \neq j$:

$$y_k = \frac{a - b\sum_{i \neq k} y_i - c_k(z)}{2b}. \tag{3.23}$$

Now, if firm j rationally anticipates that all competitors within its industry face the same costs and thus set identical output levels, i.e. $c_i(z) = c_k(z)$ and $y_i = y_k$ for all $i \neq j$, we can rewrite (3.22) and (3.23) in the following way: $2by_j = a - b(n-1)y_i - c_j(z)$ and $bny_i = a - by_j - c_i(z)$. Combining the latter two, accounting for $c_j(z) = \alpha_j(z)w_j$, $c_i(z) = \alpha_i(z)w_i$, and solving the resulting expression for y_j gives the output in (3.8). Furthermore, accounting for $l_j = a_j(z)y_j$ gives the respective employment level.

Derivation details for Eq. (3.9)

Substituting l_j from (3.8) into (3.7) and maximizing the resulting expression for w_j gives the first-order condition for union wage-setting:

$$\frac{dV_j}{dw_j} = \frac{\alpha(z)\left[a + (n-1)\alpha(z)w_i - n\alpha(z)w_j\right]}{b(n+1)} - \frac{n\alpha(z)^2(w_j - \bar{w})}{b(n+1)} = 0, \tag{3.24}$$

which can be simplified to $a + (n-1)\alpha(z)w_i - 2n\alpha(z)w_j + n\alpha(z)\bar{w} = 0$. Since the wage-setting problem is the same for all firm-level unions, we can now set $w_j = w_i$ and solve the latter equation for the union wage. This gives the respective expression in (3.9).

Derivation details for Eq. (3.16)

Substituting $y_j = y(z)$ from (3.11) into (3.6) and accounting for $c_j(z) = \alpha(z)w(z)$, with $w(z)$ being given by (3.9), we obtain $\pi_j = b[y(z)]^2 \equiv \pi(z)$, or, equivalently,

$$\pi(z) = \frac{n^2\left[a - \alpha(z)\bar{w}\right]}{(n+1)^4}. \tag{3.25}$$

Adding $\pi(z)$ over all industries we get economy-wide average profits per firm

$$\tilde{\pi} = \frac{n^2\left[a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right]}{b(n+1)^4}. \tag{3.26}$$

Furthermore, multiplying $w(z)$ and $nl(z)$ gives the total wage bill of industry z:

$$W(z) = \frac{n^2\left[a^2 + (n-1)a\bar{w}\alpha(z) - n\bar{w}^2\alpha(z)^2\right]}{b(n+1)^3}, \tag{3.27}$$

according to (3.9) and (3.11). Adding $W(z)$ over all industries and dividing the resulting expression by $(1-u)L$, gives the average wage income of production workers

$$\tilde{w} = \frac{\left[a^2 + (n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2\right]}{(n+1)\left[a\mu_1 - \bar{w}\mu_2\right]}, \tag{3.28}$$

Dividing (3.26) by (3.28) gives $\xi \equiv \tilde{\pi}/\tilde{w}$ in (3.16).

The Lorenz curve for profit income in the closed economy: $\mathfrak{J}(\bar{z})$

To determine the Lorenz curve for profit income, we first calculate aggregate profit income accruing to firms with a labor input coefficient higher than or equal to firms in industry $1-\bar{z}$. Substituting $y(z)$ from (3.8) in $\pi(z) = by(z)^2$, it is immediate that total profits in industry z, $\Pi(z) \equiv n\pi(z)$, are given by

$$\Pi(z) = \frac{n^3\left[a - \alpha(z)\bar{w}\right]^2}{b(n+1)^4}. \tag{3.29}$$

Adding up $\Pi(z)$ over all industries $z \geq 1-\bar{z}$ gives

$$\begin{aligned}\bar{\Pi}(\bar{z}) &= \int_{1-\bar{z}}^{1} \Pi(z) \\ &= \frac{n^3\left[a^2\bar{z} - 2a\bar{w}\int_{1-\bar{z}}^{1}\alpha(z)dz + \bar{w}^2\int_{1-\bar{z}}^{1}\alpha(z)^2dz\right]}{b(n+1)^4},\end{aligned} \tag{3.30}$$

with $\Pi = \bar{\Pi}(1)$ denoting economy-wide profit income. Since the number of firms is the same in all industries, $1-\bar{z}$ denotes the fraction of firms with profits lower than $\pi(1-\bar{z})$. Hence, the Lorenz curve for profit income is given by $\mathfrak{J}(\bar{z}) = \bar{\Pi}(\bar{z})/\Pi$, which can be reformulated to (3.17). Differentiating $\mathfrak{J}(\bar{z})$ and defining $\bar{\alpha} \equiv \alpha(1-\bar{z})$, gives

$$\frac{d\mathfrak{J}(\bar{z})}{d\bar{z}} = \frac{a^2 - 2a\bar{w}\bar{\alpha} + \bar{w}^2\bar{\alpha}^2}{a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2} > 0, \qquad \frac{d^2\mathfrak{J}(\bar{z})}{d\bar{z}^2} = -\frac{2\bar{w}[a - \bar{\alpha}\bar{w}]}{a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2} \times \frac{d\alpha(1-\bar{z})}{d\bar{z}} > 0, \tag{3.31}$$

which proves that the Lorenz curve $\mathfrak{J}(\bar{z})$ has the standard properties: It is positively sloped and convex (in $\bar{z}$).

To determine the impact of an increase in unemployment compensation $\bar{w}$ on $\mathfrak{J}(\bar{z})$, we differentiate $d\mathfrak{J}(\bar{z})/d\bar{z}$ with respect to $\bar{w}$. This gives

$$\frac{d^2\mathfrak{J}(\bar{z})}{d\bar{z}d\bar{w}} = -2\frac{\left(a\bar{\alpha} - \bar{\alpha}^2\bar{w}\right)\left(a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right) - \left(a\mu_1 - \bar{w}\mu_2\right)\left(a^2 - 2a\bar{w}\bar{\alpha} + \bar{w}^2\bar{\alpha}^2\right)}{\left[a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right]^2},$$

which can be further simplified to

$$\frac{d^2\mathfrak{J}(\bar{z})}{d\bar{z}d\bar{w}} = -\frac{2a\bar{\alpha}\left(a - \bar{w}\bar{\alpha}\right)}{\left[a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right]^2}G(\bar{\alpha}), \tag{3.32}$$

with

$$\begin{aligned} G(\bar{\alpha}) &\equiv a\left(1 - \frac{\mu_1}{\bar{\alpha}}\right) - \bar{w}\bar{\alpha}\left(\frac{\mu_1}{\bar{\alpha}} - \frac{\mu_2}{\bar{\alpha}}\right) \\ &= \int_0^1 \left[a - \bar{w}\alpha(z)\right]\left(1 - \frac{\alpha(z)}{\bar{\alpha}}\right)dz. \end{aligned} \tag{3.33}$$

From this, we can conclude that $d^2\mathfrak{J}(\bar{z})/d\bar{z}d\bar{w} >, =, < 0$ if $0 >, =, < G(\bar{\alpha})$. Notably, $G(\bar{\alpha}) > 0$ if $\bar{\alpha} = \alpha(1)$ or, equivalently $\bar{z} = 0$, while $G(\bar{\alpha}) < 0$ if $\bar{\alpha} = \alpha(0)$, or equivalently $\bar{z} = 1$. Furthermore, from differentiating (3.33) we can deduce that $G'(\bar{\alpha}) > 0$, and hence $G'(\bar{\alpha}) \times d\bar{\alpha}/d\bar{z} < 0$. This however implies that $G(\bar{\alpha}) = 0$ has a unique solution in $\bar{z} \in (0, 1)$, which we denote by $\bar{z}^*$. As a consequence, $G(\bar{\alpha}) > 0$ and thus $d^2\mathfrak{J}(\bar{z})/d\bar{z}d\bar{w} < 0$ if $\bar{z} < \bar{z}^*$, while $G(\bar{\alpha}) < 0$ and thus $d^2\mathfrak{J}(\bar{z})/d\bar{z}d\bar{w} > 0$ if $\bar{z} > \bar{z}^*$. From this we can deduce that the Lorenz curve for $\bar{w}_1$ lies below the Lorenz curve for $\bar{w}_0$ if $\bar{w}_1 > \bar{w}_0$, implying that higher unemployment benefits make the profit income distribution more unequal. This confirms the respective result in the text.

The Lorenz curve for wage income in the closed economy: $\mathfrak{M}(\bar{\rho})$

To determine the Lorenz curve for wage income, we need to combine two elements: the distribution of wage payments and the distribution of workers across industries. Starting with the first element, we can note that total wage payments of industry z are given by $W(z) \equiv nl(z)w(z)$. In view of (3.9) and(3.11), this implies

$$W(z) = \frac{n^2\left[a^2 + (n-1)a\alpha(z)\bar{w} - n\alpha(z)^2\bar{w}^2\right]}{b(n+1)^3} \tag{3.34}$$

Since industries are ranked according to their wages, with more productive industries paying higher ones, we can conclude that the cumulative wage income of workers who are employed in industries $z \geq 1 - \bar{z}$, is given by

$$\begin{aligned} \bar{W}(\bar{z}) &\equiv \int_{1-\bar{z}}^1 W(z)dz \\ &= \frac{n^2\left[a^2\bar{z} + (n-1)a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz - n\bar{w}^2\int_{1-\bar{z}}^1 \alpha(z)^2dz\right]}{b(n+1)^3}, \end{aligned} \tag{3.35}$$

with $W = \bar{W}(1)$ denoting economy-wide labor income. The ratio of labor income accruing to workers in industries $z \geq 1 - \bar{z}$ is determined by $\mathfrak{L}(\bar{z}) \equiv \bar{W}(\bar{z})/W$, which can be reformulated to (3.18).

The second element we need to determine is the distribution of workers across industries. Total employment in industry z is given by $L(z) \equiv nl(z)$. Substituting $l(z)$ from (3.11), we obtain

$$L(z) \equiv \frac{n^2 \alpha(z)[a - \alpha(z)\bar{w}]}{b(n+1)^2} \tag{3.36}$$

Hence, cumulative employment in industries $z \geq 1 - \bar{z}$ is given by

$$\begin{aligned} \bar{L}(\bar{z}) &\equiv \int_{1-\bar{z}}^{1} L(\bar{z}) dz \\ &= \frac{n^2 \left[a \int_{1-\bar{z}}^{1} \alpha(z) dz - \bar{w} \int_{1-\bar{z}}^{1} \alpha(z)^2 dz \right]}{b(n+1)^2}, \end{aligned} \tag{3.37}$$

with $L(1)$ being equal to economy-wide employment

$$(1-u)L = \frac{n^2 \left[a\mu_1 - \bar{w}\mu_2 \right]}{b(n+1)^2} \tag{3.38}$$

(see (3.13)). The ratio of workers who are employed in industries $z \geq 1 - \bar{z}$ is then represented by $\rho(\bar{z})$ in (3.19). Denoting the function value of $\rho(\bar{z})$ by $\bar{\rho}$ and considering the inverse function $\bar{z} = \rho^{-1}(\bar{\rho})$ in (3.18) – with the properties of this inverse function following from (3.19) – finally gives the Lorenz curve for wage income $\mathfrak{M}(\bar{\rho})$.

Differentiating $\mathfrak{M}(\bar{\rho})$ yields

$$\begin{aligned} \frac{d\mathfrak{M}(\bar{\rho})}{d\bar{\rho}} &= \frac{d\mathfrak{L}(\bar{z})}{d\bar{z}} \times \frac{d\bar{z}}{d\bar{\rho}} \\ &= \frac{a^2 + (n-1)a\bar{\alpha}\bar{w} - n\bar{\alpha}^2\bar{w}^2}{a^2 + (n-1)a\mu_1\bar{w} - n\mu_2\bar{w}^2} \times \frac{a\mu_1 - \bar{w}\mu_2}{a\bar{\alpha} - \bar{w}\bar{\alpha}^2}, \end{aligned} \tag{3.39}$$

and

$$\frac{d^2\mathfrak{M}(\bar{\rho})}{d\bar{\rho}^2} = -\frac{\left[a\mu_1 - \bar{w}\mu_2\right]^2 \left[a\bar{\alpha}^2\bar{w}^2 + a^2\left(a - 2\bar{w}\alpha\right)\right]}{\left[a^2 + (n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2\right]^2 \left[a\alpha - \bar{w}\bar{\alpha}^2\right]^3} \times \frac{d\bar{\alpha}}{d\bar{z}}, \tag{3.40}$$

where $\bar{\alpha} = \alpha(1 - \bar{z})$ has been considered. Noting $d\bar{\alpha}/d\bar{z} < 0$, the latter two equations confirm that $\mathfrak{M}(\bar{\rho})$ is a positively sloped and convex function of $\bar{\rho}$.

To determine the impact of higher unemployment compensation on the distribution of labor income, we differentiate $d\mathfrak{M}(\bar{\rho})/d\bar{\rho}$ with respect to $\bar{w}$, which yields

$$\begin{aligned} \frac{d^2\mathfrak{M}(\bar{\rho})}{d\bar{\rho}d\bar{w}} &= \frac{d^2\mathfrak{L}(\bar{z})}{d\bar{z}d\bar{w}} \times \frac{d\bar{z}}{d\bar{\rho}} + \frac{d\mathfrak{L}(\bar{z})}{d\bar{z}} \times \frac{d^2\bar{z}}{d\bar{\rho}d\bar{w}} \\ &= \frac{a^2\left[(n-1)a\left(\bar{\alpha} - \mu_1\right) - 2n\bar{w}\left(\bar{\alpha}^2 - \mu_2\right)\right] - n\bar{w}^2(n-1)a\left(\mu_1\bar{\alpha}^2 - \bar{\alpha}\mu_2\right)}{\left[a^2 + (n-1)a\mu_1\bar{w} - n\mu_2\bar{w}^2\right]^2} \times \frac{a\mu_1 - \bar{w}\mu_2}{a\bar{\alpha} - \bar{w}\bar{\alpha}^2} \\ &\quad + \frac{a^2 + (n-1)a\bar{\alpha}\bar{w} - n\bar{\alpha}^2\bar{w}^2}{a^2 + (n-1)a\mu_1\bar{w} - n\mu_2\bar{w}^2} \times \frac{a\bar{\alpha}\left(\mu_1\bar{\alpha} - \mu_2\right)}{\left[a\bar{\alpha} - \bar{w}\bar{\alpha}^2\right]^2}. \end{aligned}$$

Evaluating the latter expression at $\bar{w} = 0$, we obtain

$$\left.\frac{d^2\mathfrak{M}(\bar{\rho})}{d\bar{\rho}d\bar{w}}\right|_{\bar{w}=0} = \frac{\tilde{G}(\bar{\alpha})}{a\bar{\alpha}}, \tag{3.41}$$

with

$$\begin{aligned}\tilde{G}(\bar{\alpha}) &\equiv n\bar{\alpha}\mu_1 - (n-1)\mu_1^2 - \mu_2 \\ &= \bar{\alpha}\int_0^1 [(n-1)\mu_1 + \alpha(z)]\left(1 - \frac{\alpha(z)}{\bar{\alpha}}\right) dz.\end{aligned} \tag{3.42}$$

Notably, $\tilde{G}(\bar{\alpha}) > 0$ if $\bar{\alpha} = \alpha(0)$, i.e. if $\bar{z} = 1$, while $\tilde{G}(\bar{\alpha}) < 0$ if $\bar{\alpha} = \alpha(1)$, i.e. if $\bar{z} = 0$. Furthermore, $\tilde{G}'(\bar{\alpha}) > 0$, and hence $\tilde{G}'(\bar{\alpha}) \times d\bar{\alpha}/d\bar{z} < 0$. We can therefore safely conclude that $\tilde{G}(\bar{\alpha}) = 0$ has a unique solution in $\bar{z} \in (0,1)$, which we denote by $\bar{z}^{**}$. Then, $d^2\mathfrak{M}(\bar{\rho})/d\bar{\rho}d\bar{w}\big|_{\bar{w}=0} > 0$ if $\bar{z} < \bar{z}^{**}$, while $d^2\mathfrak{M}(\bar{\rho})/d\bar{\rho}d\bar{w}\big|_{\bar{w}=0} < 0$ if $\bar{z} > \bar{z}^{**}$. This however implies that increasing unemployment benefits from zero to a small positive level lowers wage income inequality according to the Lorenz curve criterion, thereby confirming the respective result in the main text.

Derivation details for Eq. (3.9′)

Firm j's profits in the open economy are given by

$$\pi_j = \left[a - \frac{b}{2}\sum_{i=1}^{2n} y_i - c_j(z)\right] y_j. \tag{3.43}$$

Maximizing these profits for output y_j gives the first-order condition

$$\frac{\partial \pi_j}{\partial y_j} = a - \frac{b}{2}\sum_{i\neq j}^{2n} y_i - c_j(z) - 2\frac{b}{2}y_j = 0. \tag{3.44}$$

Following the analysis for the closed economy step-by-step and noting that, in view of our symmetry assumption, firm j foresees that all domestic and foreign competitors set the same wage w_i, we can explicitly solve for firm j's profit-maximizing output level as a function of its own and all other firms' wages

$$y_j = \frac{2\left[a + (2n-1)\alpha(z)w_i - 2n\alpha(z)w_j\right]}{b(2n+1)}. \tag{3.45}$$

Noting that $l_j = \alpha(z)y_j$, substituting the resulting expression into (3.7), and maximizing for w_j gives the first-order condition for union wage-setting:

$$\frac{dV_j}{dw_j} = \frac{2\alpha(z)\left[a + (2n-1)\alpha(z)w_i - 2n\alpha(z)w_j\right]}{b(2n+1)} - \frac{4n\alpha(z)^2(w_j - \bar{w})}{b(2n+1)} = 0, \tag{3.46}$$

which can be simplified to $a + (2n-1)\alpha(z)w_i - 4n\alpha(z)w_j + 2n\alpha(z)\bar{w} = 0$. Since the wage-setting problem is the same for all firm-level unions, we can now set $w_j = w_i$ and solve the latter equation for the union wage in (3.9′).

Derivation details for Eq. (3.16′)

Substituting $y_j = y(z)$ from (3.11′) into (3.43) and accounting for $c_j(z) = \alpha(z)w(z)$, with $w(z)$ being given by (3.9′), we obtain $\pi_j = b[y(z)]^2 \equiv \pi(z)$, or, equivalently,

$$\pi^t(z) = \frac{8n^2\left[a - \alpha(z)\bar{w}\right]}{b(2n+1)^4}. \tag{3.47}$$

Adding $\pi(z)$ over all industries we get economy-wide average profits per firm in the open economy

$$\tilde{\pi}^t = \frac{8n^2\left[a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2\right]}{b(2n+1)^4}. \tag{3.48}$$

Furthermore, multiplying $w^t(z)$ and $nl^t(z)$ gives the total wage bill of industry z:

$$W^t(z) = \frac{4n^2\left[a^2 + (2n-1)a\alpha(z)\bar{w} - 2n\alpha(z)^2\bar{w}^2\right]}{b(2n+1)^3} \tag{3.49}$$

according to (3.9′) and (3.11′). Adding $W^t(z)$ over all industries and dividing the resulting expression by $(1-u^t)L$, gives the average wage income of production workers

$$\tilde{w}^t = \frac{\left[a^2 + (2n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2\right]}{(2n+1)\left[a\mu_1 - \bar{w}\mu_2\right]}, \tag{3.50}$$

Dividing (3.48) by (3.50) gives ξ^t in (3.16′).

A comparison of ξ^a and ξ^t

From a comparison of (3.16) and (3.16′), we can conclude that $\xi^t >,=,< \xi^a$ is equivalent to

$$\frac{8}{(2n+1)^2\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right]} >,=,< \frac{1}{(n+1)^2\left[a^2 + (n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2\right]}. \tag{3.51}$$

Rearranging terms and defining

$$A(n) \equiv \left(\frac{2n+2}{2n+1}\right)^3, \qquad B(n) \equiv \frac{a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2}{a^2 + (n-1)a\bar{w}\mu_1 - n\bar{w}^2\mu_2}, \tag{3.52}$$

we can further note that $\xi^t >,=,< \xi^a$ is equivalent to $A(n) >,=,< B(n)$. In order to determine how the ranking of $A(n)$ and $B(n)$ depends on firm number n, we have to characterize the properties of these two functions. Straightforward calculations give $A(0) = 8$, $\lim_{n\to\infty} A(n) = 1$ and $A'(n) < 0$. Furthermore, we find $B(0) = 1$, $\lim_{n\to\infty} B(n) = 2$ and $B'(n) > 0$. This however implies that $A(n) = B(n)$ has a unique solution in n, which we denote by n^*. Then, $A(n) > B(n)$ and thus $\xi^t > \xi^a$ if $n < n^*$, whereas $A(n) < B(n)$ and thus $\xi^t < \xi^a$ if $n > n^*$. To confine the possible values of n^*, we can can evaluate $A(n)$ and $B(n)$ at $n = 2$. This yields $A(2) = 216/125 = 1.728$ and

$$B(2) = \frac{a^2 + 3a\bar{w}\mu_1 - 4\bar{w}^2\mu_2}{a^2 + a\bar{w}\mu_1 - 2\bar{w}^2\mu_2}, \tag{3.53}$$

respectively. Rearranging terms, we find that $A(2) >,=,< B(2)$ is equivalent to

$$0,728a\left(a-\bar{w}\mu_1\right) >,=,< 0,544\bar{w}\mu_1\left(a-\bar{w}\frac{\mu_2}{\mu_1}\right). \tag{3.54}$$

However, noting $a > \bar{w}\mu_1$ and $\mu_2 > \mu_1^2$, it is immediate that the right-hand-side of the latter expression is smaller than its left-hand side, so that $A(n) > B(n)$ or, equivalently, $\xi^t > \xi^a$ if $n \leq 2$ This confirms the respective result in the main text.

The Lorenz curve for profit income in the open economy: $\mathfrak{J}^t(\bar{z})$

To determine the Lorenz curve for profit income in the open economy, we follow the respective steps in the closed economy and first calculate

$$\Pi^t(z) = \frac{8n^3\left[a-\alpha(z)\bar{w}\right]^2}{b(2n+1)^4}. \tag{3.55}$$

Adding up over all industries $z \geq 1-\bar{z}$ further implies

$$\begin{aligned}\bar{\Pi}^t(\bar{z}) &\equiv \int_{1-\bar{z}}^{1}\Pi(z)\\ &= \frac{8n^3\left[a^2\bar{z}-2a\bar{w}\int_{1-\bar{z}}^{1}\alpha(z)dz+\bar{w}^2\int_{1-\bar{z}}^{1}\alpha(z)^2dz\right]}{b(2n+1)^4},\end{aligned} \tag{3.56}$$

with $\Pi^t = \bar{\Pi}^t(1)$ being aggregate profit income in the open economy. Hence, the Lorenz curve for profit income is given by $\mathfrak{J}^t(\bar{z}) = \bar{\Pi}^t(\bar{z})/\Pi^t$, which can be reformulated to (3.17) and, thus, confirms that the Lorenz curve for profit income remains unaffected by the movement from autarky to free trade.

The Lorenz curve for wage income in the open economy: $\mathfrak{M}^t(\bar{\rho})$

In analogy to the closed economy, we first calculate total wage payments of industry z, which in views of (3.9′) and (3.11′) is given by

$$W^t(z) = \frac{4n^2\left[a^2+(2n-1)a\alpha(z)\bar{w}-2n\alpha(z)^2\bar{w}^2\right]}{b(2n+1)^3} \tag{3.57}$$

With industries being ranked according to their wages, the cumulative wage income of workers who are employed in industries $z \geq 1-\bar{z}$, is given by

$$\bar{W}^t(\bar{z}) = \frac{4n^2\left[a^2\bar{z}+(2n-1)a\bar{w}\int_{1-\bar{z}}^{1}\alpha(z)dz-2n\bar{w}^2\int_{1-\bar{z}}^{1}\alpha(z)^2dz\right]}{b(2n+1)^3}, \tag{3.58}$$

where $W^t = \bar{W}^t(1)$ determines aggregate labor income in the open economy. The ratio of labor income accruing to workers in industries $z \geq 1-\bar{z}$ is determined by $\mathfrak{L}^t(\bar{z}) \equiv \bar{W}(\bar{z})/W$, which can be reformulated to (3.18′).

Furthermore, considering (3.11′), total employment in industry z can be written as

$$L^t(z) \equiv \frac{4n^2\alpha(z)[a-\alpha(z)\bar{w}]}{b(2n+1)^2} \tag{3.59}$$

and cumulative employment in industries $z \geq 1-\bar{z}$ is given by

$$\bar{L}^t(\bar{z}) = \frac{4n^2\left[a\int_{1-\bar{z}}^{1}\alpha(z)dz - \bar{w}\int_{1-\bar{z}}^{1}\alpha(z)^2dz\right]}{b(2n+1)^2}. \tag{3.60}$$

The ratio of workers who are employed in industries $z \geq 1-\bar{z}$ is given by $\rho(\bar{z})$ in (3.19) and, thus, equals the respective ratio in the closed economy. Combining (3.18′) and (3.19), finally gives the Lorenz curve for wage income $\mathfrak{M}^t(\bar{\rho})$.

Noting that the distribution of workers across industries, $\rho(\bar{z})$, is the same in the closed and the open economy, it follows from (3.18) and (3.18′) that the movement from autarky to free trade affects the Lorenz curve only through an increase in the number of competitors (which doubles). Therefore, we can learn the impact of trade liberalization on wage income inequality from differentiating (3.39) with respect to n. This gives

$$\begin{aligned}\frac{d^2\mathfrak{M}(\bar{\rho})}{d\bar{\rho}dn} = &\frac{\left[a\bar{w}\bar{\alpha}-\bar{w}^2\bar{\alpha}^2\right]\left[a^2+(n-1)a\mu_1\bar{w}-n\mu_2\bar{w}^2\right]}{\left[a^2+(n-1)a\mu_1\bar{w}-n\mu_2\bar{w}^2\right]^2}\times\frac{a\mu_1-\bar{w}\mu_2}{a\bar{\alpha}-\bar{w}\bar{\alpha}^2}\\ &-\frac{\left[a\bar{w}\mu_1-\bar{w}^2\bar{\mu}_2\right]\left[a^2+(n-1)a\bar{\alpha}\bar{w}-n\bar{\alpha}^2\bar{w}^2\right]}{\left[a^2+(n-1)a\mu_1\bar{w}-n\mu_2\bar{w}^2\right]^2}\times\frac{a\mu_1-\bar{w}\mu_2}{a\bar{\alpha}-\bar{w}\bar{\alpha}^2}\end{aligned} \tag{3.61}$$

Tedious but straightforward calculations yield

$$\frac{d^2\mathfrak{M}(\bar{\rho})}{d\bar{\rho}dn} = \frac{a\bar{w}\bar{\alpha}\,(a-\bar{w}\bar{\alpha})\,G(\bar{\alpha})}{\left[a^2+(n-1)a\mu_1\bar{w}-n\mu_2\bar{w}^2\right]^2}\times\frac{a\mu_1-\bar{w}\mu_2}{a\bar{\alpha}-\bar{w}\bar{\alpha}^2}, \tag{3.62}$$

with $G(\bar{\alpha})$ being defined in (3.33). Considering the properties of $G(\bar{\alpha})$ from above, we can therefore conclude that a higher n lowers wage income inequality according to the Lorenz criterion. This confirms the respective result concerning the impact of trade liberalization on wage income inequality in the main text.

Asymmetric countries

This supplement provides formal details for the analysis of asymmetric countries in Section 3.5. In a first step, we analyze the case of country size differences, while technological dissimilarities are considered in a second step.

Country size differences

As outlined in the main text, we infer insights upon the role of country size differences by studying a country's opening up for trade with $k > 0$ fully symmetric trading partners. Assuming that product markets are fully integrated in the open economy, we can associate higher levels of k with a larger foreign market size, and therefore obtain insights upon the role of market size for the consequences of trade by studying the comparative-static effects of changes in k.

If there is trade between k fully symmetric countries, global demand can be calculated by adding consumption in the home and the k foreign countries. Doing this, we find that indirect world demand is given by[21]

$$p(z) = a - \frac{b}{1+k}x(z), \tag{3.63}$$

where $x(z)$ refers to world-wide consumption of good z. Applying the goods market clearing condition, we can therefore write domestic firm j's profits as follows

$$\pi_j = \left[a - b\sum_{i=1}^{(1+k)n} y_i - c_j(z)\right] y_j. \tag{3.64}$$

Maximizing these profits for y_j and following the same line of reasoning as in the main text, we can calculate the profit-maximizing output of firm j as function of its own wage, w_j and all competitors' wages, which, in view of our symmetry assumption, are identical (irrespective of their home country) and denoted by w_i:

$$y_j(z) = \frac{(1+k)\left\{a + [(1+k)n - 1]\alpha(z)w_i - (1+k)n\alpha(z)w_j\right\}}{b[1+(1+k)n]}. \tag{3.65}$$

To solve union j's optimization problem, we can substitute $l_j(z) = \alpha(z)y_j(z)$ together with (3.65) into (3.7), and maximize the respective expression for w_j. This gives the first-order condition

$$\frac{dV_j}{dw_j} = \frac{(1+k)\alpha(z)\left\{a + [(1+k)n - 1]\alpha(z)w_i - (1+k)n\alpha(z)w_j\right\}}{b[(1+k)n+1]} - \frac{(1+k)^2 n\alpha(z)^2(w_j - \bar{w})}{b[(1+k)n+1]} = 0, \tag{3.66}$$

which can be simplified to $a + [(1+k)n-1]\alpha(z)w_i - 2(1+k)n\alpha(z)w_j + (1+k)n\alpha(z)\bar{w} = 0$. Since the wage-setting problem is the same for all firm-level unions, we can now set $w_j = w_i$ and solve the latter equation for the union wage rate in sector z. This gives

$$w^t(z) = \frac{a + (1+k)n\alpha(z)\bar{w}}{\alpha(z)[1+(1+k)n]}. \tag{3.67}$$

Differentiating $w^t(z)$ with respect to k, gives $dw^t(z)/dk < 0$. Noting further that the wage rate in (3.67) equals the autarky wage rate in (3.9) if $k = 0$, we can conclude that trade exerts a union-disciplining effect irrespective of the size of k. Furthermore, noting that the case of two fully symmetric countries is captured by $k = 1$, we can also conclude that the union-disciplining effect is weaker (stronger) than in the benchmark scenario if $k < 1$ ($k > 1$).

Substituting $w^t(z)$ into (3.68), we can calculate

$$y^t(z) = \frac{(1+k)^2 n[a - \alpha(z)\bar{w}]}{b[1+(1+k)n]^2} \quad \text{and} \quad l^t(z) = \frac{\alpha(z)(1+k)^2 n[a - \alpha(z)\bar{w}]}{b[1+(1+k)n]^2} \tag{3.68}$$

[21] Since we consider trade between $1+k$ symmetric countries, all countries have, by construction, the same λ-value. Hence, by setting $\lambda = 1$ in the home country, it will be equal to one as well in all other countries. It is this feature of our analysis, which renders the way we capture country size differences so attractive from the viewpoint of analytical tractability.

which are both higher than under autarky and smaller (larger) than in the benchmark scenario of Section 3.4 if $k < 1$ ($k > 1$). In view of (3.63), it is thus immediate that, due to an expansion of firm-level output, trade always lowers consumer prices relative to the autarky scenario, with the respective effect being the stronger the larger is k. This can be confirmed by comparing

$$p^t(z) = \frac{[2n(1+k)+1]a + n^2(1+k)^2\alpha(z)\bar{w}}{[1+(1+k)n]^2} \tag{3.69}$$

to the respective findings in (3.12) and (3.12′). In a final step, we can note from the main text that profits are proportional to output, $\pi^t(z) = [b/(1+k)][y^t(z)]^2$, which gives

$$\pi^t(z) = \frac{(1+k)^3 n^2 \left[a - \alpha(z)\bar{w}\right]^2}{b[1+(1+k)n]^4}. \tag{3.70}$$

We do not compare $\pi^t(z)$ directly to the respective results under autarky and the benchmark scenario of trade between two fully symmetric countries as this comparison is tedious and not in the center of our interest. Rather we now proceed with studying economy-wide variables

To characterize welfare, we can substitute (3.69) into $\tilde{U}^t = -\mu_2^p$, which yields

$$\tilde{U}^t = -\int_0^1 \left[\frac{[2n(1+k)+1]a + n^2(1+k)^2\alpha(z)\bar{w}}{[1+(1+k)n]^2}\right]^2 dz. \tag{3.71}$$

Since trade lowers all industrial goods prices for any $k > 0$, it always exerts positive welfare effects irrespective of the prevailing market size differences. However, since the price-reducing effect is less (more) pronounced if $k < 1$ ($k > 1$), we can conclude that a country that opens up for trade with a large partner experiences a higher welfare gain than an otherwise identical country that opens up for trade with a small partner. A similar conclusion can be drawn for the impact of trade on unemployment, which is determined by

$$u^t L = L - \frac{(1+k)^2 n^2 \left(a\mu_1 - \mu_2\bar{w}\right)}{b[1+(1+k)n]^2}, \tag{3.72}$$

if trade involves transactions between $1+k$ symmetric partners. Comparing the latter to (3.13) and (3.13′), we can conclude that trade lowers unemployment, irrespective of the size of k, while the respective effect turns out to be less (more) pronounced than in the benchmark scenario of trade between two identical economies if $k < 1$ ($k > 1$).

With respect to the distributional effects of trade, we first look at its impact on the profit-wage ratio. To determine this ratio, we need to divide average profits[22]

$$\tilde{\pi}^t = \frac{(1+k)^3 n^2[a^2 - 2a\mu_1\bar{w} + \mu_2\bar{w}^2]}{b[1+(1+k)n]^4} \tag{3.73}$$

[22] Average profits can be calculating by adding up $\pi^t(z)$ from (3.70) over all industries z.

by the average wage rate[23]

$$\tilde{w}^t = \frac{a^2 + [(1+k)n - 1]a\mu_1\bar{w} - (1+k)n\mu_2\bar{w}^2}{[1+(1+k)n][a\mu_1 - \bar{w}\mu_2]}. \tag{3.74}$$

The profit-wage ratio is therefore given by

$$\xi^t = \frac{(1+k)^3 n^2 [a\mu_1 - \bar{w}\mu_2][a^2 - 2a\mu_1\bar{w} + \mu_2\bar{w}^2]}{b[1+(1+k)n]^3 \left\{a^2 + [(1+k)n-1]a\mu_1\bar{w} - (1+k)n\mu_2\bar{w}^2\right\}}. \tag{3.75}$$

Differentiating the latter with respect to k, we can show that $d\xi^t/dk >, =, < 0$ if

$$q(n,k) \equiv 3a(a - \mu_1\bar{w}) + (1+k)n\bar{w}\,[2 - (1+k)n]\,[a\mu_1 - \mu_2\bar{w}] >, =, < 0. \tag{3.76}$$

Noting $q(1,0) > 0$, $\lim_{n\to\infty} q(n,0) = -\infty$ and $\partial q(\cdot)/\partial n < 0$ for any $n \geq 1$, $k > 0$, we can conclude that $q(n,0) = 0$ has a unique solution in $n > 1$, which we denote n_0. Thus, $q(n,0) >, =, < 0$ if $n_0 >, =, < n$. Noting further that $\partial q(\cdot)/\partial k < 0$ holds for any $n \geq 1, k > 0$, and recollecting that ξ^t equals the autarky ratio if $k = 0$, it is immediate that the profit-wage ratio unambiguously falls in response to trade if $n \geq n_0$. We therefore focus on a parameter domain with $n \in [1, n_0)$ in the subsequent analysis. In this case, ξ^t has a unique maximum at $k = \tilde{k}(n) > 0$, with $\tilde{k}'(n) < 0$, which is implicitly determined by $q(n,k) = 0$. To see how changes in k affect the probability of an increase in the profit-wage ratio when a country moves from autarky to trade, it is worth considering the $\xi^t/\xi^a - k$ patterns for different levels of n, as depicted in Figure 3.3.[24] According to this figure, we can draw two conclusions. First, whenever trade induces an increase in the profit wage ratio for $k = 1$ it must also increase the profit-wage ratio for $k < 1$. Second, it is possible that trade increases the profit-wage ratio if $k < 1$, while it decreases the ratio for $k = 1$. In view of these two insights, we can conclude that trade has more likely a positive impact of ξ if $k < 1$, i.e. if the country opens up for trade with a smaller partner country.

In a next step, we can now look at the Lorenz curve for profit income. To determine this curve, we first need to calculate total profits in sectors $z \geq 1 - \bar{z}$. Substituting $\pi^t(z)$ from (3.70) into $\bar{\Pi}^t(\bar{z}) = \int_{1-\bar{z}}^1 n\pi^t(z)dz$, we get

$$\bar{\Pi}^t(\bar{z}) = \frac{n^3(1+k)^3[a^2\bar{z} - 2a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz - \bar{w}^2\int_{1-\bar{z}}^1 \alpha(z)^2 dz]}{b[1+(1+k)n]^4}. \tag{3.77}$$

Noting that economy-wide profits are given by $\Pi^t = \bar{\Pi}^t(1)$, and evaluating $\mathfrak{J}^t(\bar{z}) = \bar{\Pi}^t(\bar{z})/\Pi^t$, it is easily confirmed that the Lorenz curve does not change when a country opens up for k identical trading partner. From this, we can infer that the respective invariance result in Section 3.4 extends to the case of trade between two countries that only differ in their size.

For calculating the Lorenz curve for wage income, we need to combine the cross-sectoral of

[23] To determine firm-level wage payments, we have to multiply the wage rate in (3.67) with the employment level (3.68). Multiplying the resulting expression by n then gives the wage bill of industry z: $W^t(z)$. Adding up $W^t(z)$ over all industries and dividing the resulting expression by $(1 - u^t)L$, according to (3.72), finally gives $\tilde{w}$.

[24] For drawing this figure, we have made use of the following properties: (i) $\xi^t/\xi^a = 1$ if $k = 0$; (ii) $\lim_{k\to\infty} \xi^t/\xi^a = 0$; (iii) $q(1,1) > 0$ and thus $d\xi^t/dn > 0\big|_{n=1,k\leq 1} > 0$. Furthermore, the line denoted $n > 2$ has been drawn for a $n \in (n^*, n_0)$, where n^* is the unique solution to $\xi^t = \xi^a$ if $k = 1$ (see appendix).

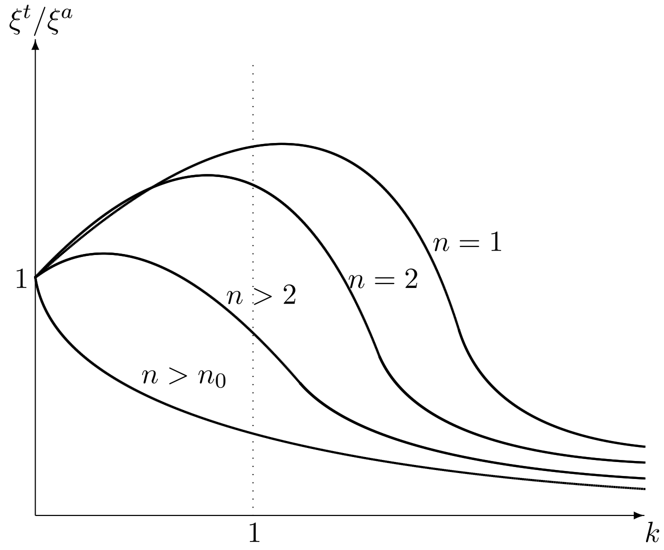


Figure 3.3: $\xi^t/\xi^a - k$ patterns for different levels of n

industry-wide wage payments, $\mathfrak{L}^t(\bar{z})$, with the cross-sectoral employment distribution, $\rho^t(\bar{z})$. To characterize the latter, we first substitute $l^t(z)$ from (3.68) into $\bar{L}^t(\bar{z}) = \int_{1-\bar{z}}^1 nl^t(z)dz$. This gives the total employment in sectors $z \geq 1 - \bar{z}$, which are the $\bar{z}$ sectors with the lowest wage income:

$$\bar{L}^t(\bar{z}) = \frac{(1+k)^2 n^2 \left[a \int_{1-\bar{z}}^1 \alpha(z)dz - \int_{1-\bar{z}}^1 \alpha(z)^2 dz\right]}{b\left[1+(1+k)n\right]^2}. \tag{3.78}$$

Noting that economy-wide employment, $(1-u^t)L$, equals $\bar{L}^t(1)$, we can calculate the share of workers with a job in industries $z \geq 1 - \bar{z}$: $\rho^t(\bar{z}) = \bar{L}^t(\bar{z})/[(1-u^t)L]$. This gives the same expression as under autarky. Hence, similar to the analysis in Section 3.4, trade with $k > 0$ fully symmetric economies does not change the cross-sectoral composition of the workforce. To determine $\mathfrak{L}^t(\bar{z})$, we first add industry-wide wage payments over all industries $z \geq 1 - \bar{z}$. For this purpose, we can substitute $w^t(z)$ from (3.67) and $l^t(z)$ from (3.68) into $\bar{W}^t(z) = \int_{1-\bar{z}}^1 nw^t(z)l^t(z)dz$, which gives

$$\bar{W}^t(\bar{z}) = \frac{(1+k)^2 n^2 \left\{a^2\bar{z} + \left[(1+k)n-1\right] a\bar{w} \int_{1-\bar{z}}^1 \alpha(z)dz - n(1+k)\bar{w}^2 \int_{1-\bar{z}}^1 \alpha(z)^2 dz\right\}}{b\left[1+(1+k)n\right]^3}, \tag{3.79}$$

with $W^t = \bar{W}^t(1)$ being economy-wide labor income. Dividing $\bar{W}^t(\bar{z})$ by W^t, then gives

$$\mathfrak{L}^t(\bar{z}) = \frac{a^2 + [(1+k)n-1]a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz - (1+k)n\bar{w}^2 \int_{1-\bar{z}}^1 \alpha(z)^2 dz}{a^2 + [(1+k)n-1]a\bar{w}\mu_1 - (1+k)n\bar{w}^2\mu_2}. \tag{3.80}$$

Since the employment ratio across all industries stays constant, we can infer insights upon the role of k for the Lorenz curve for labor income from analyzing the impact of changes in k on $\mathfrak{L}^t(\bar{z})$. However, by noting that an increase in k exerts qualitatively the same impact on $\mathfrak{L}^t(\bar{z})$ as an increase in n, we do not need further calculations but instead can conclude from the respective insights in the appendix that – similar to an increase in n – an increase in k lowers inequality among production workers. With $k = 0$ referring to the autarky scenario, this implies that trade lowers labor income inequality, irrespective of the size of k, while the respective effect is the less pronounced the smaller is the trading partner (i.e. the smaller is k). This completes our formal analysis of trade between countries of different size.

Ricardian technology differences

Since the assumptions for the model variant with Ricardian technology differences are discussed in detail in the main text, we do not repeat them here. Furthermore, because the two countries only differ in technology, world-wide consumer demand in (3.3′) remains the same as in the baseline scenario. In view of product market clearing, we can thus write profits of a domestic firm j in the following way[25]

$$\pi_j = \left[a - \frac{b}{2}\left(\sum_{i=1}^{n} y_i + \sum_{i=1}^{n} y_i^*\right) - c_j(z)\right] y_j, \tag{3.81}$$

where an asterisk has been introduced to refer to foreign country variables. Substituting $c_j(z) = \alpha_j(z)w_j$ and maximizing profits π_j gives the first-order condition

$$\frac{d\pi_j}{dy_j} = a - \frac{b}{2}\sum_{i\neq j} y_i - \frac{b}{2}\sum_{i=1}^{n} y_i^* - by_j - \alpha(z)w_j = 0. \tag{3.82}$$

Doing the same for domestic firm k and foreign firm f, we obtain

$$\frac{d\pi_k}{dy_k} = a - \frac{b}{2}\sum_{i\neq k} y_i - \frac{b}{2}\sum_{i=1}^{n} y_i^* - by_k - \alpha(z)w_k = 0 \tag{3.83}$$

and

$$\frac{d\pi_f^*}{dy_f^*} = a - \frac{b}{2}\sum_{i=1}^{n} y_i - \frac{b}{2}\sum_{i\neq f} y_i^* - by_f^* - \alpha^*(z)w_f^* = 0, \tag{3.84}$$

respectively. Since the maximization problem is symmetric for all domestic firms and all foreign firms, respectively, we can set $k = i$, for all $i \neq j$ domestic firms, and $f = i$ for all i foreign firms in (3.83) and (3.84). Doing this, we can calculate

$$y_i = \frac{a - (b/2)y_j - (n+1)\alpha(z)w_i + n\alpha^*(z)w_i^*}{bn}, \tag{3.85}$$

$$y_i^* = \frac{a - (b/2)y_j + (n-1)\alpha(z)w_i - n\alpha^*(z)w_i^*}{bn}. \tag{3.86}$$

Substituting these two expressions into (3.82) and accounting again for the aforementioned symmetry, we get domestic firm j's output as a function of its own wage, w_j and the domestic and foreign competitors' wage rates, w_i and w_i^*, respectively:

$$y_j = \frac{2\left[a - 2n\alpha(z)w_j + (n-1)\alpha(z)w_i + n\alpha^*(z)w_i^*\right]}{b(2n+1)}. \tag{3.87}$$

[25] Since the same rationale applies when calculating domestic and foreign variables, we concentrate on domestic ones and only discuss foreign variables, where this is necessary for the derivation of our results.

Substituting the latter together with $l_j = \alpha(z)y_j$ into objective function (3.7) and maximizing the resulting expression for w_j, gives the first-order condition for the union's optimization problem:

$$\frac{dV_j}{dw_j} = \frac{2\alpha(z)}{b(2n+1)} \left[a - 4n\alpha(z)w_j + (n-1)\alpha(z)w_i + n\alpha^*(z)w_i^* + 2n\alpha(z)\bar{w}\right] = 0 \tag{3.88}$$

Noting that the optimization problem is the same for all unions, we can now set $w_j = w_i$ and solve the first-order condition for the common domestic wage in industry z, $w^t(z)$, as a function of the common foreign wage in the same industry, $w^{*t}(z)$:

$$w^t(z) = \frac{a + n\alpha^*(z)w^{*t}(z) + 2n\alpha(z)\bar{w}}{\alpha(z)(3n+1)}. \tag{3.89}$$

Following exactly the same line of reasoning for the foreign country, we can calculate

$$w^{t*}(z) = \frac{a + n\alpha(z)w^t(z) + 2n\alpha^*(z)\bar{w}}{\alpha^*(z)(3n+1)}. \tag{3.90}$$

We thus have a system of two equations that allows us to explicitly solve for the two wage rates. This gives

$$w^t(z) = \frac{(4n+1)a + 2n\bar{w}[(3n+1)\alpha(z) + n\alpha^*(z)]}{\alpha(z)(2n+1)(4n+1)} \tag{3.91}$$

$$w^{t*}(z) = \frac{(4n+1)a + 2n\bar{w}[(3n+1)\alpha^*(z) + n\alpha(z)]}{\alpha^*(z)(2n+1)(4n+1)}. \tag{3.92}$$

Substituting wages (3.91) and (3.92) into (3.87) and accounting for $l^t(z) = \alpha(z)y^t(z)$, we can calculate

$$y^t(z) = \frac{4n\left\{(4n+1)[a - \alpha(z)\bar{w}] + 2n^2\bar{w}[\alpha^*(z) - \alpha(z)]\right\}}{b(2n+1)^2(4n+1)} \tag{3.93}$$

$$l^t(z) = \frac{4n\alpha(z)\left\{(4n+1)[a - \alpha(z)\bar{w}] + 2n^2\bar{w}[\alpha^*(z) - \alpha(z)]\right\}}{b(2n+1)^2(4n+1)}. \tag{3.94}$$

Doing the same for the foreign country and substituting the output of domestic and foreign firms into (3.3′), we obtain the equilibrium world market price for industrial good z:

$$p^t(z) = \frac{(4n+1)a + 2n^2\bar{w}[\alpha(z) + \alpha^*(z)]}{(2n+1)^2}. \tag{3.95}$$

Finally, firm-level profits are given by $\pi^t(z) = (b/2)\left[y^t(z)\right]^2$, while industry-wide profits equal $\Pi^t(z) = n\pi^t(z)$. This completes our discussion on firm- and industry-level variables and we now turn to solving for economy-wide variables.

The first of these variables is unemployment, which can be calculated by adding up employment over all firms and industries and subtracting the resulting expression from exogenous labor supply L. In view of (3.94), this gives for the home country (3.13″). Furthermore, substituting the world price from (3.95) into $\tilde{U}^t = -\mu_2^p$ gives welfare (3.15″). To compare the welfare levels in (3.15′) and (3.15″), it is useful to solve the respective integrals. In the benchmark scenario with fully symmetric countries, this gives

$$\tilde{U}^t\Big|_{\delta=0} = -\frac{(4n+1)^2a^2 + 8n^2(4n+1)a\mu_1\bar{w} + 16n^4\mu_2\bar{w}^2}{(2n+1)^4}, \tag{3.96}$$

while under technological dissimilarity, we obtain

$$\tilde{U}^t\Big|_{\delta>0} = -\frac{(4n+1)^2a^2 + 8n^2(4n+1)a\mu_1\bar{w} + 16n^4\mu_2\bar{w}^2 - 8n^4\bar{w}^2\delta}{(2n+1)^4}. \tag{3.97}$$

The welfare differential is thus equal to $\tilde{U}^t\Big|_{\delta>0} - \tilde{U}^t\Big|_{\delta=0} = 8n^4\bar{w}^2\delta/(2n+1)^4 > 0$, which confirms the respective finding in the main text.

In order to characterize inter-group income inequality, we calculate the profit-wage ratio. Average profits are obtained by aggregating profits $\pi^t(z)$ over all industries. This gives[26]

$$\tilde{\pi}^t = \frac{8n^2\left[(4n+1)^2(a - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2) + 4n^2(2n^2+4n+1)\bar{w}^2\delta\right]}{b(2n+1)^4(4n+1)^2}. \tag{3.98}$$

For determining average wage income, we need to add up total wage payments of domestic firms in all industries and divide the respective expression by economy-wide employment as characterized by (3.96). In view of (3.91) and (3.94), this gives[27]

$$\tilde{w}^t = \frac{(4n+1)^2[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2] - 2n^2(4n^2-2n-1)\bar{w}^2\delta}{(2n+1)(4n+1)^2[a\mu_1 - \bar{w}\mu_2] - 2n^2(2n+1)(4n+1)\delta\bar{w}}. \tag{3.99}$$

Dividing (3.98) by (3.99), gives the profit-wage ratio for the case of technological dissimilar countries

$$\begin{aligned}\xi^t = &\frac{8n^2}{b(2n+1)^3(4n+1)}\frac{\left[(4n+1)\left(a\mu_1 - \bar{w}\mu_2\right) - 2n^2\bar{w}\delta\right]}{(4n+1)^2[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2] - 2n^2(4n^2-2n-1)\bar{w}^2\delta} \\ &\times \frac{\left[(4n+1)^2(a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2) + 4n^2(2n^2+4n+1)\bar{w}^2\delta\right]}{(4n+1)^2[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2] - 2n^2(4n^2-2n-1)\bar{w}^2\delta}\end{aligned} \tag{3.100}$$

In order to analyze the effect of productivity differences on inter-group inequality, we can note that ξ^t in (3.100) equals the respective ratio for symmetric countries in (3.100) if $\delta = 0$. Hence, we can infer insights on how technological dissimilarity affects the profit-wage ratio, by differentiating (3.100) with respect to δ. In view of $\xi^t = \tilde{\pi}^t/\tilde{w}^t$, this gives

$$\frac{d\xi^t}{d\delta} = \frac{1}{\tilde{w}}\left[\frac{d\tilde{\pi}}{d\delta} - \frac{d\tilde{w}}{d\delta}\xi^t\right]. \tag{3.101}$$

[26]Noting that profits are proportional to the square of output, i.e. $\pi^t(z) = b[y^t(z)]^2$, we can calculate

$$\pi^t(z) = \frac{8n^2\left\{(4n+1)[a - \alpha(z)\bar{w}] + 2n^2\bar{w}[\alpha^*(z) - \alpha(z)]\right\}^2}{b(2n+1)^4(4n+1)^2}.$$

Substituting the latter into $\tilde{\pi}^t = \int_0^1 \pi^t(z)dz$, gives the expression in (3.98).

[27]Substituting the wage from (3.91) and employment from (3.94) into $W^t = \int_0^1 nw^t(z)l^t(z)dz$, gives

$$W^t = \frac{4n^2\{(4n+1)^2[a^2 + (2n-1)a\mu_1\bar{w} - 2n\bar{w}^2\mu_2] - 2n^2(4n^2-2n-1)\delta\bar{w}^2\}}{b(2n+1)^3(4n+1)^2}.$$

Dividing the latter by $(1 - u^t)L$, according to (3.96), we obtain (3.99).

Noting

$$\frac{d\tilde{w}}{d\delta} = \frac{2n^2\bar{w}^2(4n+1)^2(2n+1)\Big[(4n+1)a\left(a-\bar{w}\mu_1\right)+(2n+1)^2\left(a\bar{w}\mu_1-\bar{w}^2\mu_2\right)\Big]}{\left\{(2n+1)(4n+1)^2[a\mu_1-\bar{w}\mu_2]-2n^2(2n+1)(4n+1)\delta\bar{w}\right\}^2} > 0, \quad (3.102)$$

$d^2\tilde{w}/d\delta^2 > 0$ as well as

$$\frac{d\tilde{\pi}}{d\delta} = \frac{8n^2}{b(2n+1)^4}\frac{4n^2(2n^2+4n+1)\bar{w}^2}{(4n+1)^2} > 0, \quad (3.103)$$

$d^2\tilde{\pi}/d\delta^2 = 0$, it is tedious but straightforward to show that

$$\left.\frac{d\xi^t}{d\delta}\right|_{\delta=0} = \frac{16n^4\bar{w}^2}{b(2n+1)^4(4n+1)^2\tilde{w}}\left\{2(2n^2+4n+1) - \frac{\left[(4n+1)a\left(a-\bar{w}\mu_1\right)+(2n+1)^2\left(a\bar{w}\mu_1-\bar{w}^2\mu_2\right)\right]\left(a^2-2a\bar{w}\mu_1+\bar{w}^2\mu_2\right)}{\left(a\mu_1\bar{w}-\bar{w}^2\mu_2\right)\left[a^2+(2n-1)a\bar{w}\mu_1-2n\bar{w}^2\mu_2\right]}\right\}. \quad (3.104)$$

Rearranging terms, we can conclude that $d\xi^t/d\delta\big|_{\delta=0} >,=,< 0$ if

$$\begin{aligned}(4n^2+8n+2)\big(a\mu_1\bar{w}-\bar{w}^2\mu_2\big)\big[a^2+(2n-1)a\bar{w}\mu_1-2n\bar{w}^2\mu_2\big]\\ >,=,< \left[(4n+1)a\left(a-\bar{w}\mu_1\right)+(2n+1)^2\left(a\bar{w}\mu_1-\bar{w}^2\mu_2\right)\right]\big(a^2-2a\bar{w}\mu_1+\bar{w}^2\mu_2\big)\end{aligned}$$

or, equivalently, if

$$(2n+1)(4n^2+8n+2)\left[a\bar{w}\mu_1-\bar{w}^2\mu_2\right]^2 >,=,< (4n+1)\left[a^2-2a\bar{w}\mu_1+\bar{w}^2\mu_2\right]^2. \quad (3.105)$$

Since it is in general not clearcut, whether the left-hand side or the right-hand side of the latter expression is larger, we can conclude that the impact of technological dissimilarity on the profit-wage ratio is not clearcut, either.

To get insights on the role of profit income inequality, we have to determine $\mathfrak{J}^t(\bar{z})$ for the case of $\delta > 0$. For this purpose, we follow the formal steps in the main text and first characterize total profit income of firm owners in industries $z \geq 1-\bar{z}$. Substituting sector-wide profits in industry z

$$\begin{aligned}\Pi^t(z) = \frac{8n^3}{b(2n+1)^4(4n+1)^2}\Big\{&(4n+1)^2\left(a^2-2a\alpha(z)\bar{w}+\alpha(z)^2\bar{w}^2\right)\\ &+4n^2(4n+1)\bar{w}\Big[a\big(\alpha^*(z)-\alpha(z)\big)-\alpha(z)\alpha^*(z)\bar{w}+\alpha(z)^2\bar{w}\Big]\\ &+4n^4\bar{w}^2\left[\alpha^*(z)^2-2\alpha(z)\alpha^*(z)+\alpha(z)^2\right]\Big\}^2 \end{aligned} \quad (3.106)$$

into $\bar{\Pi}^t(\bar{z}) = \int_{1-\bar{z}}^1 \Pi^t(z)dz$, we get

$$\bar{\Pi}^t(\bar{z}) = \frac{8n^3}{b(2n+1)^4(4n+1)^2}\Big\{(4n+1)^2\left(a^2\bar{z} - 2a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz + \bar{w}^2\int_{1-\bar{z}}^1 \alpha(z)^2dz\right) + 4n^2\bar{w}\int_{1-\bar{z}}^1 \{(4n+1)\big[a - \bar{w}\alpha(z)\big] + n^2\bar{w}\big[\alpha^*(z) - \alpha(z)\big]\}\big[\alpha^*(z) - \alpha(z)\big]dz \quad (3.107)$$

Noting that economy-wide profits are given by $\Pi^t = \bar{\Pi}^t(1)$, we can calculate the share of profit-income that is realized in industries $z \geq 1 - \bar{z}$:

$$\mathfrak{I}^t(\bar{z}) = \frac{(4n+1)^2\left[a^2\bar{z} - 2a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz + \bar{w}^2\int_{1-\bar{z}}^1 \alpha(z)^2dz\right]}{(4n+1)^2(a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2) + 4n^2(2n^2+4n+1)\bar{w}^2\delta} + \frac{4n^2\bar{w}\int_{1-\bar{z}}^1 \{(4n+1)\big[a - \bar{w}\alpha(z)\big] + n^2\bar{w}\big[\alpha^*(z) - \alpha(z)\big]\}\big[\alpha^*(z) - \alpha(z)\big]dz}{(4n+1)^2(a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2) + 4n^2(2n^2+4n+1)\bar{w}^2\delta}. \quad (3.108)$$

This is the Lorenz curve for profit income in an open economy with trade between two technological dissimilar countries. Differentiating $\mathfrak{I}^t(\bar{z})$ and accounting for $\bar{\alpha} \equiv \alpha(1-\bar{z})$, $\bar{\alpha}^* \equiv \alpha^*(1-\bar{z})$, gives

$$\frac{d\mathfrak{I}^t(\bar{z})}{d\bar{z}} = \frac{\big[(4n+1)(a - \bar{w}\bar{\alpha}) + 2n^2\bar{w}(\bar{\alpha}^* - \bar{\alpha})\big]^2}{(4n+1)^2(a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2) + 4n^2(2n^2+4n+1)\bar{w}^2\delta} \quad (3.109)$$

which is unambiguously positive. Furthermore, noting that $d\bar{\alpha}/d\bar{z} < 0$ and $d\bar{\alpha}^*/d\bar{z} > 0$, it is easily confirmed that the Lorenz curve is convex.

To analyze the effect of Ricardian productivity differences on the distribution of profit income we can compare $\mathfrak{I}^t(\bar{z})$ in (3.108) with the respective expression for trade between two fully symmetric trading partners (which is the same as under autarky) in (3.17). Since such a comparison is difficult, we choose a different approach and compare the first derivatives of the two Lorenz curves in Eqs. (3.31) and (3.109), respectively. Doing this, we find that the respective derivative is larger, equal, or smaller under technological dissimilarity than in the benchmark scenario of two fully symmetric countries if

$$\kappa(\bar{z}) \equiv (4n+1)\frac{\bar{\alpha}^* - \bar{\alpha}}{(a - \bar{w}\bar{\alpha})} + n^2\bar{w}\left(\frac{\bar{\alpha}^* - \bar{\alpha}}{a - \bar{w}\bar{\alpha}}\right)^2 - \frac{(2n^2+4n+1)\bar{w}\delta}{a^2 - 2a\bar{w}\mu_1 + \bar{w}^2\mu_2} >, =, < 0 \quad (3.110)$$

Noting that $(4n+1)(a - \bar{w}\bar{\alpha}) + n^2\bar{w}(\bar{\alpha}^* - \bar{\alpha}) > 0$ must hold, according to (3.93), if the production in both countries is fully diversified (see the assumptions in the main text), it is immediate from inspection of (3.110) that $\kappa(\bar{z}) < 0$ holds for any $\bar{\alpha} \geq \bar{\alpha}^*$, which, in view of $d\bar{\alpha}/d\bar{z} < 0$, $d\bar{\alpha}^*/d\bar{z} > 0$, means for sufficiently small $\bar{z}$. Noting further that $\Delta\mathfrak{I}^t(\bar{z}) \equiv \mathfrak{I}^t(\bar{z})\big|_{\delta>0} - \mathfrak{I}^t(\bar{z})\big|_{\delta=0} = 0$ if $\bar{z} = 0$, we can thus conclude that (i) $d\Delta\mathfrak{I}^t(z)/d\bar{z} < 0$ and thus (ii) $\Delta\mathfrak{I}^t(\bar{z}) < 0$ for small levels of $\bar{z}$. However, in view of $\Delta\mathfrak{I}^t(\bar{z}) = 0$ if $\bar{z} = 1$, it is also clear that there must be some high levels of $\bar{z}$ for which $d\Delta\mathfrak{I}^t(z)/d\bar{z} > 0$. To shed further light on this, we can differentiate (3.110). This yields

$$\kappa'(\bar{z}) = \left[(4n+1) + 2n^2\bar{w}\frac{\bar{\alpha}^* - \bar{\alpha}}{a - \bar{w}\bar{\alpha}}\right]\left[\frac{1}{a - \bar{w}\bar{\alpha}}\frac{d\bar{\alpha}^*}{d\bar{z}} - \frac{a - \bar{w}\bar{\alpha}^*}{(a - \bar{w}\bar{\alpha})^2}\frac{d\bar{\alpha}}{d\bar{z}}\right], \quad (3.111)$$

which, in view of $d\bar{\alpha}/d\bar{z} < 0$ and $d\bar{\alpha}^*/d\bar{z} > 0$, is unambiguously positive if $\bar{\alpha}^* > \bar{\alpha}$. This implies that, if $d\Delta\mathfrak{J}(\bar{z})/d\bar{z} \geq 0$ at $\bar{z}^*$, the derivative must be strictly positive for any $\bar{z} > \bar{z}^*$.[28] In view of $\Delta\mathfrak{J}(1) = 0$, this however implies that $\Delta\mathfrak{J}(\bar{z}) < 0$ holds for all $\bar{z} < 1$ that are consistent with $\bar{\alpha}^* > \bar{\alpha}$. Together with our insights from above that $\Delta\mathfrak{J}(\bar{z}) < 0$ holds for all $\bar{z} > 0$ that are consistent with $\bar{\alpha} \geq \bar{\alpha}^*$, we can thus safely conclude that the Lorenz curve for profit income in the case of trade between two technologically dissimilar countries lies strictly below the respective Lorenz curve for profit income in the case of trade between two fully symmetric countries, which provides a formal proof for the respective discussion in the main text.

To characterize the Lorenz curve for wage income, we must combine information upon the distribution of wage payments across industries, $\mathfrak{L}^t(\bar{z})$, with the distribution of workers across industries, $\rho^t(\bar{z})$. Starting with the analysis of $\mathfrak{L}^t(\bar{z})$, we can first calculate sector-wide wage payments $W^t(z) = nw^t(z)l^t(z)$. Accounting for (3.91) and (3.94), we can calculate

$$\begin{aligned} W^t(z) = \frac{4n^2}{b(2n+1)^3(4n+1)^2}\Big\{&(4n+1)^2a^2 - (4n+1)^2 a\alpha(z)\bar{w} + 2n^2(4n+1)a\alpha^*(z)\bar{w} \\ &- 2n^2(4n+1)a\alpha(z)\bar{w} + 2n(3n+1)(4n+1)a\alpha(z)\bar{w} + 2n^2(4n+1)a\alpha^*(z)\bar{w} \\ &- 2n(3n+1)(4n+1)\alpha(z)^2\bar{w}^2 - 2n^2(4n+1)\alpha(z)\alpha^*(z)\bar{w}^2 + 4n^3(3n+1)\alpha(z)\alpha^*(z)\bar{w}^2 \\ &- 4n^3(3n+1)\alpha(z)^2\bar{w}^2 + 4n^4\alpha^*(z)^2\bar{w}^2 - 4n^4\alpha(z)\alpha^*(z)\bar{w}^2\Big\} \end{aligned} \quad (3.112)$$

Substituting the latter into $\bar{W}^t(\bar{z}) = \int_{1-\bar{z}}^1 W^t(z)dz$ we obtain the total wage bill of workers in industries $z \geq 1 - \bar{z}$, which are the industries that offer the lowest wages:

$$\begin{aligned} \bar{W}^t(\bar{z}) = \frac{4n^2}{b(2n+1)^3(4n+1)^2}\Big\{&(4n+1)^2\left[a^2\bar{z} + (2n-1)a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz - 2n\bar{w}^2\int_{1-\bar{z}}^1 \alpha(z)^2 dz\right] \\ &+ 2n^2\bar{w}\int_{1-\bar{z}}^1 \left[2(4n+1)a + (6n^2-2n-1)\bar{w}\alpha(z) + 2n^2\bar{w}\alpha^*(z)\right]\big(\alpha^*(z) - \alpha(z)\big)dz\Big\} \end{aligned} \quad (3.113)$$

Noting that economy-wide wage income is given by $W^t = \bar{W}^t(1)$ and accounting for $\mathfrak{L}^t(z) = \bar{W}^t(\bar{z})/W^t$, we can calculate

$$\begin{aligned} \mathfrak{L}^t(\bar{z}) = &\frac{(4n+1)^2\left[a^2\bar{z} + (2n-1)a\bar{w}\int_{1-\bar{z}}^1 \alpha(z)dz - 2n\bar{w}^2\int_{1-\bar{z}}^1 \alpha(z)^2dz\right]}{(4n+1)^2\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right] - 2n^2(4n^2-2n-1)\delta\bar{w}^2} \\ &+ \frac{2n^2\bar{w}\int_{1-\bar{z}}^1 \left[2(4n+1)a + (6n^2-2n-1)\bar{w}\alpha(z) + 2n^2\bar{w}\alpha^*(z)\right]\big(\alpha^*(z)-\alpha(z)\big)dz}{(4n+1)^2\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right] - 2n^2(4n^2-2n-1)\delta\bar{w}^2}, \end{aligned} \quad (3.114)$$

[28]Recollect from above that $d\Delta\mathfrak{J}(\bar{z})/d\bar{z} \geq 0$ requires a $\bar{z}$ such that $\bar{\alpha}^* > \bar{\alpha}$.

with

$$\frac{d\mathfrak{L}^t(\bar{z})}{d\bar{z}} = \frac{(4n+1)^2\left[a^2\bar{z} + (2n-1)a\bar{w}\bar{\alpha} - 2n\bar{w}^2\bar{\alpha}(z)^2\right]}{(4n+1)^2\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right] - 2n^2(4n^2-2n-1)\delta\bar{w}^2} + \frac{2n^2\bar{w}\left[2(4n+1)a + (6n^2-2n-1)\bar{w}\bar{\alpha} + 2n^2\bar{w}\bar{\alpha}^*\right]\left(\bar{\alpha}^* - \bar{\alpha}\right)}{(4n+1)^2\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right] - 2n^2(4n^2-2n-1)\delta\bar{w}^2} > 0. \tag{3.115}$$

However, this is only one part of the Lorenz curve for wage income and in order to get a comprehensive picture of the distribution of labour income among production workers, we must combine $\mathfrak{L}^t(\bar{z})$ with the share of workers employed in industries $z \geq 1 - \bar{z}$. Substituting (3.94) into $\bar{L}^t(\bar{z}) = \int_{1-\bar{z}}^1 nl^t(z)dz$, we calculate aggregate employment in these industries:

$$\bar{L}^t(\bar{z}) = \frac{4n^2}{b(2n+1)^2(4n+1)}\left\{(4n+1)\left[a\int_{1-\bar{z}}^1 \alpha(z)dz - \bar{w}\int_{1-\bar{z}}^1 \alpha(z)^2dz\right] - 2n^2\bar{w}\left[\int_{1-\bar{z}}^1 \alpha(z)^2dz - \int_{1-\bar{z}}^1 \alpha(z)\alpha^*(z)dz\right]\right\}. \tag{3.116}$$

Dividing (3.116) by $\bar{L}^t(1) = (1-u^t)L$, as characterized by (3.96), we obtain the share of workers who have a job in industries $z \geq 1 - \bar{z}$:

$$\rho^t(\bar{z}) = \frac{(4n+1)[a\int_{1-\bar{z}}^1 \alpha(z)dz - \bar{w}\int_{1-\bar{z}}^1 \alpha(z)^2dz] - 2n^2\bar{w}[\int_{1-\bar{z}}^1 \alpha(z)^2dz - \int_{1-\bar{z}}^1 \alpha(z)\alpha^*(z)dz]}{(4n+1)[a\mu_1 - \bar{w}\mu_2] - 2n^2\bar{w}\delta}, \tag{3.117}$$

with

$$\frac{d\rho^t(\bar{z})}{d\bar{z}} = \frac{(4n+1)\bar{\alpha}[a - \bar{w}\bar{\alpha}] + 2n^2\bar{\alpha}\bar{w}[\bar{\alpha}^* - \bar{\alpha}]}{(4n+1)[a\mu_1 - \bar{w}\mu_2] - 2n^2\bar{w}\delta} > 0. \tag{3.118}$$

The Lorenz curve is fully characterized by $\mathfrak{L}^t(\bar{z})$ and $\rho^t(\bar{z})$ and has the usual properties: It is increasing and convex.

To learn about the impact of technological dissimilarity on wage income inequality, we can compare the Lorenz curve for labour income in the scenario of trade between two technologically dissimilar countries with the one in the benchmark scenario of trade between two fully symmetric countries. Since a direct comparison of $\mathfrak{M}^t(\bar{\rho})$ for the two scenarios turns out to be tedious, we try to get insights on the ranking of inequality in the two scenarios by analyzing the role of technological dissimilarity separately for $\mathfrak{L}^t(\bar{z})$ and $\rho^t(\bar{z})$. Staring with $\mathfrak{L}^t(\bar{z})$, we can infer insights upon the ranking of $\mathfrak{L}^t(\bar{z})\big|_{\delta=0}$ and $\mathfrak{L}^t(\bar{z})\big|_{\delta>0}$ by investigating how technological dissimilarity affects the derivative $d\mathfrak{L}^t(\bar{z})/d\bar{z}$. Defining $\Delta\mathfrak{L}^t(\bar{z}) \equiv \mathfrak{L}^t(\bar{z})\big|_{\delta>0} - \mathfrak{L}^t(\bar{z})\big|_{\delta=0} >, =, < 0$, we can see from a comparison of (3.115) and

$$\left.\frac{d\mathfrak{L}^t(\bar{z})}{d\bar{z}}\right|_{\delta=0} = \frac{(4n+1)^2\left[a^2\bar{z} + (2n-1)a\bar{w}\bar{\alpha} - 2n\bar{w}^2\bar{\alpha}(z)^2\right]}{(4n+1)^2\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right]}, \tag{3.119}$$

that $d\Delta\mathfrak{L}^t(\bar{z})/d\bar{z} >,=,< 0$ if $2n^2(4n+1)^2\bar{w}\chi(\bar{z}) >,=,< 0$, where

$$\chi(\bar{z}) \equiv \left(\bar{\alpha}^* - \bar{\alpha}\right)\left[2(4n+1)a + (6n^2-2n-1)\bar{w}\bar{\alpha} + 2n^2\bar{w}\bar{\alpha}^*\right]\left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right] + \left[a^2\bar{z} + (2n-1)a\bar{w}\bar{\alpha} - 2n\bar{w}^2\bar{\alpha}(z)^2\right](4n^2-2n-1)\delta\bar{w}. \quad (3.120)$$

It is obvious that $\chi(\bar{z}) > 0$ and thus $d\Delta\mathfrak{L}^t(\bar{z})/d\bar{z} > 0$ hold for all $\bar{z}$ that are consistent with $\bar{\alpha}^* \geq \bar{\alpha}$, which, in view of $d\bar{\alpha}/dz < 0$ and $d\bar{\alpha}^*/dz > 0$, refers to large levels of $\bar{z}$. In view of $\Delta\mathfrak{L}^t(1) = 0$, we can therefore conclude that $\Delta\mathfrak{L}^t(\bar{z}) < 0$ must hold for large levels of $\bar{z}$ – more specifically, for all $\bar{z} < 1$, for which $\bar{\alpha}^* \geq \bar{\alpha}$. Differentiating $\chi(\bar{z})$ further implies

$$\begin{aligned}\chi'(\bar{z}) = \left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right]\Bigg\{&\left[2(4n+1)a + (4n^2-2n-1)\bar{w}\bar{\alpha} + 4n^2\bar{w}\bar{\alpha}^*\right]\frac{d\bar{\alpha}^*}{d\bar{z}} \\ &- \left[2(4n+1)a + (6n^2-2n-1)\bar{w}\bar{\alpha} + 2n^2\bar{w}\bar{\alpha}^* - (6n^2-2n-1)\bar{w}\left(\bar{\alpha}^* - \bar{\alpha}\right)\right]\frac{d\bar{\alpha}}{d\bar{z}}\Bigg\} \\ &+ \left[(2n-1)a - 4n\bar{w}\bar{\alpha}(z)\right](4n^2-2n-1)\delta\bar{w}^2\frac{d\bar{\alpha}}{d\bar{z}}. \quad (3.121)\end{aligned}$$

The latter can be reformulated to

$$\begin{aligned}\chi'(\bar{z}) = \left[a^2 + (2n-1)a\bar{w}\mu_1 - 2n\bar{w}^2\mu_2\right]\Bigg\{&\left[2(4n+1)a + (4n^2-2n-1)\bar{w}\bar{\alpha} + 4n^2\bar{w}\bar{\alpha}^*\right]\frac{d\bar{\alpha}^*}{d\bar{z}} \\ &- \left[(6n^2+6n+1)\bar{w}\bar{\alpha} + 2n^2\bar{w}\bar{\alpha}^* - (6n^2-2n-1)\bar{w}\left(\bar{\alpha}^* - \bar{\alpha}\right)\right]\frac{d\bar{\alpha}}{d\bar{z}}\Bigg\} \\ &- \Big[2(4n+1)a(a - \bar{w}\mu_1)(a - \bar{w}\bar{\alpha}) + (2n+1)\bar{w}\bar{\alpha}(z)(4n^2-2n-1)\delta\bar{w}^2\Big]\frac{d\bar{\alpha}}{d\bar{z}} \\ &- \Big[4n(4n+1)\bar{w}\left(a\mu_1 - \bar{w}\mu_2\right) - (2n-1)(4n^2-2n-1)\delta\bar{w}^2\Big](a - \bar{w}\bar{\alpha})\frac{d\bar{\alpha}}{d\bar{z}}.\end{aligned} \quad (3.122)$$

Noting from (3.13″) that $u^t < 1$ requires $(4n+1)(a\mu_1 - \mu_2\bar{w}) > 2n^2\delta\bar{w}$ and accounting for $d\bar{\alpha}/d\bar{z} < 0$, $d\bar{\alpha}^*/d\bar{z} > 0$, we can thus conclude that $\chi'(\bar{z}) > 0$ for all $\bar{z}$ associated with $\bar{\alpha} \geq \bar{\alpha}^*$. This implies that, if $\chi(\bar{z}) \geq 0$ and thus $d\Delta\mathfrak{L}^t(\bar{z})/d\bar{z} \geq 0$ for $\bar{z}^*$ (which requires that $\bar{\alpha} > \bar{\alpha}^*$ at $\bar{z}^*$), then $\chi(\bar{z}) > 0$ and thus $d\Delta\mathfrak{L}^t(\bar{z})/d\bar{z} > 0$ must hold for any $\bar{z} > \bar{z}^*$. In view of $\Delta\mathfrak{L}^t(1) = 0$, this also implies that $\Delta\mathfrak{L}^t(\bar{z}) < 0$ must hold for any $\bar{z} < 1$ associated with $\bar{\alpha} \geq \bar{\alpha}^*$. Together with our previous insights that $\Delta\mathfrak{L}^t(\bar{z}) < 0$ also holds for any $\bar{z} > 0$ associated with $\bar{\alpha} \leq \bar{\alpha}^*$, we can thus safely $\Delta\mathfrak{L}^t(\bar{z}) < 0$ holds for any $\bar{z} \in (0,1)$. Hence, technological dissimilarity renders the distribution of industry-wide wage payments less equal. The impact of this effect can be read off from Figure 3.4, where we see that a reduction of $\mathfrak{L}^t(\bar{z})$ for a given $\rho^t(\bar{z})$ induces higher wage income inequality, according to the Lorenz criterion: $\mathfrak{M}^t\bar{\rho}\big|_{\delta=0} > \mathfrak{M}^t\bar{\rho}\big|_{\delta>0}$ for any $\bar{\rho} \in (0,1)$.

With these insights at hand, we now turn to the second component of the Lorenz curve and analyze how technological dissimilarity affects $\rho^t(\bar{z})$. For this purpose, we define $\Delta\rho^t(\bar{z}) \equiv \rho^t(\bar{z})\big|_{\delta>0} - \rho^t(\bar{z})\big|_{\delta=0}$ and note that $d\Delta\rho^t(\bar{z})/d\bar{z} >,=,< 0$ if $2n^2(4n+1)\bar{w}\bar{\alpha}\psi(\bar{z}) >,=,< 0$, where

$$\psi(\bar{z}) \equiv (\bar{\alpha}^* - \bar{\alpha})(a\mu_1 - \bar{w}\mu_2) + \delta(a - \bar{w}\bar{\alpha}), \quad (3.123)$$

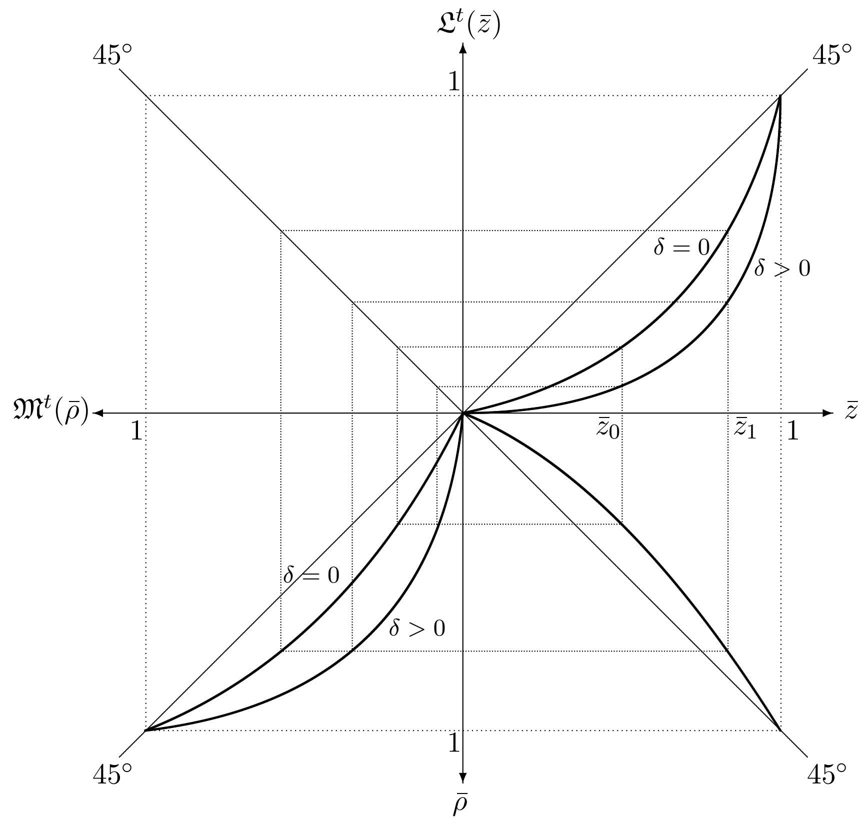


Figure 3.4: The distributional consequences of changes in $\mathfrak{L}^t(\bar{z})$ for given $\rho^t(\bar{z})$

according to (3.118) and

$$\left.\frac{d\rho^t(\bar{z})}{d\bar{z}}\right|_{\delta=0} = \frac{\bar{\alpha}[a - \bar{w}\bar{\alpha}]}{a\mu_1 - \bar{w}\mu_2}. \tag{3.124}$$

It is easily confirmed that $\psi(\bar{z}) > 0$ and thus $d\Delta\rho^t(\bar{z})/d\bar{z} > 0$ holds for any $\bar{z}$ associated with $\bar{\alpha}^* \geq \bar{\alpha}$, i.e. for sufficiently high $\bar{z}$. In view of $\Delta\rho^t(1)$,we can thus conclude that $\Delta\rho^t(\bar{z}) < 0$ holds for any $\bar{z}$ consistent with $\bar{\alpha}^* \geq \bar{\alpha}$. Differentiating $\psi(\bar{z})$ further gives

$$\psi'(\bar{z}) = (a\mu_1 - \bar{w}\mu_2)\left(\frac{d\bar{\alpha}^*}{d\bar{z}} - \frac{d\bar{\alpha}}{d\bar{z}}\right) - \delta\bar{w}\frac{d\bar{\alpha}}{d\bar{z}}, \tag{3.125}$$

which is unambiguously positive, in view of $d\bar{\alpha}/d\bar{z} < 0$, $d\bar{\alpha}^*/d\bar{z} > 0$. However, since (i) $\Delta\rho^t(0) = \Delta\rho^t(1) = 0$ and (ii) $d\Delta\rho^t(\bar{z})/d\bar{z} > 0$ for high levels of $\bar{z}$, it is immediate that $\Delta\rho^t(\bar{z})$ has a unique minimum on the relevant interval and at the same time is negative for any $\bar{z} \in (0, 1)$. This implies that workers are less equally distributed across industries if countries are technological dissimilar. To see how this affects the distribution of wage income, we can look at Figure 3.5. There, we see that, for a given $\mathfrak{L}^t\bar{z}$, the relocation of workers towards high-productivity industries lowers the income inequality within the group of production workers: $\mathfrak{M}^t\bar{\rho}\big|_{\delta=0} < \mathfrak{M}^t\bar{\rho}\big|_{\delta>0}$ for any $\bar{\rho} \in (0, 1)$.

Combining the insights from Figures 3.4 and 3.5, we can thus conclude that technological dissimilarity exerts two counteracting effects on the distribution of wage income, and since we

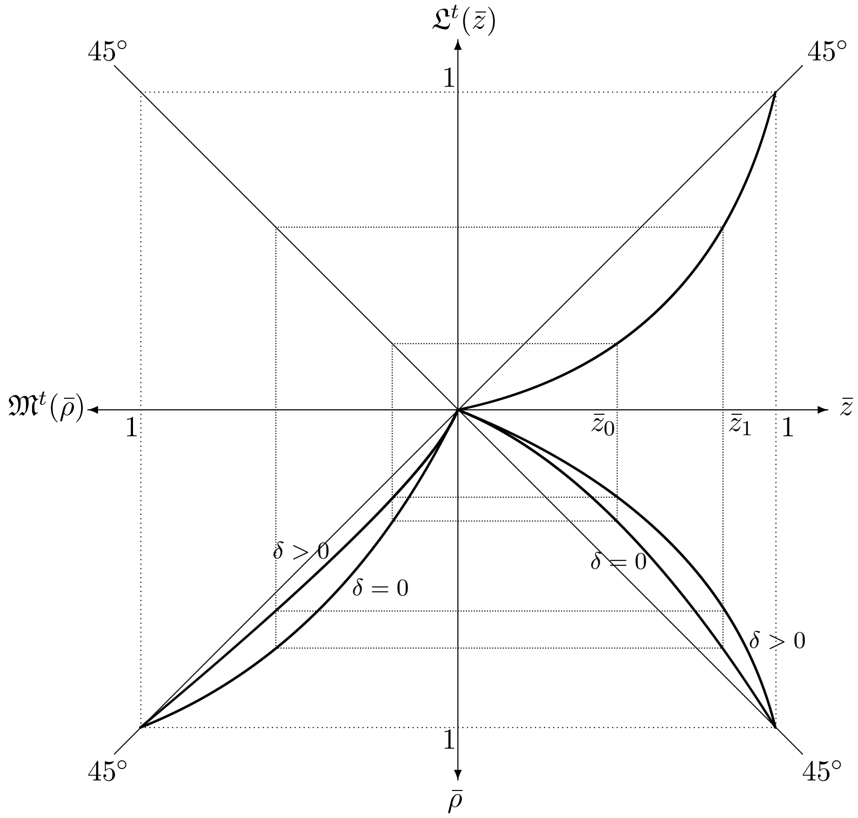


Figure 3.5: The distributional consequences of changes in $\rho^t(\bar{z})$ for given $\mathfrak{L}^t(\bar{z})$

are not able to determine which of the two effects is stronger, we cannot rank $\mathfrak{M}^t(\bar{\rho})\big|_{\delta=0}$ and $\mathfrak{M}^t(\bar{\rho})\big|_{\delta>0}$. Furthermore, we have shown in a simulation exercise, for which the program code is attached to this supplement, that trade between two technologically dissimilar countries does not necessarily lower labor income inequality relative to the closed economy. This completes the formal discussion in this supplement.

4 Union Wage Setting and International Trade with Footlose Capital

4.1 Introduction

Since Calmfors and Driffill (1988) have published their seminal work on a hump-shaped relationship between the degree of centralization in collective bargaining and aggregate unemployment, it has been commonly acknowledged that sector-level unions are more successful in securing economic rents for their members than more centralized as well as more decentralized ones, with adverse macroeconomic consequences. However, even though the 'hump-shape hypothesis' seems to be well suited for explaining why continental European countries have suffered from significantly higher unemployment rates than Scandinavian or Anglo-Saxon ones over the last two decades, empirical research does not provide strong supportive evidence for this hypothesis (see, for instance, Nickell, 1997; Flanagan, 1999, 2003). In the years following the publication by Calmfors and Driffill (1988), economists have therefore searched for a rationale that can explain the lack of supportive evidence, and openness to international trade features prominently on the list of possible arguments. While there seems to be broad agreement among economists that differences in union wage-setting institutions are in general less important in open economies (see, for instance, Bean, Danthine, Bernholz, and Malinvaud, 1990; Danthine and Hunt, 1994),[1] we still know surprisingly little about how different forms of openness, such as international trade or capital mobility, contribute to this result.

Filling the gap and providing a more comprehensive picture about how different forms of openness affect the macroeconomic consequences of differing wage-setting institutions is the purpose of this paper. To tackle this issue, we set up a general oligopolistic equilibrium (GOLE) model along the lines of Neary (2003, 2009), with a unit mass of sectors and a small (endogenous) number of firms in each industry. Enriching this framework with a simple textbook model of monopoly unions – in which unions set wages first and firms adjust employment afterwards – gives an analytically tractable general equilibrium version of a unionized oligopoly model with pure economic rents and involuntary unemployment in equilibrium (see, for instance, Egger and Etzel, 2012a).[2] The crucial innovation of our paper is the introduction of capital as a second factor

[1] It is noteworthy that this insight does not necessarily extend to other labor market institutions. For instance, Brecher (1974) and Davis (1998) point out that in an otherwise standard two-country, two-sector, two-factor Heckscher-Ohlin model, in which one country introduces a binding minimum wage, factor price equalization in the opening economy leads to an increase in unemployment in the country that suffers from the labor market friction. This suggests that the adverse employment effects of minimum wages may become even more pronounced in an open economy.

[2] A similar model has been proposed by Bastos and Kreickemeier (2009) and Kreickemeier and Meland (2011). However, assuming that only part of the industries are unionized, these models generate full employment and are thus not equipped to study the relationship between the degree of centralization in union wage setting and economy-wide unemployment.

of production into the workhorse GOLE model. To keep the analysis tractable, we assume that capital is employed as fixed input, while labor serves as a variable input in the production process. This kind of production technology is common in models of international trade (cf. Lawrence and Spiller, 1983; Flam and Helpman, 1987, for two early contributions), and it has been used by Martin and Rogers (1995) to set up "the most tractable of all the economic geography models" (see Baldwin, 2005, p. 68).

We embed this extended GOLE framework into a two-country model, in which the two economies are symmetric in all respects, except for their wage-setting institutions. To capture the institutional differences, we assume that one country is populated by firm-level unions, while the other country is populated by sector-level unions.[3] While workers are not mobile across country borders, capital owners can at least in the long run invest their resources where the investment yields the highest return. Of course, there is a difference between capital mobility and the actual movement of capital owners, who act as entrepreneurs in our setting. In line with the so-called footloose capital approach to economic geography,[4] we abstract from mobility of capital owners and assume that the return to foreign investment, which equals the operating profit from foreign production, is repatriated to the parent country.

In a first step of our analysis, we study the two economies under autarky and reproduce a key finding of Calmfors and Driffill (1988): Sector-level unions set higher wages than firm-level ones, causing higher unemployment and lower welfare in the closed economy. Equipped with this insight, we then analyze how opening up for trade changes the outcome in the two economies. Thereby, we distinguish two possible scenarios of openness. In the first one, we assume that product markets are fully integrated, while capital markets remain segmented. Since this captures the idea that capital owners do not immediately adjust their investment decisions after a globalization shock, we refer to this scenario as the *short run*. In this short-run scenario, trade raises competition in the product market and lowers the ability of unions to set excessive wages for 'insiders'. This generates an employment and welfare stimulus in both economies and thus raises the magnitude of economic rents that can be distributed between capital owners and workers. Since unions set lower wages in the open economy, the share of rents attributed to capital owners increases and this group is thus unambiguously better off than in the closed economy. However, also the group of workers benefits from product market integration, because the negative consequences of falling wages are counteracted and dominated by the employment stimulus and a ceteris paribus reduction in the price level resulting from stronger product market competition in the open economy.

Regarding the role of country-specific wage-setting institutions in the open relative to the closed economy, our model reproduces a well known result from previous research. Product market integration lowers the wage gap between the two economies, arising from differences in the prevailing wage-setting institutions, and this reduces the differential in unemployment and welfare ceteris paribus. However, there is also a counteracting effect. Fiercer competition in the global market magnifies the employment and welfare differences associated with a given wage

[3]We do not discuss economy-wide agreements as a third alternative, because agreements at the highest level of centralization have become an exception in the 21^{st} century (see OECD, 2004).

[4]For a taxonomy of the different modeling approaches that are common in the economic geography literature, see Baldwin (2005).

gap, because production shifts towards the country that offers the lower production costs in the open economy. There are hence two counteracting effects in our model and it is not clearcut in general whether differences in the degree of centralization in union wage-setting lose part of their impact on the macroeconomic performance of countries in response to product market integration. Nonetheless, our model establishes the common result that product market integration lowers differences in unemployment and welfare, when focusing on empirically plausible parameter domains. For instance, if those who are unemployed receive a compensation which is less than 2/3 of the going wage rate, the common result is reproduced provided that at least two firms are active in either country and each industry.

In the *long run*, capital is footloose and searches for the most profitable investment opportunities in the global economy. This generates capital flows from the country that hosts sector-level unions to the country that hosts firm-level unions, and these flows continue until the return to capital investment, i.e. the profit of the firm, is equalized between the two locations. Abstracting from extra costs of investing abroad, this *no arbitrage* condition is reached if wages are equalized in the two locations. However, one should not be tempted to conclude from the observation of factor price equalization that differences in the degree of union wage setting lose their impact on macroeconomic variables. On the contrary, the outflow of capital lowers employment and welfare in the country that hosts the sector-level union and raises these two macroeconomic performance measures in the country of capital inflow. This points to an important conclusion: It is not openness *per se* that helps explaining the lack of empirical evidence for the hump-shape hypothesis put forward by Calmfors and Driffill (1988). Rather, it is the integration of product markets as a specific form of openness that provides a rationale for the missing evidence, while other forms of openness, as for instance capital market integration, do not provide such a rationale. Aside from its implications on aggregate employment and welfare, we also analyze how capital mobility influences the groups of capital owners and workers specifically. Intuitively, the additional investment opportunities increase the real income of capital owners in the country that hosts sector-level unions, while workers lose in this economy since capital outflow is associated with an export of jobs in our setting. Things are different in the country that hosts the firm-level union. Due to capital inflow, firms headquartered in this country lose their competitive advantage vis-á-vis foreign producers, and hence the capital owners running these firms are worse off than in the short run. Finally, workers in the country that attracts foreign capital are definitely better off than in the short run, because the establishment of new local firms implies additional domestic jobs.

In a final step of our analysis, we investigate to what extent the common trend among OECD countries to implement less centralized forms of collective bargaining and to move towards firm-level agreements (see OECD, 2004) can be successful in securing domestic jobs and thus guarantee gains from trade for domestic workers also in the long run. The message from our analysis is clear: Decentralization can be successful if it occurs early, because in this case it can prevent the capital outflow. If decentralization is a response to the export of jobs, its implications are less promising. Decentralization – be it politically enforced or voluntarily imposed by unions – may be ineffective in stopping an already existing capital outflow and reversing the foreign investment decision of firms. Furthermore, it is worth noting that in an open economy, decentralization not only affects the domestic labor market but also generates negative spillovers on foreign workers due to labor market linkages arising from integrated product and capital markets. To be more specific, a movement from sector-level to firm-level wage setting reduces the relative competitiveness of foreign producers and thus their employment in the short run. Furthermore, if decentralization is successful in preventing capital outflow and job exports, it additionally generates long-run losses in terms of foreign employment.

Our paper is of course not the first one that studies the role of unions in open economies, and some of our results have already been established in previous work. For instance, the argument that opening up to trade lowers the ability of unions to set excessive wages can already be found in Huizinga (1993) and Sørensen (1993). Naylor (1998, 1999) broadens our understanding of the consequences of product market integration by looking at marginal reductions in trade costs. While these studies were concerned with partial equilibrium effects on union wage setting in one particular industry, Bastos and Kreickemeier (2009) have pointed to the role of general equilibrium feedback effects. In their GOLE model with a partially unionized labor market, the competitive wage rises in the open economy and this counteracts the ceteris paribus decline of union wages in a partial equilibrium environment. As a consequence, union wages may actually increase in response to a country's movement from autarky to free trade when general equilibrium feedback effects are accounted for. While all of these studies have contributed significantly to our understanding of the role of labor unions in the context of product market integration, they do not provide insights on how differences in wage-setting institutions shape the outcome in open economies.

The first study that has addressed differences in the degree of centralization in collective bargaining in the context of international trade is Bean, Danthine, Bernholz, and Malinvaud (1990). In an open economy version of the model proposed by Calmfors and Driffill (1988), these authors show that differences in unemployment rates between countries with differing degrees of centralization in collective bargaining decline when product markets become more integrated. Relying on insights from a similar setting, Danthine and Hunt (1994) therefore conclude that the hump shape in the relationship between the degree of centralization in collective bargaining and unemployment flattens in an open economy.[5] Sørensen (1994) looks at the role of centralization in union wage-setting from a different angle and investigates how differences in wage-setting institutions affect the pattern of specialization in a two-sector trade model. The degree of centralization in collective bargaining also features prominently in a literature that broaches the role of central bank independence and its interaction with non-atomistic wage setters in determining key macroeconomic variables, such as unemployment or inflation (see, for instance, Cukierman and Lippi, 1999; Soskice and Iversen, 2000). Daniels, Nourzad, and VanHoose (2006) extend the discussion to an open economy model that allows for international trade flows. However, none of the existing studies in these two strands of the literature addresses the differential impact of product and capital market integration, which is in the center of this paper's interest.

[5] It is worth noting that in Danthine and Hunt (1994) the impact of product market integration on the role of wage-setting institutions is unique, because they consider a model with perfectly competitive producers and inter-industry trade, implying that product market integration does not expose firms of a given industry to stronger foreign competition in the product market.

Since capital market integration is associated with job relocation in our setting, our analysis is also related to a sizable literature on the interaction between union wage setting and multinational activity. To the best of our knowledge, this interaction has first been addressed by Mezzetti and Dinopoulos (1991), who point out that the threat to shift production abroad improves a firm's bargaining position and reduces the negotiated wage. Zhao (1995) and Eckel and Egger (2009) argue that this threat point argument provides an incentive to set up a foreign production facility from which the firm can import in the case of disagreement with the union. Leahy and Montagna (2000) look explicitly on the role of centralization in union wage setting for the investment incentives of multinational firms and investigate under which conditions inward foreign direct investment is welfare improving. Lommerud, Meland, and Sørgard (2003) show that a fall in trade costs may render multinational activity more attractive in the presence of unions, which indicates that the interaction between different forms of globalization may be complicated when collective bargaining leads to rent sharing between firms and workers.

Furthermore, the idea of footloose capital relates our analysis to a relatively small literature studying union wage setting in the context of economic geography. In an early contribution to this literature, Munch (2003) studies the location of firms in unionized countries with oligopolistic market structure. Unions in this setting negotiate a premium on wages paid in a competitive outside sector, and this generates agglomeration forces for the following reason. The more firms are located in one country, the more workers are covered by union wage setting and the larger is labor income, ceteris paribus. With segmented markets, a movement of firms to a country therefore increases the local market and thus provides a stimulus for movement of additional foreign firms. Due to this market size externality, the country that hosts the weaker unions will end up hosting all firms if trade costs are sufficiently small and labor supply is sufficiently high. While there is also a tendency of clustering firms in our setting, there are no agglomeration forces. On the one hand, we abstract from an outside sector, so that capital outflow raises economy-wide unemployment and therefore moderates union wage claims. This lowers the incentives of firms to follow those who have already moved abroad. On the other hand, we consider an integrated world market in the open economy, so that a market size externality does not exist in our setting, so that we can safely abstract from mobility of capital owners, without affecting equilibrium production patterns.

Picard and Toulemonde (2006) also shed light on the role of union wage setting for the existence of agglomeration forces in open economies, but instead of the oligopolistic market structure in Munch (2003), they consider monopolistically competitive firms. Picard and Toulemonde (2003) add technological externalities to the picture of possible motives for agglomeration forces, while closing demand linkages by focusing on a partial equilibrium environment. In this setting, Picard and Toulemonde (2003) show that adjustments in union wage claims are an important obstacle to a full clustering of industrial production. Finally, Persyn (2013) deviates from the common assumption that firms make their investment decision prior to union wage setting and investigates the wage setting of unions, who take into account their impact on firm location. All these studies shed light on important aspects regarding the role of union wage setting for the agglomeration of economic activity. However, by considering an outside sector that serves as large labor reservoir, they are not suited to shed light on the link between footloose capital and economy-wide unemployment, which is at the heart of our interest.

The remainder of the paper is organized as follows. Section 4.2 introduces the theoretical framework and studies the differences between firm-level and sector-level wage setting in a closed economy. In Section 4.3, we consider two open economies that are fully symmetric in all respects, except for the prevailing degree of centralization in union wage setting, and study how the movement from the closed to an open economy affects aggregate employment and welfare as well as the real income of capital owners and workers. We distinguish between two scenarios of openness: the short run, in which product markets are fully integrated, while investment decisions are given and capital thus remains immobile; and the long run, in which both product and capital markets are fully integrated. In Section 4.4, we investigate whether decentralization in the country that hosts sector-level unions can be successful in preventing capital outflow and the export of domestic jobs. The last section concludes with a brief summary of the most important results.

4.2 The closed economy

We start our formal analysis with a detailed model description and a characterization of the autarky equilibrium.

4.2.1 Assumptions

We consider an economy that is populated by L workers, each of them supplying one unit of labor, and K capital owners, each of them supplying one unit of capital. Capital is required as a fixed input for starting up and operating firms, while labor is used as a variable input in the production process. Product markets are modeled along the lines of Neary (2003, 2009), who provides a workhorse for studying oligopolistic competition in a general equilibrium environment. Regarding the remuneration of the two factors, we assume that capital owners are entrepreneurs and thus receive operating profits as a return on their capital input. There is no imperfection in the capital market and free entry of firms. On the contrary, there is imperfection in the labor market due to union wage-setting. The remainder of this subsection provides a detailed description of preferences, technology, competition, and labor market institutions.

Preferences and consumer demand
We assume that preferences are described by an additively separable utility function over a continuum of different goods z, with the sub-utility for each of these goods being quadratic. The utility function of consumer c is given by

$$U_c[\{x_c(z)\}] = \int_0^1 ax_c(z) - \frac{1}{2}bx_c(z)^2 dz, \tag{4.1}$$

and his/her budget constraint equals

$$\int_0^1 p(z)x_c(z)dz \le I_c, \tag{4.2}$$

where $p(z)$ denotes the price of good z, and I_c is income of consumer c. Provided that the budget constraint is binding, the solution to the consumer's utility maximization problem, gives his/her inverse demand function for good z:

$$p(z) = \frac{1}{\lambda_c}[a - bx_c(z)], \tag{4.3}$$

where λ_c is the consumer's marginal utility of income, which is a function of the first and second (uncentered) moments of prices,

$$\mu \equiv \int_0^1 p(z)dz \quad \text{and} \quad \sigma \equiv \int_0^1 p(z)^2 dz, \tag{4.4}$$

respectively, as well as income, I_c. Rearranging the consumer's budget constraint, we can calculate

$$\lambda_c = \frac{a\mu - bI_c}{\sigma}. \tag{4.5}$$

To determine economy-wide consumer demand, $X(z)$, we aggregate x_c over all consumers. This gives

$$p(z) = \frac{1}{\lambda}[A - bX(z)], \tag{4.6}$$

where $A \equiv (K + L)a$, $\lambda \equiv \sum_c \lambda_c = (A\mu - bI)/\sigma$, and $I \equiv \sum_c I_c$. This captures a nice property of consumer preferences in this model: Since preferences are quasi-homothetic, there exists a positive representative consumer, so that maximizing this consumer's utility subject to the economy-wide budget constraint gives aggregate demand for consumer goods. The representative consumer also has a normative interpretation in our setting and his/her preferences can therefore be used as a measure of social welfare. As extensively discussed in Neary (2009), ignoring constants, we can calculate $\tilde{U} = -\lambda^2\sigma$ as a monotonically transformed measure of the representative consumer's indirect utility. And we can refer to changes in $\tilde{U}$ when being interested in economy-wide welfare effects.

Technology, production, and competition

In each sector, an endogenous number of firms, $n(z)$, produces a homogeneous sector-specific output. Firm number, $n(z)$, is finite and firms therefore take into account their impact on price $p(z)$, when setting quantities in Cournot competition. However, in view of a continuum of industries, firms rationally ignore their impact on economy-wide variables, such as λ or I. Regarding production, we assume that firms in all industries employ the same technology. They invest one unit of capital as a fixed input and must hire one unit of labor for each unit of output they want to produce. Denoting output of firm j in industry z by $y_j(z)$, considering product market clearing, i.e. $\sum_{k=1}^{n(z)} y_k(z) = X(z)$, and accounting for demand function (4.6), we can write firm-level profits as follows:

$$\Pi_j(z) \equiv \lambda\pi_j(z) = \left[A - b\sum_{k=1}^{n(z)} y_k(z) - \lambda w_j(z)\right] y_j(z). \tag{4.7}$$

As explained in Neary (2009), $\lambda\pi_j(z)$ can be interpreted as real profits *at the margin*, and changes in this variable do not exert direct welfare implications. However, such changes are still instructive as they indicate adjustments of the competitive environment in the product market. Throughout our analysis we focus on the case of a positive supply of all firms and, therefore, restrict our attention to parameter configurations that lead to $A > \lambda w_j(z)$ for all j and z.

Labor market institutions

We assume that wages are unilaterally set by unions before firms set their employment level, produce and sell their products to consumers.[6] Unions maximize an objective function $V = (w - \bar{w})\ell$, where ℓ is the number of employed union members, which, in the case of a *closed shop*, equals the employment level of all firms in which the respective union is active (see Booth, 1995), w is the union wage, and $\bar{w} \equiv \beta\tilde{w}$ is unemployment compensation, which is a constant share $\beta \in (0, 1)$ of a country's economy-wide average wage, $\tilde{w}$. In the background, there is a proportional tax on both sources of labor income, wages and unemployment benefits, which provides the revenues for financing unemployment compensation. This income tax has the attractive feature of being a lump-sum instrument, which allows for redistributing resources towards those who do not have a job, without affecting the maximization problems of capital owners, firms, and unions in our model.[7] For that reason, there is no difference from the perspective of unions between setting gross or net wages, while choosing gross notation helps saving on parameters in the subsequent analysis. Furthermore, while wage w and unemployment compensation $\bar{w}$ are nominal variables, the outcome of the union's maximization problem would of course be unaffected if both of these variables were divided by a common deflator, such as the consumer price index or λ^{-1}.

It is well established in the labor market literature that the wage-setting behavior of unions crucially depends on the degree of centralization in the wage-setting process. The literature distinguishes three possible degrees of centralization: the firm level, the sector level, and the country level. According to OECD (2004) the degree of centralization has continuously declined over the last decades, rendering firm-level and sector-level wage-setting predominant in most industrialized countries.[8] We therefore focus on these two forms of union wage-setting in the subsequent analysis and investigate, in particular, how differences in the degree of centralization affect the labor and product market outcomes in our model. When being organized at the sector-level (index s), unions take into account the impact of their wage claims on sector-wide employment. However, setting a uniform wage for all firms in the industry, they do not care how a given sector-wide employment is distributed across firms in the respective industry. This is captured by setting $\ell = \sum_{k=1}^{n(z)} l_k(z)$. Things are different in the case of firm-level unions (index f) who are only interested in the consequences of their wage claims for their firm's employment level. This is captured by setting $\ell = l_j(z)$ and allowing for firm-specific wage rates.[9] In summary, we

[6] Limiting union activity to wage setting, we ignore other important aspects of their activities and may therefore end up with a too negative picture of their welfare consequences (see, for instance, Donado and Wa¨lde, 2012). However, this should not be a particular problem for our analysis, because the main purpose of this paper is shedding light on the differential impact of union wage-setting in the closed and the open economy.

[7] In this respect, the choice of the tax instrument is in the spirit of Davidson and Matusz (2006) and, in the context of this paper, it allows us to highlight the role of wage-setting institutions in isolation from tax policy.

[8] For instance, firm-level wage setting can be found in Japan, Canada, U.K., or the U.S., while sector-level wage setting is typical for central and northern European countries, such as Austria, Germany, the Netherlands or Sweden.

[9] Of course, the observation that unions are only interested in firm-level employment does not mean that firm-

can express the objectives of sector-level and firm-level unions in the following way:

$$V^s(z) = \left[w^s(z) - \bar{w}\right] \sum_{k=1}^{n(z)} l_k(z), \qquad V_j^f(z) = \left[w_j(z) - \bar{w}\right] l_j(z). \tag{4.8}$$

This completes our discussion of the basic model ingredients, and we are now equipped to solve for the autarky equilibrium.

4.2.2 The autarky equilibrium

The equilibrium outcome is characterized by the solution to a three-stage game in which capital owners decide on firm entry at stage one, unions enter and set wages at stage two, while firms choose employment and compete in quantities at stage three. We solve this three stage game through backward induction.

Output competition at Stage 3:
Under Cournot competition, firms set their output to maximize profits (4.7) subject to $y_j(z) \geq 0$. The (interior) solution to this maximization problem is given by the first-order condition, which can be reformulated to

$$y_j(z) = \frac{A - b\sum_{k \neq j} y_k(z) - \lambda w_j(z)}{2b}. \tag{4.9}$$

Sector-level unions set a uniform industry-wide wage and since the profit-maximization problem is the same for all firms in this industry, we have $w_k(z) = w(z)$ and thus $y_k(z) = y(z)$ for all $k = 1, ..., n(z)$. Things are different if unions are organized at the firm-level. In this case, union wage claims are only binding for workers of a specific firm. However, since firms have perfect foresight, producer j rationally anticipates symmetry of all competitors, implying $w_k(z) = w_{-j}(z)$ and thus $y_k(z) = y_{-j}(z)$ for all $k \neq j$.[10] In view of these insights, we can reformulate Eq. (4.9) in the following way:

$$y(z) = \frac{A - \lambda w(z)}{b(n(z)+1)}, \qquad y_j(z) = \frac{A + (n(z)-1)\lambda w_{-j}(z) - n(z)\lambda w_j(z)}{b(n(z)+1)}. \tag{4.10}$$

Wage setting at Stage 2:
In view of our technology assumptions, we have $l_j(z) = y_j(z)$. Substituting the latter into union objectives (4.8), accounting for (4.10), and maximizing the resulting expressions for $w(z)$ and $w_j(z)$, respectively, gives the first-order conditions

$$\frac{dV^s(z)}{dw(z)} = \frac{A - 2\lambda w(z) + \lambda\bar{w}}{b(n(z)+1)} = 0, \quad \frac{dV_j^f(z)}{dw_j(z)} = \frac{A + (n(z)-1)\lambda w_{-j}(z) - 2n(z)\lambda w_j + n(z)\lambda\bar{w}}{b(n(z)+1)} = 0.$$

level unions disregard the impact of higher wage claims on the competitors' employment levels. Since firms set quantities in oligopolistic competition after the unions have chosen w, a higher wage claim reduces competitiveness of the own firm and thus leads to output and employment adjustments of the firm's competitors in the subsequent Cournot competition.

[10] We use subscript $-j$ for referring to all firms differing from j.

Due to symmetry of all firms and unions in industry z, we can now set $w_j(z) = w_{-j}(z) = w(z)$. Solving for wages, therefore gives

$$\lambda w^s(z) = \frac{A + \lambda \bar{w}}{2}, \qquad \lambda w^f(z) = \frac{A + n(z)\lambda \bar{w}}{n(z) + 1} \tag{4.11}$$

in the case of sector-level and firm-level unions, respectively. According to (4.11), wage setting of sector-level unions does not depend on the competitive environment in the product market, while firm-level unions set lower wages in response to stronger product market competition as captured by a higher n. This result is well known from a large literature analyzing wage setting in unionized oligopoly. However, it refers to a partial equilibrium outcome as we have treated unemployment benefits as exogenous so far. In general equilibrium, the average wage, $\tilde{w}$, and thus the level of unemployment benefits, $\bar{w} = \beta\tilde{w}$, are endogenously determined. And the equilibrium outcome of these two variables as well as the equilibrium number of firms that are active in industry z, $n(z)$, depend on how capital owners allocate K on the unit mass of industries.

Capital allocation and firm entry at Stage 1:

Capital owners make the investment decision to maximize their profit income. Substituting wage rates (4.11) into output functions (4.10) and noting further that $\Pi_j = by_j^2$, we can calculate firm-level profits

$$\Pi^s(z) = \frac{1}{b}\left(\frac{A - \lambda\bar{w}}{2b\,(n(z)+1)}\right)^2, \qquad \Pi^f(z) = \frac{1}{b}\left(\frac{n(z)\,(A - \lambda\bar{w})}{(n(z)+1)^2}\right)^2, \tag{4.12}$$

where firm indices have been neglected because all firms in an industry are symmetric. Differentiating (4.12) with respect to $n(z)$, we see that real profit income at the margin shrinks in the number of competitors. Hence, income maximization of capital owners requires an equal number of firms in all industries and thus an allocation of K according to the no arbitrage condition $\Pi(z) = \Pi$ for all z. With a unit mass of industries, we therefore get $n = K$ and, since in equilibrium industries are symmetric in all respects, we can omit sector indices from now on. Furthermore, in view of the *ex-post* symmetry of sectors, we can set $\bar{w} = \beta w$. Equipped with this insight, we can now solve for equilibrium wages, employment and profits in the symmetric autarky equilibrium. This gives

$$W^s \equiv \lambda w^s = \frac{A}{2-\beta}, \qquad W^f \equiv \lambda w^f = \frac{A}{1 + n(1-\beta)}. \tag{4.13}$$

It is easily confirmed that $n > 1$ implies $W^s > W^f$, so that our model reproduces the textbook result that sector-level unions set higher wages than firm-level unions (see Calmfors and Driffill, 1988, for supportive empirical evidence). Of course, when interpreting the two expressions in (4.13) we must keep in mind that W^s and W^f are real wages at the margin, and differences in these two variables therefore do not have a direct welfare implication. However, looking at these variables is still instructive as they capture the strength of labor market imperfection. To be more specific, substituting (4.13) into (4.10) and accounting for the symmetry of industries, we can calculate firm-level output and employment under the two labor market regimes: $y^s = l^s =$

$W^s(1-\beta)/[b(n+1)]$, $y^f = l^f = W^f n(1-\beta)/[b(n+1)]$.

Higher wage claims of sector-level unions lead to higher production costs and lower firm-level output and employment than in the case of firm-level unions. With firms and industries being symmetric in equilibrium, economy-wide employment equals nl. Denoting the unemployment rate by u and focussing on parameter configurations for which not all workers find a job in equilibrium, total employment under the two labor market regimes is given by

$$(1-u^s)L = \frac{nA(1-\beta)}{b(n+1)(2-\beta)}, \qquad (1-u^f)L = \frac{n^2A(1-\beta)}{b(n+1)[1+n(1-\beta)]}. \tag{4.14}$$

From (4.14) we can conclude that in an interior equilibrium with involuntary unemployment, i.e. $u > 0$, labor supply is a non-binding constraint and thus aggregate employment independent of labor endowment L (see Brecher, 1974, for a similar result). Furthermore, sector-level unions generate a stronger labor market imperfection leading to higher unemployment than in the case of firm-level unions i.e. $u^s > u^f$. With prices being the same in all industries, it follows from (4.4) and (4.5) that $\tilde{U} = -A + b\lambda I/P$, where λI is total real income at the margin and $P = \lambda p$ is the consumer price index. Noting further that a binding budget constraint requires that aggregate revenues, $Pny = P(1-u)L$, equal aggregate income, λI, we can safely conclude that $\lambda I/P = (1-u)L$. Hence, $u^s > u^f$ implies that welfare is lower with sector-level than with firm-level unions: $\tilde{U}^s < \tilde{U}^f$. Summing up, (4.14) captures the well known result that in a closed economy sector-level unions are more detrimental for the economic performance of a country than firm-level unions (see Calmfors and Driffill, 1988).

In a final step, we now analyze how different degrees of centralization in union wage setting affect the two income groups, capital owners and workers, in our model. Welfare of an income group can be measured by the indirect utility of this group's representative agent, which, assuming identical preferences of workers and capital owners, can be expressed as an increasing function of total real group-specific income. In view of (4.13) and (4.14), we can determine economy-wide labor income, $\Phi \equiv (1-u)LW$:[11]

$$\Phi^s = \frac{nA^2(1-\beta)}{b(n+1)(2-\beta)^2}, \qquad \Phi^f = \frac{n^2A^2(1-\beta)}{b(n+1)\left[1+n(1-\beta)\right]^2}. \tag{4.15}$$

In a similar vein, we can account for $\Pi = by^2$ to calculate economy-wide profit income $\Psi = n\Pi$: $\Psi^s = \Phi^s(1-\beta)/(n+1)$, $\Psi^f = \Phi^f n(1-\beta)/(n+1)$.

Since, by definition, economy-wide labor and profit income must add up to total income, i.e. $\Phi + \Psi = \lambda I$, we can write $\Phi = \phi\lambda I$ and $\Psi = \psi\lambda I$, where ϕ and ψ denote the income shares attributed to workers and capital owners, respectively. For the two wage-setting institutions, we can thus calculate

$$\phi^s = \frac{n+1}{n+2-\beta}, \qquad \psi^s = \frac{1-\beta}{n+2-\beta}, \tag{4.16}$$

$$\phi^f = \frac{n+1}{(n+1)+n(1-\beta)}, \qquad \psi^f = \frac{n(1-\beta)}{(n+1)+n(1-\beta)}, \tag{4.17}$$

[11] With unemployment benefits being financed by a tax on labor income, total gross wage income equals total net wage income in our model, implying that taxation *per se* does not affect the distribution of income between firm owners and workers in our setting.

where $\phi^s > \phi^f$ and $\psi^s < \psi^f$, provided that $n > 1$. Noting further that a binding budget constraint implies that total income must equal total revenues, $\lambda I = Pny$, we can calculate total real labor and capital income, $\Phi/P = \phi(1-u)L$ and $\Psi/P = \psi(1-u)L$, respectively. Using (4.14), (4.16) and (4.17), we obtain

$$\left(\frac{\Phi}{P}\right)^s = \frac{nA(1-\beta)}{b\,[n+2-\beta]\,(2-\beta)}, \qquad \left(\frac{\Phi}{P}\right)^f = \frac{n^2A(1-\beta)}{b\,[(n+1)+n(1-\beta)]\,[1+n(1-\beta)]}, \tag{4.18}$$

$$\left(\frac{\Psi}{P}\right)^s = \frac{1-\beta}{n+1}\left(\frac{\Phi}{P}\right)^s, \qquad \left(\frac{\Psi}{P}\right)^f = \frac{n(1-\beta)}{n+1}\left(\frac{\Phi}{P}\right)^f. \tag{4.19}$$

From inspection of (4.19), we can infer that capital owners are better off with wage setting at the firm instead of the sector level. This is intuitive, as we know from above that both total economic rents, $(1-u)L$, as well as the share of rents attributed to capital owners, ψ, are larger with wage-setting at the firm-level. Furthermore, from (4.18) we can infer that, despite our finding of $\phi^s > \phi^f$, workers are also better off under firm-level wage setting, i.e. $(\Phi/P)^f > (\Phi/P)^s$. However, this does not mean that *all* workers necessarily prefer firm-level to sector-level unions.[12]

4.3 The open economy

Let us now consider trade between two countries, $i = 1, 2$, whose economies are of the type analyzed in Section 4.2. We abstract from international shipment costs and assume that product markets are fully integrated, so that consumers in both countries pay the same price. Labor is internationally immobile, and we distinguish two scenarios with respect to capital mobility. In the first one, we assume that the capital investment decision is given and thus firm allocation the same as in the closed economy. We refer to this scenario as the short run because it captures the idea that de-investment of capital takes time. In the long run, capital is footloose and invested where it generates the highest return, which may be at home or abroad. Of course, the outflow of capital must be distinguished from actual movements of capital owners, who are assumed to stay in their home country and repatriate profits when capital is invested abroad. This is a common assumption in footloose capital models and implies that the number of consumers within an economy remains unaffected by adjustments in the investment decision of capital owners, which simplifies welfare comparisons in the subsequent analysis enormously. Regarding labor market institutions, we assume that the two economies differ in the degree of centralization in union wage setting. To be more specific, we assume that country 1 is populated by sector-level unions, while country 2 is populated by firm-level ones. This implies that in the closed economy the labor market friction is more severe in country 1 than in country 2 and that country 1 ends up with lower employment and welfare as well as with lower income of both capital owners and workers under autarky.

To characterize the open economy equilibrium, we can follow the analysis in Section 4.2 step by step. For studying product market competition, we first need to sum up consumer demand

[12] In a supplement, which is available upon request, we show that if unemployment compensation is not too generous, those who have a job (as well as those who are unemployed) in both scenarios are better off with sector-level than with firm-level bargaining.

in the two economies. This gives the indirect demand function

$$p^t(z) = \frac{1}{\bar{\lambda}}\left[2A - b\bar{x}^t(z)\right], \tag{4.20}$$

where superscript t is introduced for referring to trade variables and, $\bar{\lambda} \equiv \lambda_1 + \lambda_2$ denotes the world representative consumer's marginal utility of income. Applying the product market clearing condition, firm j's profits are given by

$$\Pi_j^t(z) \equiv \bar{\lambda}\pi_j^t(z) = \left(2A - b\sum_{k=1}^{n^t(z)} y_k(z) - \bar{\lambda}w_j(z)\right) y_j(z), \tag{4.21}$$

where $n^t(z)$ is the total number of domestic and foreign firms: $n^t(z) = n(z) + n^*(z)$, with the asterisk indicating the foreign country variable. Solving the firm's profit maximization problem, we can calculate j's optimal output

$$y_j(z) = \frac{2A + n^*(z)\bar{\lambda}w^*(z) + (n(z)-1)\,\bar{\lambda}w(z) - (n(z)+n^*(z))\,\bar{\lambda}w_j(z)}{b\,(n(z)+n^*(z)+1)} \tag{4.22}$$

as a function of the own as well as the domestic and foreign competitors' wage rates, $w_j(z)$, $w(z)$, and $w^*(z)$, respectively.

To solve for the unions' wage setting problem, we can substitute (4.22) into the union objectives in (4.8) and maximize the resulting expressions for the respective union wage rates. As formally shown in the Appendix, this gives a system of two equations that characterize the optimal wage choices for a given capital allocation:

$$\begin{aligned}\bar{\lambda}w_1(z) = {} & \frac{2A\left[2\left(n_1(z)+n_2(z)\right)+1\right] + n_2(z)\left(n_1(z)+n_2(z)\right)\bar{\lambda}\bar{w}_2}{3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2} \\ & + \frac{\left(n_2(z)+1\right)\left[2n_1(z)+n_2(z)+1\right]\bar{\lambda}\bar{w}_1}{3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2},\end{aligned} \tag{4.23}$$

$$\begin{aligned}\bar{\lambda}w_2(z) = {} & \frac{2A\left[n_1(z)+2n_2(z)+2\right] + n_1(z)\left(n_2(z)+1\right)\bar{\lambda}\bar{w}_1}{3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2} \\ & + \frac{2\left(n_2(z)+1\right)\left(n_1(z)+n_2(z)\right)\bar{\lambda}\bar{w}_2}{3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2}.\end{aligned} \tag{4.24}$$

Regarding capital allocation at Stage 1, we distinguish between a short-run perspective, in which firm numbers are determined by the investment decisions of the closed economy, and a long-run perspective, in which investment decisions are adjusted to maximize the income of capital owners in the open economy. We start with an analysis of the short-run equilibrium.

A short-run trade equilibrium with immobile capital

Since the capital allocation in the short run is the same as under autarky, we have $n_1(z) = n_2(z) = n(z)$. Accounting for $\bar{w}_i = \beta w_i$, we can therefore simplify wage rates (4.23) and (4.24) in the following way:

$$W_1^{sr} \equiv \left(\bar{\lambda} w_1\right)^{sr} = \frac{2A\left[(2n+1)+2n(1-\beta)\right]}{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)}, \tag{4.25}$$

$$W_2^{sr} \equiv \left(\bar{\lambda} w_2\right)^{sr} = \frac{2A\left[(2n+1)+(n+1)(1-\beta)\right]}{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)}, \tag{4.26}$$

where superscript '*sr*' refers to the short run. Substituting (4.25) and (4.26) into Eq. (4.22) yields short-run equilibrium output levels $y_1^{sr} = W_1^{sr}(n+1)(1-\beta)/[b(2n+1)]$, $y_2^{sr} = W_2^{sr}2n(1-\beta)/[b(2n+1)]$. In view of symmetry of all producers in country i, we thus obtain total employment levels by substituting $l_i = y_i$ into $(1-u_i)L = nl_i$:

$$(1-u_1^{sr})L = \frac{2nA(n+1)(1-\beta)\left[(2n+1)+2n(1-\beta)\right]}{b(2n+1)\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}}, \tag{4.27}$$

$$(1-u_2^{sr})L = \frac{4n^2A(1-\beta)\left[(2n+1)+(n+1)(1-\beta)\right]}{b(2n+1)\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}}. \tag{4.28}$$

As formally shown in the Appendix, we can infer from contrasting (4.14) with (4.27) and (4.28) that product market integration provides an employment stimulus relative to the closed economy. And this stimulus is essential for gains from trade in our model. Since prices are identical in all industries, consumers equally distribute their income on the unit mass of industrial goods. In this case, a pari passu increase in the employment of all firms allows for a proportional increase in the consumption of all products in the open economy, implying that welfare unambiguously goes up. Put differently, similar to the closed economy country-level aggregate employment is equal to total real income in this economy, which is an adequate welfare measure in our setting. Since product market integration raises employment in both countries relative to the closed economy, welfare must be higher in the open economy than under autarky.

In addition, we can determine the relative importance of wage-setting institutions for the two macroeconomic performance measures in the open as compared to the closed economy by looking at the sign of $\Delta u^{sr} - \Delta u$, with $\Delta u^{sr} \equiv u_1^{sr} - u_2^{sr}$ and $\Delta u \equiv u^s - u^f$. It is formally shown in the Appendix that the sign of $\Delta u^{sr} - \Delta u$ is equivalent to the sign of $-1 + (1-\beta)(n^2-1)$, which in general can be positive or negative. However, noting that even in countries with generous unemployment compensation schemes, those who do not find a job receive a compensation that is smaller than 2/3 of the going wage rate,[13] i.e. $\beta < 2/3$, we can conclude that $n \geq 2$ is sufficient for $\Delta u^s < \Delta u$ when focusing on empirically relevant parameter domains. In this case, our model reproduces the well known result that product market integration reduces the impact that differences in the degree of centralization exert on key macroeconomic variables, such as unemployment and welfare (see Danthine and Hunt, 1994).

The following proposition summarizes the main insights from the analysis above.

Proposition 6 *Product market integration increases total employment and aggregate welfare in both countries, irrespective of the degree of centralization in the wage-setting process. Fur-*

[13]For instance, gross replacement rates are smaller than 2/3 for all OECD countries. This is also true for standard measures of net replacement rates. Only if social assistance and housing benefits are added, net replacement rates are larger than 2/3 for some of the OECD countries. (Source: http://www.oecd.org/dataoecd/60/8/49971171.xlsx)

thermore, provided that $\beta < 2/3$ and $n \geq 2$, differences in the the degree of centralization in the union wage-setting are less important for unemployment and welfare in the short-run open economy than under autarky.

Proof. Analysis in the text and derivation details in the Appendix. ■

In a next step, we are interested in the group-specific effects of product market integration. Substituting W_i from (4.25) and (4.26) as well as $(1-u_i)L$ from (4.27) and (4.28) into $\Phi_i = (1-u_i)LW_i$ we can determine economy-wide labor income at the margin in the two economies:

$$\Phi_1^{sr} = \frac{4nA^2(n+1)(1-\beta)\left[(2n+1)+2n(1-\beta)\right]^2}{b(2n+1)\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}^2}, \tag{4.29}$$

$$\Phi_2^{sr} = \frac{8n^2A^2(1-\beta)\left[(2n+1)+(n+1)(1-\beta)\right]^2}{b(2n+1)\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}^2}. \tag{4.30}$$

In a similar vein, we can substitute y_i from into $\Psi_i = n\Pi_i = bny_i^2$ to economy-wide profit income at the margin in the two economies: $\Psi_1^{sr} = \Phi_1^{sr}(n+1)(1-\beta)/(2n+1)$ and $\Psi_2^{sr} = \Phi_2^{sr}2n(1-\beta)/(2n+1)$. Noting from the discussion of the closed economy that $\Phi_i + \Psi_i = \bar{\lambda}I_i$ and $P(1-u_i)L = \bar{\lambda}I_i$, we can furthermore compute

$$\phi_1^{sr} = \frac{2n+1}{(2n+1)+(n+1)(1-\beta)}, \qquad \psi_1^{sr} = \frac{(n+1)(1-\beta)}{(2n+1)+(n+1)(1-\beta)}, \tag{4.31}$$

$$\phi_2^{sr} = \frac{2n+1}{(2n+1)+2n(1-\beta)}, \qquad \psi_2^{sr} = \frac{2n(1-\beta)}{(2n+1)+2n(1-\beta)}. \tag{4.32}$$

Contrasting (4.31) and (4.32) with their counterparts in the closed economy, we see that trade improves the relative position of firm owners and lowers the share of total rents that is attributed to workers. This is not surprising, as we know from above that trade reduces union wage claims. While the reduction of wages ceteris paribus lowers welfare of those workers who already had a job prior to product market integration, it does not mean that workers lose on average. The reason is that prices fall and employment expands in response to the trade shock, and this generates two counteracting positive effects on the welfare of workers.

To shed light on which of the opposing effects dominates, we can substitute (4.27) and (4.28) together with (4.31) and (4.32) into $\Phi_i/P = \phi_i(1-u_i)L$. This allows us to calculate total real wage income (and thus welfare) of workers:

$$\left(\frac{\Phi_1}{P}\right)^{sr} = \frac{2nA(n+1)(1-\beta)\left[(2n+1)+2n(1-\beta)\right]}{b\left[(2n+1)+(n+1)(1-\beta)\right]\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}} \tag{4.33}$$

$$\left(\frac{\Phi_2}{P}\right)^{sr} = \frac{4n^2A(1-\beta)\left[(2n+1)+(n+1)(1-\beta)\right]}{b\left[(2n+1)+2n(1-\beta)\right]\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}}. \tag{4.34}$$

In the Appendix, we show that, in view of (4.18), (4.33) and (4.34), group-specific welfare of workers is unambiguously higher in the (short-run) open than in the closed economy.

To determine total real profit income (and thus welfare) of capital owners, in the open economy, we substitute (4.27) and (4.28) together with (4.31) and (4.32) into $\Psi_i/P = \psi_i(1-u_i)L$, which yields

$$\left(\frac{\Psi_1}{P}\right)^{sr} = \frac{(n+1)(1-\beta)}{2n+1}\left(\frac{\Phi_1}{P}\right)^{sr}, \qquad \left(\frac{\Psi_2}{P}\right)^{sr} = \frac{2n(1-\beta)}{2n+1}\left(\frac{\Phi_2}{P}\right)^{sr}. \tag{4.35}$$

Since we know from our analysis above that product market integration raises both the size of total economic rents, $(1-u_i)L$, as well as the share of these rents attributed to capital owners, ψ_i, it is immediate that capital owners must be unambiguously better off in the open than in the closed economy.

The following proposition summarizes the short-run effects of product market integration on group-specific welfare of capital owners and workers.

Proposition 7 *Product market integration increases real income and thus welfare of capital owners as well as workers in both countries, irrespective of the degree of centralization in the wage-setting process.*

Proof. Analysis in the text and derivation details in the Appendix. ■

Since both workers and capital owners are better off in the open economy, one may be tempted to conclude that both income groups should welcome efforts of policy makers to further deepen economic integration. However this conclusion would be short-sighted for at least two reasons. On the one hand, while workers as a group benefit from trade liberalization due to an expansion in aggregate employment, this is not true for each individual worker. In particular, those who already had a job in the closed economy may experience an income loss due to wage moderation of unions in the open economy and thus may oppose further economic integration. On the other hand, globalization in the 21^{st} century is more than just the shipment of goods across borders. In the last few decades the increasing ability of firms to shift production to low-cost destinations has become a major concern of workers in the industrialized world. Hence, it is important to shed further light on this facet of globalization for getting a better understanding about why workers are often not enthusiastic about openness. Studying the consequences of capital mobility and the associated relocation of jobs is the purpose of the following subsection.

A long-run trade equilibrium with footloose capital

In the long run, capital owners adjust their investment decisions in order to maximize profit income. Abstracting from extra costs of foreign investment, we can conclude that an interior equilibrium with full diversification requires $\Pi_1(z) = \Pi_2(z) \equiv \Pi^t(z)$ and $\Pi^t(z) = \Pi^t$ for all z. In view of linear demand, the two no arbitrage conditions imply that firm-level output must be the same in both countries and all industries and thus $w_i(z) \equiv w$ for all z and $i = 1, 2$, according to (4.22). There exists a unique full diversification equilibrium, which is characterized by a symmetric firm allocation across industries, i.e. $n_i(z) = n_i$ for all z, and $n_1 = 1$, $n_2 = 2n - 1$.[14] This outcome is intuitive, as we know from the analysis of the short-run scenario that, with an equal number of firms in either country, production costs are higher in country 1 than country 2, i.e. $(\bar{\lambda} w_1)^{sr} > (\bar{\lambda} w_2)^{sr}$. And due to this production cost differences, there is an incentive

[14]Since the formal proof of the existence of a unique diversification equilibrium is tedious and probably of just little interest for a broader readership, we have deferred the respective proof to a supplement, which is available upon request.

for capital owners to de-invest in country 1 and to set up a new production facility in country 2. As a consequence, capital flows from country 1 to country 2, and this flow continues until profit income is equalized, i.e. until union wage-setting generates the same outcome in the two economies, irrespective of the prevailing differences in the degree of centralization in union wage-setting. This requires $n_1 = 1$, because in this case the sector-level union in country 1 degenerates to a firm-level union.[15]

With the equilibrium firm allocation at hand, we can now calculate employment, welfare and group-specific income in the long-run open economy equilibrium. Setting $\bar{\lambda} w_i = \bar{\lambda} w$, $n_1 = 1$, and $n_2 = 2n - 1$, we can rewrite (4.23) and (4.24) in the following way:

$$W^{lr} \equiv (\bar{\lambda} w)^{lr} = \frac{2A}{1 + 2n(1-\beta)}, \tag{4.36}$$

where superscript 'lr' refers to the long-run open economy equilibrium. Substituting the latter into (4.22) gives firm-level employment and output in the long-run trade equilibrium: $y^{lr} = W^{lr} 2n(1-\beta)/[b(2n+1)]$. Comparing the output levels from the short-run and long-run equilibrium, it follows that $y_1^{sr} < y^{lr} < y_2^{sr}$. This ranking is intuitive. On the one hand, firms in country 1 lose their competitive disadvantage in the long run and thus experience an output increase. On the other hand, firms in country 2 lose their competitive advantage relative to foreign producers and thus experience an output reduction.

To determine aggregate employment in country i, we can add up firm-level employment (output) over all firms that are active in country i. This gives

$$\left(1 - u_1^{lr}\right) L = \frac{4nA(1-\beta)}{b(2n+1)\left[1 + 2n(1-\beta)\right]}, \qquad \left(1 - u_2^{lr}\right) L = \frac{4n(2n-1)A(1-\beta)}{b(2n+1)\left[1 + 2n(1-\beta)\right]}. \tag{4.37}$$

Comparing (4.37) with the aggregate employment levels of the short-run open economy equilibrium in (4.27) and (4.28), we see that capital flows towards the country with more decentralized wage setting lower employment in country 1 and raise employment in country 2. From inspection of Eq. (4.14), we can further note that if unemployment compensation is not too generous and the number of competitors not too small the negative employment effect triggered by capital outflow in country 1 may be strong enough to reverse the positive short-run effect of product market integration. The higher is n, the more capital flows from country 1 to country 2, and the stronger is the negative employment effect in country 1. The higher is β, the smaller is firm-level employment and the smaller is ceteris paribus the number of domestic jobs replaced by foreign ones in the case of capital outflow.

To determine country-specific welfare, we must look at total real income $\bar{\lambda} I_i / P$. Noting that total labor income equals $\Phi_i = (1 - u_i) L W$, while total capital income is $\Psi_i = nby^2$, we can

[15] One might speculate that an outcome with $n_1 = 2n - 1$ and $n_2 = 1$ is an alternative candidate for a long-run equilibrium firm allocation. However, this is not true. While $n_2 = 1$ indeed implies that unions in country 2 set sector-wide wages that are binding for all workers employed in domestic production of the respective industry, there remains an asymmetry in union coverage in the two economies, and hence the outcome of wage setting in the two countries would not be the same in this case.

calculate:

$$\left(\frac{\bar{\lambda}I_1}{P}\right)^{lr} = \frac{4nA(1-\beta)}{b(2n+1)\left[1+2n(1-\beta)\right]}\,\frac{(2n+1)+2n^2(1-\beta)}{(2n+1)+2n(1-\beta)}, \tag{4.38}$$

$$\left(\frac{\bar{\lambda}I_2}{P}\right)^{lr} = \frac{4nA(1-\beta)}{b(2n+1)\left[1+2n(1-\beta)\right]}\,\frac{(2n-1)(2n+1)+2n^2(1-\beta)}{(2n+1)+2n(1-\beta)}. \tag{4.39}$$

according to (4.36) and (4.37).[16] Noting from the analysis above that under autarky as well as in the short run open economy aggregate income is equal to total employment, $\bar{\lambda}I_i/P_i = (1-u_i)L$, we can infer the welfare effects of capital relocation from a comparison of (4.14), (4.27), (4.28), (4.38) and (4.39). As formally shown in the Appendix, the inflow of capital unambiguously raises welfare in country 2, whereas capital outflow has negative welfare consequences in country 1. However, this does not mean that country 1 is worse off in the long-run open economy equilibrium than under autarky. On the contrary, provided that capital owners repatriate their profits from their foreign production activity, welfare losses associated with capital outflow are unambiguously lower than the welfare gains from product market integration in the short run.

Regarding the impact of the degree in union wage-setting on the relative macroeconomic performance in the two economies, we show in the Appendix that capital outflow raises both the employment as well as the welfare differential between the two economies, and this effect is strong enough to render the respective differentials larger than under autarky. Hence, the finding in Bean, Danthine, Bernholz, and Malinvaud (1990) and Danthine and Hunt (1994) that in an open economy differences in wage-setting institutions are less important for the economic performance of countries does no longer hold – at least in our setting – if one accounts for international capital mobility as an important feature of open economies. All other things equal, the surge of international capital flows over the last few decades may therefore lead to a revitalization of the hump-shape relationship between the degree of centralization in union wage-setting and unemployment as identified by Calmfors and Driffill (1988) for the closed economy.

The following proposition summarizes the impact of capital mobility on aggregate employment and welfare as well as their differentials between the two economies.

Proposition 8 *In the long run, capital inflows increase aggregate employment and welfare in country 2, while capital outflows reduce employment and welfare in country 1. Furthermore, welfare is definitely higher in the long-run open economy equilibrium than under autarky. The same is true for employment in country* 2*, while it is not clear in general whether in the long run openness increases or reduces employment in country* 1 *relative to autarky. Finally, in the long run open economy, the employment and welfare differentials between the two economies are even more pronounced than under autarky.*

Proof. Analysis in the text and derivation details in the Appendix. ■

Being not only interested in aggregate but also in group-specific effects, we additionally determine real income of workers and entrepreneurs. Looking first at the group of workers, we can

[16] Total income of country 1 is given by $\left(\bar{\lambda}I_1\right)^{lr} = \Phi_1^{lr}\left[1+2n^2(1-\beta)/(2n+1)\right]$, while total income of country 2 is given by $\left(\bar{\lambda}I_2\right)^{lr} = \Phi_2^{lr}\left[1+2n^2(1-\beta)/(4n^2-1)\right]$. Furthermore, the value of total *domestic* output equals $n_i\,(Py)^{lr} = \Phi_i^{lr}\left[1+2n(1-\beta)/(2n+1)\right]$. Putting together and substituting for y^{lr} and n_i, we can calculate $\left(\bar{\lambda}I_1/P\right)^{lr}, \left(\bar{\lambda}I_2/P\right)^{lr}$ in Eqs. (4.38) and (4.39), respectively.

calculate[17] and $n_1 = 1$, $n_2 = 2n - 1$, then gives (4.40) and (4.41), respectively.

$$\left(\frac{\Phi_1}{P}\right)^{lr} = \frac{4nA(1-\beta)}{b[1+2n(1-\beta)][(2n+1)+2n(1-\beta)]}, \tag{4.40}$$

$$\left(\frac{\Phi_2}{P}\right)^{lr} = \frac{4n(2n-1)A(1-\beta)}{b[1+2n(1-\beta)][(2n+1)+2n(1-\beta)]}. \tag{4.41}$$

Comparing (4.40) with total real wage income of workers in the short-run open economy, we find that capital outflow harms workers in country 1. However, this does not mean that workers also lose relative to autarky. Contrasting (4.40) with the respective expression for the closed economy in (4.18), we find that welfare losses of workers due to capital outflow do not necessarily dominate the short-run welfare stimulus this group experiences from product market integration. To be more specific, we find that workers are the more likely better off in the long-run open economy equilibrium than under autarky, the more generous is unemployment compensation and the weaker is product market competition. Furthermore, due to capital inflow and the establishment of new local jobs, workers in country 2 are unambiguously better off in the long-run open economy equilibrium than in the short run or under autarky.

In a final step, we look at total real capital income. In the absence of extra costs for foreign investment, profit income must be the same in the two economies, and it is given by[18]

$$\left(\frac{\Psi}{P}\right)^{lr} = \frac{8n^3A(1-\beta)^2}{b(2n+1)[(2n+1)+2n(1-\beta)][1+2n(1-\beta)]}. \tag{4.42}$$

Intuitively, capital mobility improves investment opportunities of capital owners in country 1, who are therefore unambiguously better off in the long-run open economy equilibrium than in the short run or under autarky. Things are different for capital owners in country 2. The inflow of capital reduces the competitive advantage of country 2 firms relative to country 1 firms, with negative consequences for the market position of country 2 firms. As a consequence, capital owners in country 2 lose relative to the short-run open economy equilibrium, while they are still better off than under autarky.

Proposition 9 *In the long run, better investment opportunities reinforce the short-run stimulus of trade on total real capital income in country* 1*. Capital outflow lowers welfare of workers in country* 1 *relative to the short-run open economy equilibrium, but these losses need not be high enough to destroy all benefits from product market integration. Capital inflow lowers income of capital owners in country* 2*, but does not entirely destroy this group's benefits from product market integration. Finally, capital inflow reinforces the short-run gains of workers in country* 2.

Proof. Analysis in the text and derivation details in the Appendix. ■

[17] From Footnote 16, we know that $(\Phi_i/P)^{lr} = n_i y^{lr}\left[1+2n(1-\beta)/(2n+1)\right]^{-1}$. Substituting y^{lr} from above

[18] Substituting y^{lr} into $\Psi = nby^2$ and $P = 2(A - bny)$, it is straightforward to compute $(\Psi/P)^{lr}$ in (4.42).

4.4 Decentralization in union wage setting

In view of our insights from the previous section that workers in the country that hosts sector-level unions are hurt in the long run due to capital outflow, we now analyze how a shift from sector-level to firm-level wage setting in country 1 affects the capital allocation in our model. Decentralization in union wage setting not only refers to a common trend within OECD countries over the last few decades, but also captures a possible form of policy intervention that aims at banning those factors which render capital outflow attractive. That this is a relevant policy option can be inferred from the observation that in the aftermath of the Eurozone crisis, the European Council has suggested to "review the wage setting arrangements, and, where necessary, the degree of centralization in the bargaining process, [. . .], while maintaining the autonomy of the social partners in the collective bargaining process" (European Council, 2011) as one promising instrument to stabilize the system.

But can decentralization be a successful reform? To answer this question, it is worth noting that with firm-level wage setting everywhere, the real wage at the margin is the same in both locations and given by W^{lr}, while firm-level output is y^{lr}. This outcome does not depend on where capital is invested. In view of this invariance result, we have to impose an additional assumption that allows us to determine capital allocation in the case of indifference. A plausible solution to this problem can be derived from the observation that in the case of indifference capital owners will refuse to adjust their investment decisions if de-investment would involve just infinitesimally small costs. However, this implies that if decentralization in union wage setting occurs after a long-run equilibrium with firm allocation $n_1 = 1$ and $n_2 = 2n - 1$ has been established (*ex-post* decentralization, in short), it is ineffective and leaves all long-run equilibrium variables unchanged. On the contrary, if decentralization occurs prior to the capital outflow (*ex-ante* decentralization, in short) it is fully effective and bans the long-run incentives for de-investment in country 1.[19]

Since *ex-post* decentralization does not alter the long-run equilibrium outlined in Section 4.3, we focus on the impact of *ex-ante* decentralization in the subsequent analysis. Noting that wage claims and output after the reform are given by W^{lr} and y^{lr}, respectively, we can calculate aggregate employment materializing under firm-level union wage-setting in both economies (and symmetric firm allocation $n_1 = n_2 = n$). This gives:

$$(1 - u^r)L = \frac{4n^2 A(1-\beta)}{b(2n+1)[1+2n(1-\beta)]}, \tag{4.43}$$

where superscript r indicates post-reform (or post-decentralization) variables. With output per firm increasing and the number of active firms remaining constant, total employment in country 1 is higher than in the short-run open economy equilibrium. Hence, the decentralization in union wage-setting is not only successful in abolishing the incentives for capital outflow, but it also provides an additional short-run stimulus for domestic employment, because it lowers union wage claims and thus the competitive disadvantage of domestic firms in the international market. Of

[19] In the subsequent analysis, we disregard other policy measures that may be used to alter investment decisions in a country's favor, such as subsidies. While it is clear that governments have an incentive to use tax instruments strategically in our setting, considering them would not provide any novel insights relative to Haufler and Wooton (2010) and Ferrett and Wooton (2010), and this is the reason why we ignore them.

course, this increase in the competitiveness of domestic firms generates negative spillovers on the foreign labor market. Since firms in country 2 lose their competitive advantage vis-á-vis the producers in country 1, they choose lower output and therefore employ less workers than in the (pre-decentralization) short-run open economy equilibrium. In contrast to the long-run open economy equilibrium studied in Section 4.3, there is furthermore no capital inflow that compensates for the decline in production triggered by the improvement in the competitiveness of country 1 firms, and hence aggregate employment in country 2 unambiguously falls in response to decentralization in the wage setting of country 1 unions. With welfare being directly linked to aggregate employment in this paper, it is immediate that the positive employment effects in country 1 are associated with welfare gains, while the employment reduction in country 2 is accompanied by welfare losses.

Equipped with these insights, we now take a closer look at the group-specific welfare effects of *ex-ante* decentralization in the wage-setting of country 1. Welfare of workers is determined by total real labor income $(\Phi/P)^r$, while welfare of capital owners is determined by total real profits $(\Psi/P)^r$. To calculate these variables, we can first determine total real labor income and total real profit income *at the margin*, $\Phi^r = W^r(1-u^r)L$ and $\Psi^r = nb(y^r)^2$, respectively. Substituting W^{lr}, y^{lr}, and (4.43), we obtain

$$\Phi^r = \frac{8n^2A^2(1-\beta)}{b(2n+1)[1+2n(1-\beta)]^2}, \qquad \Psi^r = \frac{16n^3A^2(1-\beta)^2}{b(2n+1)^2[1+2n(1-\beta)]^2}. \tag{4.44}$$

Similar to the analysis in Sections 4.2 and 4.3, it is also useful to calculate the share of economic rents that accrues to workers and capital owners, $\phi = \Phi^r/(\lambda I)^r$ and $\psi = \Psi^r/(\lambda I)^r$, respectively. Noting that $(\lambda I)^r = \Psi^r + \Phi^r$ must hold by definition, we can calculate

$$\phi^r = \frac{2n+1}{(2n+1)+2n(1-\beta)}, \qquad \psi^r = \frac{2n(1-\beta)}{(2n+1)+2n(1-\beta)}, \tag{4.45}$$

respectively. Contrasting (4.45) with the respective findings in (4.31) and (4.32) gives the following rankings $\phi_1^{sr} > \phi_2^{sr} = \phi^r$ and $\psi_1^{sr} < \psi_2^{sr} = \psi^r$. We can therefore conclude that decentralization attributes a larger share of rents to capital owners in country 1, while leaving rent-sharing in country 2 unaffected. To put it differently, the spillover effects identified above alter the total size of economic rents in country 2, but not the way these rents are distributed between capital owners and workers there.

Total real income of workers can now be calculated by substituting (4.43) and (4.45) into $(\Phi/P)^r = \phi^r(1-u^r)L$, which gives

$$\left(\frac{\Phi}{P}\right)^r = \frac{4n^2A(1-\beta)}{b[1+2n(1-\beta)][(2n+1)+2n(1-\beta)]}. \tag{4.46}$$

From a comparison of (4.46) with (4.33), we can conclude that it is not clearcut in general whether workers in country 1 gain or lose due to ex-ante decentralization relative to the short-run open economy equilibrium. As formally shown in the Appendix, the outcome depends on the competitive environment in the product market as well as the generosity of unemployment compensation. If unemployment benefits are small and competition sufficiently strong, workers in country 1 are worse off after the decentralization in the wage-setting of local unions. However, this does not mean that workers should oppose the reform. Decentralization in union wage setting, while generating short-run losses, may still be to the benefit of workers, because it helps avoiding the capital outflow and thus the even more disastrous long-run outcome in (4.40).

Things are different in country 2, where workers face double losses from *ex-ante* decentralization in the wage setting of country 1. On the one hand, they lose because firms in country 2 experience a fall in their competitiveness relative to producers in country 1 and therefore hire less workers in the short run (see above). On the other hand, they also lose because the reform abolishes the incentives for capital relocation and thus destroys the long-run gains of workers in country 2 due to import of jobs. One final remark is in order here. While workers in both countries lose from *ex-ante* decentralization, one should not be tempted to conclude that globalization – by increasing the pressure to decentralize wage setting – lowers the welfare of workers. On the contrary, product market integration generates huge short-run benefits for workers in our setting and these benefits (while smaller) do still exist after the change in wage-setting institutions.

To round off the analysis in this section, we finally calculate group-specific welfare of capital owners. Substituting (4.43) and (4.45) into $(\Psi/P)^r = \psi^r(1-u^r)L$, we obtain

$$\left(\frac{\Psi}{P}\right)^r = \frac{8n^3A(1-\beta)^2}{b(2n+1)[1+2n(1-\beta)][(2n+1)+2n(1-\beta)]}. \tag{4.47}$$

which replicates the outcome for the long-run open economy equilibrium in (4.42). We can therefore infer the impact of *ex-ante* decentralization on welfare of capital owners from the respective discussion in Section 4.3. Capital owners in country 1 are better off after the change in the local wage setting institutions than in the short run open economy equilibrium or under autarky. Capital owners in country 2 lose relative to the (pre-decentralization) short run open economy equilibrium but are still better off than in the closed economy.

The following proposition summarizes the main insights from the analysis above.

Proposition 10 *For the effectiveness of decentralization in union wage-setting, the timing is important. If decentralization occurs after the capital outflow, it is not successful in restoring the initial capital allocation. However, if decentralization occurs early, it can prevent the capital outflow with positive consequences for domestic employment and welfare, and possibly the real income of workers. This success comes at the cost of negative spillovers on country* 2*, where employment, welfare, and real labor income shrink in response to decentralization in the wage-setting of country* 1 *unions. At least in the long run, capital owners are not affected by the decentralization in country* 1*, because they can always enforce the outcome of firm-level wage-setting by relocating their investment accordingly.*

Proof. Analysis in the text and derivation details in the Appendix. ■

The general recommendation from our analysis for policy makers who aim at securing domestic jobs in an open economy is clear. Act early to prevent capital outflow, because it may be difficult (if not impossible) to reverse the investment decisions of domestic capital owners once they have set up their production facilities abroad. The costs of responding late to new challenges in an open economy may be even more significant if agglomeration forces are at work. In this case, a government that aims at persuading domestic capital owners to invest at home instead of abroad may have to pay the full agglomeration rent – in addition to the direct costs of de-investment in the foreign country – when these capital owners have already closed their domestic plants because of the strong local wage-setting institutions.

4.5 Concluding remarks

This paper presents a general oligopolistic equilibrium model with unionized labor markets and two countries that differ in the degree of centralization in union wage setting. In this framework, we investigate how openness alters the way in which the degree of centralization in union wage setting affects key macroeconomic variables, such as welfare and unemployment. Thereby we distinguish two forms of openness: a short-run scenario, in which product markets are fully integrated, while capital markets remain segmented; and a long-run scenario, in which both product and capital markets are integrated. In the short run, product market integration has the expected effects. It lowers the scope of unions to set excessive wages, with positive effects on welfare and economy-wide employment in both economies. Furthermore, the results from our analysis are consistent with findings from previous research that differences in the degree of centralization in union wage-setting are less important for unemployment and welfare in open economies. We also shed light on group-specific effects of openness and show that even though product market integration alters the way economic rents are distributed in the society, the overall increase in production generates benefits for both income groups in our model: capital owners and workers.

However, our analysis also makes clear that these optimistic conclusions regarding the consequences of openness refer to a short-run perspective. When capital becomes internationally mobile it searches for the best investment opportunities worldwide and therefore moves to the country with less centralized wage setting and lower labor costs. The capital outflow reduces welfare and employment in the country with the higher degree of centralization in union wage-setting and alters the distribution of income in this economy significantly. While workers are worse off due to an export of jobs, capital owners benefit from having access to better investment opportunities. Things are exactly the opposite in the country with the more decentralized level of wage-setting. Due to an inflow of capital this country experiences a welfare gain and an employment expansion. Furthermore, while workers benefit from an inflow of capital and the establishment of new local jobs, capital owners are worse off, because their firms lose their competitive advantage in the product market. Our results also indicate that in the long run, openness does not reduce the impact the degree of centralization exerts on macroeconomic performance measures, but instead widens the gap in unemployment and welfare between the two economies.

To round off the discussion in this paper, we have looked at the consequences of decentralization of wage-setting in the country with the more severe labor market imperfection. The results from this analysis make clear that such a reform can be successful in preventing capital outflow when it occurs early, i.e. before the relocation of capital starts. Early attempts to decentralize union wage-setting can indeed be essential for securing benefits of product market integration in the long run and for rendering globalization a success story for all income groups. On the contrary, if decentralization starts after capital owners have adjusted their investment decisions in the long run, the reform is less promising and may fail to restore the initial capital allocation. In this case, long-run losses of some income groups may be unavoidable, rendering strong and persistent opposition by the respective income groups a real threat to globalization.

While we hope that this paper broadens the understanding of how different wage-setting institutions shape the outcome in open economies, it is clear that the analysis builds on many simplifying assumptions which are attractive from the perspective of analytical tractability, but at the same time limit the ability of our model to inform policy makers on how to solve real world problems. One restrictive feature of our analysis is the assumption of identical unemployment compensation schemes. Since we know that OECD countries systematically differ in this respect, it may be a worthwhile task for future research to consider more explicitly the interaction between union wage-setting institutions and unemployment compensation schemes for determining unemployment and welfare in open economies. Another restrictive assumption in our model is the immobility of workers. While it is evident that capital and product markets are more integrated than labor markets, the increasing mobility of workers has also been an important aspect of globalization in the last few decades. Whereas a detailed discussion on how migration alters the insights from our analysis is beyond the scope of this paper, it is worth noting that the higher probability of getting a job abroad may be a key rationale for emigration in our setting. Hence, if migration were possible, workers would follow capital in the long run, and this points to differences in the degree of centralization in union wage setting as an important source of agglomeration, with industry production concentrating in those locations that offer the least restrictive labor market institutions.

4.6 Appendix

Derivation of Eq. (4.22)

Maximizing profits (4.21) for $y_j(z)$, gives the first-order condition $d\Pi_j^t(z)/dy_j = 0$. Solving the latter for y_j, gives the best-reply function $2by_j(z) = 2A - b\sum_{k\neq j} y_k(z) - \bar{\lambda}w_j(z)$. We can now note two things: first, a structurally identical best-response function can be calculated for any other producer $k \neq j$; second, due to perfect foresight, firm j rationally anticipates that all competitors of country $i = 1, 2$ choose the same output in equilibrium. Introducing an asterisk for indicating foreign variables, we can thus rewrite the best response function of firm j in the following way:

$$y_j(z) = \frac{2A - b\,(n(z) - 1)\,y(z) - bn^*(z)y^*(z) - \bar{\lambda}w_j(z)}{2b}, \tag{4.48}$$

where $y(z)$, $y^*(z)$ refers to the common output of domestic and foreign competitors, respectively. Accounting for the symmetry assumption of domestic and foreign competitors in the first order-conditions of the respective producers, we can furthermore calculate

$$y(z) = \frac{2A - bn^*(z)y^*(z) - by_j(z) - \bar{\lambda}w(z)}{n(z)b} \tag{4.49}$$

$$y^*(z) = \frac{2A - b\,(n(z) - 1)\,y(z) - by_j(z) - \bar{\lambda}w^*(z)}{(n^*(z) + 1)\,b}, \tag{4.50}$$

where $\bar{\lambda}w(z)$ and $\bar{\lambda}w^*(z)$ refer to the common wage rates of domestic and foreign competitors of firm j, respectively. We can now solve system (4.49) and (4.50) for $y(z)$ and $y^*(z)$. This gives

$$y(z) = \frac{2A - by_j(z) + n^*(z)\bar{\lambda}w^*(z) - (n^*(z) + 1)\,\bar{\lambda}w(z)}{(n(z) + n^*(z))\,b}, \tag{4.51}$$

$$y^*(z) = \frac{2A - by_j(z) + (n(z) - 1)\,\bar{\lambda}w(z) - n(z)\bar{\lambda}w^*(z)}{(n(z) + n^*(z))\,b}. \tag{4.52}$$

Substituting (4.51) and (4.52) into (4.48), finally gives (4.22). *QED*

Derivation of Eqs. (4.23) and (4.24)

Since sector-level unions choose a uniform wage rate for all employees in the respective sector, we can set $w_{1j}(z) = w_1(z)$ in (4.22) to determine industry-wide employment in country 1: $\sum_{j=1}^{n(z)} l_{1j}(z) = ny_1(z)$. Substituting the latter into the union objective of sector-level union in (4.8), gives

$$V_1 = \frac{[w_1(z) - \bar{w}_1]\,n_1(z)\left[2A + n_2(z)\bar{\lambda}w_2(z) - (n_2(z) + 1)\,\bar{\lambda}w_1(z)\right]}{b\,(n_1(z) + n_2(z) + 1)}.$$

Maximizing V_1 for $w_1(z)$ gives the first-order condition $dV_1/w_1(z) = 0$, which can be reformulated to

$$\bar{\lambda}w_1(z) = \frac{2A + n_2(z)\bar{\lambda}w_2(z) + (n_2(z) + 1)\,\bar{\lambda}\bar{w}_1}{2\,(n_2(z) + 1)}. \tag{4.53}$$

In a similar vein, we can substitute (4.22) together with $l_{2j}(z) = y_{2j}(z)$ into the objective function of firm-level unions in (4.8), which gives

$$V_{2j}(z) = \frac{[w_{2j}(z) - \bar{w}_2]\left[2A + n_1(z)\bar{\lambda}w_1(z) + (n_2(z) - 1)\,\bar{\lambda}w_2(z) - (n_2(z) + n_1(z))\,\bar{\lambda}w_{2j}(z)\right]}{b\,(n_1(z) + n_2(z) + 1)}.$$

Maximizing this objective for $w_2j(z)$ gives the first-order condition $dV_{2j}/dw_{2j} = 0$. Rearranging terms and noting that $w_{2j}(z) = w_2(z)$ must hold due to ex-post symmetry we can calculate

$$\bar{\lambda}w_2(z) = \frac{2A + n_1(z)\bar{\lambda}w_1(z) + (n_1(z) + n_2(z))\,\bar{\lambda}\bar{w}_2}{2n_1(z) + n_2(z) + 1}. \tag{4.54}$$

Eqs. (4.53) and (4.54) constitute a system of two equations, which jointly determine wage rates $\bar{\lambda}w_1(z)$ and $\bar{\lambda}w_2(z)$ in (4.23) and (4.24). *QED*

The impact of product market integration on economy-wide employment

Using (4.14) and (4.27), we can show that the sign of $\Delta_1^u \equiv (1 - u_1^{sr})L - (1 - u^s)L$ is equivalent to the sign of $\bar{\gamma}_1^u \equiv (2n+1)(2n^2+2n+1) + (1-\beta)(n+1)(2n^2+5n+1) + (1-\beta)^2 2n(n+1)$ and thus positive. In a similar way, we can infer from (4.14) and (4.28) that the sign of $\Delta_2^u \equiv (1 - u_2^{sr})L - (1 - u^f)L$ is equivalent to the sign of $\bar{\gamma}_2^u \equiv (2n+1)(2n+3) + (1-\beta)(n+1)(2n^2 + 3n + 3) + (1-\beta)^2 2n(n+1)$, and hence is also positive. Putting together, we can thus conclude that product market integration stimulates employment in both locations. *QED*

The impact of product market integration on rent sharing

Looking first at country 1, we can infer from a comparison of (4.16) and (4.32) that

$$\Delta_1^{\psi} \equiv \psi_1^{sr} - \psi^s = \frac{n^2(1-\beta)}{[(2n+1) + (n+1)(1-\beta)][(n+1) + (1-\beta)]} > 0, \tag{4.55}$$

while for country 2, we get

$$\Delta_2^{\psi} \equiv \psi_2^{sr} - \psi^f = \frac{n(1-\beta)}{[(2n+1) + 2n(1-\beta)][(n+1) + n(1-\beta)]} > 0. \tag{4.56}$$

Hence, we see that capital owners in both countries are able to extract a larger share of economic rents in the short-run open economy equilibrium than under autarky.

The impact of product market integration on the employment and welfare differential between the two economies

In the closed economy the employment differential between the two countries is given by $\Delta u \equiv (1 - u^f)L - (1 - u^s)L = (u^s - u^f)L$:

$$\Delta u = \frac{n(n-1)A(1-\beta)}{b(n+1)(2-\beta)\,[1 + n(1-\beta)]}, \tag{4.57}$$

according to (4.14). Furthermore, accounting for (4.27) and (4.28), we can compute the respective differential in the short-run open economy:

$$\Delta u^{sr} = \frac{2n(n-1)A(1-\beta)}{b\left\{(n+1)(1-\beta)\left[(3n+1)+2n(1-\beta)\right]+(2n+1)\right\}}. \tag{4.58}$$

Combining (4.57) and (4.58), it is straightforward to show that the sign of $\Delta u - \Delta u^{sr}$ is equivalent to $\delta_u^{sr} \equiv -1 + (1-\beta)(n^2-1)$. Hence, $\Delta u - \Delta u^{sr}$ is positive if $\beta < 2/3$ and $n \geq 2$. Finally, noting that aggregate employment equals total real income in the two economies and and that total real income is a suitable welfare measure in our model, we can conclude that product market integration lowers the employment and welfare differential between the two economies. *QED*

The impact of product market integration on real labor income

Looking first at country 1, we can note that total real labor income (and thus the welfare of workers) in the short-run open economy is higher than, equal to, or smaller than in the closed economy if $\Delta_1^{\Phi} \equiv (\Phi_1/P)^{sr} - (\Phi/P)^{s} >, =, < 0$. In view of (4.18) and (4.33), we can furthermore show that the sign of Δ_1^{Φ} is equivalent to the sign of $\gamma_1(n,\beta) \equiv 4n^3 + 6n^2 + 4n + 1 + (1-\beta)\left(2n^2+7n+2\right)(n+1) - (1-\beta)^2\left(3n^2-6n-1\right)(n+1) - 2(1-\beta)^3 n\,(n-1)\,(n+1)$. Noting that $\gamma_1(n,\beta) > 0$ holds for any possible combination of $n \geq 1$ and $\beta \in (0,1)$, we can conclude that trade increases real income and welfare of workers in country 1. Looking at country 2, we can note that total labor income in the open economy is higher than, equal to, or lower than under autarky if $\Delta_2^{\Phi} \equiv (\Phi/P)^{sr} - (\Phi/P)^{s} >, =, < 0$. In view of (4.18) and (4.34), we can furthermore show that the sign of Δ_2^{Φ} is equivalent to the sign of $\gamma_2(n,\beta) \equiv (2n+1)(2n+3) + (1-\beta)[(n+1)^2(2n+1) + (2n+1)^2 + 1] + 2(1-\beta)^2 n(n^2+n+2)$. Noting that $\gamma_2(n,\beta) > 0$ holds for any $n \geq 1$ and $\beta \in (0,1)$, we can thus safely conclude that product market integration increases real income and welfare of workers in country 2. *QED*

The impact of trade and capital mobility on aggregate employment

Let us first look at country 1. The employment effects of capital outflow are determined by the sign of $\bar{\Delta}_1^u \equiv u_1^{sr} - u_1^{lr}$, which in view of (4.27) and (4.37) is equal to the sign of $\bar{\gamma}_1^u(n,\beta) \equiv -(n-1)\left[(2n+1) + 2(n+1)(2n+1)(1-\beta) + 4n(n+1)(1-\beta)^2\right]$. Since $\bar{\gamma}_1(n,\beta) \leq 0$ holds for all $n \geq 1$ and $\beta \in (0,1)$, aggregate employment in country 1 must be lower in the long run than in the short-run open economy. Furthermore, to see whether capital mobility reverses the positive employment stimulus from product market integration, we have to look at $\tilde{\Delta}_1^u \equiv u_1^s - u_1^{lr}$. From (4.14) and (4.37), it follows that the sign of $\tilde{\Delta}_1^u$ is equivalent to the sign of $\tilde{\gamma}_1^u(n,\beta) \equiv (2n+3) - 2(1-\beta)\left(2n^2-n-2\right)$. It is obvious that $\tilde{\gamma}_1^u(n,1) = 2n+3 > 0$, while $\tilde{\gamma}_1^u(n,0) = -4n^2+4n+7$, where $\tilde{\gamma}_1^u(0,0) = 7$ and $\lim_{n\to\infty}\tilde{\gamma}_1^u(n,0) < 0$ imply that the sign of $\tilde{\gamma}_1^u(n,0)$ is ambiguous. In addition, we can show that $\tilde{\gamma}_1^u(1,\beta) = 7 - 2\beta > 0$. Accounting for the properties of $\tilde{\gamma}_1^u(n,\beta)$, we can therefore conclude that openness may have negative long-run employment effects in country 1 if n is sufficiently large, while β is sufficiently small. Turning to country 2, we can note that capital provides an employment stimulus if $\bar{\Delta}_2^u \equiv u_2^{sr} - u_2^{lr} \geq 0$. Noting that, in view of (4.28) and (4.37), the sign of Δ_2^u is equivalent to the sign of $\bar{\gamma}_2^u(n,\beta) \equiv (n-1)\left[(2n+1) + (1-\beta)(2n^2+4n+1) + 2n(n+1)(1-\beta)^2\right]$ and thus positive for any $n > 1$ and

$\beta \in (0,1)$, we can safely conclude that capital inflow reinforces the employment stimulus from product market integration. *QED*

The impact of trade and capital mobility on aggregate welfare

Let us first look at country 1. The welfare implications of capital outflow can be inferred from the sign of $\bar{\Delta}_1^U \equiv \left(\bar{\lambda} I_1/P\right)^{lr} - \left(\bar{\lambda} I_1/P\right)^{sr}$. Noting from our previous analysis that $(\lambda I_1/P)^{sr} = (1-u_1^{sr})\,L$, it follows from (4.27) and (4.38) that the sign of $\bar{\Delta}_1^U$ is equivalent to the sign of $\bar{\gamma}_1^U(n,\beta) \equiv -(n-1)\big[(2n+1)^2 + 2(1-\beta)(2n+1)(2n^2+2n+1) + 4(1-\beta)^2 n(n+1)^2\big]$. Since $\bar{\gamma}_1(n,\beta) < 0$ holds for any $n > 1$ and $\beta \in (0,1)$, it is clear that capital outflow lowers welfare relative to the short-run open economy. To see, whether this detrimental effect can be strong enough to reverse the positive welfare implications of product market integration, we have to determine the sign of $\tilde{\Delta}_1^U \equiv \left(\bar{\lambda} I_1/P\right)^{lr} - \left(\bar{\lambda} I/P\right)^{s}$. Noting that $\left(\bar{\lambda} I/P\right)^{s} = (1-u^s)L$, we can infer from (4.14) and (4.38) that $\tilde{\Delta}_1^U$ must be positive because $\tilde{\gamma}_1^U(n,\beta) \equiv (2n+1)(2n+3) + 4(1-\beta)(n+1)^2 + 4(1-\beta)^2 n^2 > 0$ holds for any $n > 1$ and $\beta \in (0,1)$. Therefore, we can safely conclude that welfare in country 1 is higher in the long run open economy equilibrium than under autarky. To determine the welfare effects of capital inflow in country 2, we can evaluate $\bar{\Delta}_2^U \equiv \left(\bar{\lambda} I_2/P\right)^{lr} - \left(\bar{\lambda} I_2/P\right)^{sr}$. Noting that $(\lambda I_2/P)^{sr} = (1-u_2^{sr})\,L$ and accounting for (4.28) and (4.39), we can show that the sign of $\bar{\Delta}_2^U$ is equivalent to the sign of $\bar{\gamma}_2^U(n,\beta) \equiv (n-1)\big[(2n+1)^2 + (1-\beta)(4n^3+10n^2+6n+1) + 2(1-\beta)^2 n(n^2+3n+1)\big]$. Since $\bar{\gamma}_2^U(n,\beta)$ is positive for any $n > 1$, $\beta \in (0,1)$, we can thus safely conclude that capital inflow amplifies the positive short-run welfare gains from product market integration. *QED*

The impact of trade and capital mobility on the employment and welfare differential

In the closed economy, the employment differential between the two countries is given by (4.57). In the long-run open economy, the respective differential is given by $\Delta u^{lr} \equiv (1-u_2^{lr})L - (1-u_1^{lr})L$:

$$\Delta u^{lr} \equiv \frac{8n(n-1)A(1-\beta)}{b(2n+1)\,[1+2n(1-\beta)]}, \tag{4.59}$$

according to (4.37). Combining (4.57) and (4.59), we can show that the sign of $\Delta u - \Delta u^{lr}$ is equivalent to the sign of $\delta_u^{lr} \equiv -(6n+3) - 2(1-\beta)(4n^2+7n+2) - (1-\beta)^2 8n(n+1)$, which is negative. In a similar vein, we can compare (4.58) and (4.59) to see that the sign of $\Delta u^{sr} - \Delta u^{lr}$ is equivalent to the sign of $\tilde{\delta}_u^{lr} \equiv -(7n+3) - 2(1-\beta)(n+1)(5n+2) - (1-\beta)^2 8n(n+1)$ and thus negative.

Let us now turn to the welfare differential. Accounting for (4.38) and (4.39), we can show that the real income differential between the two countries in the long-run open economy equilibrium is given by $\Delta\tilde{U}^{lr} \equiv (\bar{\lambda} I_2/P)^{lr} - (\bar{\lambda} I_1/P)^{lr}$:

$$\Delta\tilde{U}^{lr} \equiv \frac{8n(n-1)A(1-\beta)}{b[1+2n(1-\beta)][(2n+1)+2n(1-\beta)]}. \tag{4.60}$$

Noting further that $\Delta\tilde{U} \equiv (\bar{\lambda} I/P)^{f} - (\bar{\lambda} I/P)^{s} = \Delta u$ holds in the closed economy, we can infer from comparing (4.57) with (4.60) that the sign of $\Delta\tilde{U} - \Delta\tilde{U}^{lr}$ is equivalent to the sign of $\delta_U^{lr} \equiv -(6n+7) - 4(1-\beta)(n^2+3n+2) - (1-\beta)^2 4n(n+2)$ and thus negative. Finally, noting that $\Delta\tilde{U}^{sr} \equiv (\bar{\lambda}I_2/P)^{sr} - (\bar{\lambda}I_1/P)^{sr} = \Delta u^{sr}$, it follows from (4.58) and (4.60) that the sign of $\Delta\tilde{U}^{sr} - \Delta\tilde{U}^{lr}$ is equivalent to the sign of $\tilde{\delta}_U^{lr} \equiv -(6n+3) - 4(1-\beta)(2n^2+3n+2) - 4(1-\beta)^2 n(n+2)$ and thus negative. Putting together, we can therefore conclude that both the employment differential and the welfare differential are more pronounced in the long-run open economy equilibrium than in the short run or under autarky. *QED*

The impact of trade and capital mobility on total real labor income

For country 1, we can infer the impact of capital outflow on total real labor income from the sign of $\bar{\Delta}_1^\Phi \equiv (\Phi_1/P)^{lr} - (\Phi_1/P)^{sr}$. In view of (4.33) and (4.40), we can conclude that $\bar{\gamma}_1^\Phi(n,\beta) \equiv -(n-1)\big[(2n+1)^2 + 4(1-\beta)(n+1)(2n^2+3n+1) + 2(1-\beta)^2(n+1)(8n^2+7n+1) + 4(1-\beta)^3(n+1)n\big] < 0$ implies $\bar{\Delta}_1^\Phi < 0$, so that capital outflow reduces total real labor income in country 1 relative to the short-run open economy equilibrium. To see whether this income loss is strong enough to reverse the positive real income stimulus from product market integration, we have to determine the sign of $\tilde{\Delta}_1^\Phi \equiv (\Phi_1/P)^{lr} - (\Phi/P)^s$. In view of (4.18) and (4.40) we can conclude that the sign of $\tilde{\Delta}_1^\Phi$ is equivalent to the sign of $\tilde{\gamma}_1^\Phi(n,\beta) \equiv (2n+3) - 4(1-\beta)(n^2-2) - 4(1-\beta)^2(n^2-1)$. It is easily confirmed that $\tilde{\gamma}_1^\Phi(n,1) = 2n+3 > 0$, while $\tilde{\gamma}_1^\Phi(n,0) = 15 + 2n - 8n^2$, where $\tilde{\gamma}_1^\Phi(0,0) = 15 > 0$ and $\lim_{n\to\infty} \tilde{\gamma}_1^\Phi(n,0) < 0$ imply that the sign of $\tilde{\gamma}_1^\Phi(n,0)$ is ambiguous. Accounting for the properties of $\tilde{\gamma}_1^\Phi(n,\beta)$, we can therefore conclude that openness may generate long-run welfare losses of workers if n is sufficiently large, while β is sufficiently small. Turning to country 2, we can infer the impact of capital inflow on total real labor income by determining the sign of $\bar{\Delta}_2^\Phi \equiv (\Phi_2/P)^{lr} - (\Phi_2/P)^{sr}$. Accounting for (4.34) and (4.41), we can conclude that $\bar{\gamma}_2^\Phi(n,\beta) \equiv (n-1)\big[(2n+1)^2 + (1-\beta)\left(2n^2+4n+1\right) + 2(1-\beta)^2 n(n+1)\big] > 0$ implies $\bar{\Delta}_2^\Phi > 0$, so that capital inflow amplifies the positive welfare implications for workers triggered by product market integration. *QED*

The impact of trade and capital mobility on total real capital income

Let us first look at country 1, where we can infer the impact of capital inflow on total real capital income from determining the sign of $\bar{\Delta}_1^\Psi \equiv (\Psi_1/P)^{lr} - (\Psi_1/P)^{sr}$. Accounting for (4.35) and (4.42), we can show that the sign of $\bar{\Delta}_1^\Psi$ is equivalent to the sign of $\bar{\gamma}_1^\Psi(n,\beta) \equiv (n-1)\big[(2n+1)^2(3n+1) + 2(1-\beta)n(n+1)(2n+1)(4n+3) + 4(1-\beta)^2 n^2(n+1)(3n+2)\big]$, which is positive for any $n > 1$ and $\beta \in (0,1)$. Hence, we can safely conclude that capital outflow reinforces the positive short-run impact of product market integration on total real capital income. Turning to country 2, we can infer the impact of capital inflow on total real income of domestic capital owners from the sign of $\bar{\Delta}_2^\Psi \equiv (\Psi_2/P)^{lr} - (\Psi_2/P)^{sr}$, which is equivalent to the sign of $\bar{\gamma}_2^\Psi \equiv -(1-\beta)n(n-1)$ and thus negative. This implies that capital inflow lowers total real income of capital owners in country 2 relative to the short-run open economy equilibrium. To see whether this negative impact is strong enough to reverse the short-run benefits of this income group from product market integration, we can look at the sign of $\tilde{\Delta}_2^\Psi \equiv (\Psi_2/P)^{lr} - (\Psi_2/P)^f$. Accounting for (4.19) and (4.42), we can show that the sign of $\tilde{\Delta}_2^\Psi$ is equivalent to the sign of $\tilde{\gamma}_2^\Psi \equiv 4n^2 + 12n + 7 + (1-\beta)12n(n+1) + (1-\beta)^2 4n^2$ and thus positive. Hence, capital owners in country 2, while losing from capital inflow, are better off in a long-run open economy equilibrium than under autarky. *QED*

The impact of ex-ante decentralization in union wage-setting on employment and welfare

Let us first look at country 1, where we can infer the employment effects of ex-ante decentralization in union wage setting from determining the sign of $\hat{\Delta}_1^u \equiv u_1^{sr} - u_1^r$. Accounting for (4.27) and (4.43), we can show that the sign of $\hat{\Delta}_1^u$ is equivalent to the sign of $\hat{\gamma}_1^u(n,\beta) \equiv (n-1)[(2n+1)+2n(n+1)(1-\beta)]$. Since $\hat{\gamma}_1^u(n,\beta) > 0$ holds for any $n > 1$ and $\beta \in (0,1)$ we can conclude that ex-ante decentralization in the wage-setting of domestic unions stimulates employment and – in the absence of international capital flows – also welfare in country 1 relative to the short-run open economy equilibrium in Section 4.3. These positive aggregate effects of decentralization also extend to the long run, because we know from the previous analysis that capital outflow, which is prevented by the reform of country 1's wage-setting institutions, is associated with a decline in employment and welfare in country 1. For country 2, we can infer the employment and welfare effects of ex-ante decentralization in union wage-setting from the sign of $\hat{\Delta}_2^u \equiv u_2^{sr} - u_2^r$, which, in view of (4.28) and (4.43), is equivalent to the sign of $\hat{\gamma}_2^u(n,\beta) \equiv -(1-\beta)n(n-1)$ and thus negative. We can therefore conclude that ex-ante decentralization in the wage-setting of country 1 unions lowers employment and welfare in country 2 relative to the short-run and – since there are no international capital flows after the reform – the long-run open economy equilibrium in Section 4.3. *QED*

The impact of ex-ante decentralization in union wage-setting on total real labor income

For country 1, we can infer the short-run impact of ex-ante decentralization in the wage-setting of local unions on total real labor income from the sign of $\hat{\Delta}_1^\Phi \equiv (\Phi_1/P)^r - (\Phi_1/P)^{sr}$. In view of (4.33) and (4.46), we can show that the sign of $\hat{\Delta}_1^\Phi$ is equivalent to the sign of $(n-1)\hat{\gamma}_1^\Phi$, with $\hat{\gamma}_1^\Phi \equiv (2n+1)^2 + (1-\beta)2n(n+1)(2n+1) - (1-\beta)^2 2n(n+1)^2 - (1-\beta)^3 4n^2(n+1)$. It is easily confirmed that $\hat{\gamma}_1^\Phi(n,1) = (2n+1)^2 > 0$, while $\hat{\gamma}_1^\Phi(n,0) = -2n^3 + 2n^2 + 4n + 1$, where $\hat{\gamma}_1^\Phi(1,0) = 1 > 0$, and $\lim_{n\to\infty} \hat{\gamma}_1^\Phi(n,0) < 0$ imply that the sign of $\hat{\gamma}_1^\Phi(n,0)$ is not clearcut in general. To be more specific, there exists a unique $\hat{n}(\beta) > 1$ such that $\hat{\gamma}_1^\Phi(n,0) > 0$ if $n < \hat{n}(\beta)$, while $\hat{\gamma}_1^\Phi(n,0) < 0$ if $n > \hat{n}(\beta)$. Accounting for the properties of $\hat{\gamma}_1^\Phi(n,\beta)$, we can therefore conclude that ex-ante decentralization in the wage-setting of domestic unions can lower total real labor income in country 1 relative to the short-run open economy in Section 4.3, if n is sufficiently high, while β is sufficiently small. Otherwise, workers in country 1 benefit form this change in local wage-setting institutions. Regarding the long-run implications of the ex-ante decentralization in domestic union wage-setting, it is straightforward to infer from (4.40) and (4.46) that $(\Phi_1/P)^r - (\Phi_1/P)^{lr} > 0$. Furthermore, we can determine the short-run consequences of ex-ante decentralization in the wage-setting of country 1 for total real labor income in country 2 when looking at the sign of $\hat{\Delta}_2^\Phi \equiv (\Phi_2/P)^r - (\Phi_2/P)^{sr}$, which, in view of (4.34) and (4.46), is equivalent to the sign of $\hat{\gamma}_2^\Phi \equiv -(1-\beta)n(n-1)$ and thus negative. Since we also know from the previous analysis that capital inflow renders workers in country 2 better off, we can conclude that decentralization in the wage-setting of country 1 unions lowers total real labor income in country 2 relative to the short-run and long-run open economy equilibria analyzed in Section 4.3. *QED*

Net wage income with sector-level and firm-level unions

A balanced budget of the government requires

$$t^\eta(1-u^\eta)LW^\eta = (1-t^\eta)\, u^\eta L\beta W^\eta, \tag{4.61}$$

where t^η is the proportional income tax rate under labor market regime $\eta = s, f$. Solving (4.61) for t^η, we can calculate $1-t^\eta = (1-u^\eta)/\left[1-u^\eta(1-\beta)\right]$. Substituting u^η from (4.14), therefore implies

$$1-t^s = \frac{nA(1-\beta)}{bL(n+1)(2-\beta)\beta + nA(1-\beta)^2}, \tag{4.62}$$

$$1-t^f = \frac{n^2A(1-\beta)}{bL(n+1)\left[1+n(1-\beta)\right]\beta + n^2A(1-\beta)^2}. \tag{4.63}$$

Furthermore, we can combine $(1-u^\eta)L(W/P)^\eta = (\Phi/P)^\eta$ with the insight that $(\Phi/P)^\eta = \phi^\eta(1-u^\eta)L$, to see that real gross income of an employed production worker, $(W/P)^\eta$, equals ϕ^η, while real net income of this worker equals $\omega^\eta \equiv (1-t^\eta)\phi^\eta$. Substituting $1-t^\eta$ from above, then gives

$$\omega^s \equiv \frac{nA(1-\beta)\phi^s}{bL(n+1)(2-\beta)\beta + nA(1-\beta)^2}, \quad \omega^f \equiv \frac{n^2A(1-\beta)\phi^f}{bL(n+1)\left[1+n(1-\beta)\right]\beta + n^2A(1-\beta)^2}, \tag{4.64}$$

With respect to the ranking of ω^s and ω^f, we can note from (4.16), (4.17), and (4.64) that $\omega^s >,=,< \omega^f$ is equivalent to $\rho(\beta) >,=,< 0$, with

$$\rho(\beta) \equiv (n-1)\left\{n^2A(1-\beta)^3 - \beta bL(n+1)\left[1+\beta n(2-\beta)\right]\right\}. \tag{4.65}$$

It is easily shown that $\rho(0) > 0$, $\rho(1) < 1$ and $\rho'(\beta) < 0$, which confirms the respective statement in Footnote 12.[20] *QED*

The allocation of capital in a long-run open economy equilibrium

It is the aim of this proof to show that there exists a unique full diversification equilibrium, in which both countries produce all goods.[21] Throughout the proof, we ignore the integer problem and assume that long-run adjustments of investment decisions do not generate costs. The capital allocation problem in the open economy has two dimensions. On the one hand, within an industry capital owners have to decide in which country they invest and, one the other hand, capital owners

[20] Of course, an interior equilibrium requires $u^\eta > 0$ and, in view of $u^f < u^s$, we can conclude from inspection of (4.14) that $n^2A(1-\beta) < bL(n+1)\left[1+n(1-\beta)\right]$ is sufficient for positive unemployment rates in both countries. However, this parameter restriction does not influence our findings regarding the ranking of ω^s and ω^f.

[21] We do not study the existence of specialization equilibria, in which at least one country ceases production in a subset of industries.

must determine the industry in which they set up a firm. Accordingly, we can conclude that in any full diversification equilibrium the following two *no arbitrage* conditions must hold: (i) $\Pi_i(z) = \Pi^t(z)$ for $i = 1, 2$, implying that capital owners cannot further increase their income by choosing a different country for their investment in industry z; (ii) $\Pi^t(z) = \Pi^t$ for all z, implying that capital owners cannot increase their income by choosing a different industry for their investment.

We first look at no arbitrage condition (i). Recollecting from the main text that linear consumer demand implies $\Pi_i(z) = by_i(z)^2$, we can conclude that in a full diversification equilibrium $y_1(z) = y_2(z)$ must hold. In view of (4.51) and (4.52), we can further note that $y_1(z) = y_2(z)$ is equivalent to $\bar{\lambda}w_1 = \bar{\lambda}w_2$, and from (4.23) and (4.24) we can infer that international factor price equalization requires

$$(2A - \bar{\lambda}\bar{w}_1)\left[n_1(z) - 1\right] = \left(\bar{\lambda}\bar{w}_2 - \bar{\lambda}\bar{w}_1\right)\left[n_1(z) + n_2(z)\right]\left[n_2(z) + 2\right], \tag{4.66}$$

$$(2A - \bar{\lambda}\bar{w}_2)\left[n_1(z) - 1\right] = \left(\bar{\lambda}\bar{w}_2 - \bar{\lambda}\bar{w}_1\right)\left[n_1(z) + n_2(z) + 1\right]\left[n_2(z) + 1\right]. \tag{4.67}$$

Recollecting from the main text that sector-level unions set a uniform wage rate for all producers in the respective industry, we can note that $w_j(z) = w(z)$ holds in this case. Combining (4.22) with (4.23) and (4.24) therefore yields

$$\begin{aligned} y_1(z) = {} & \frac{\left(2A - \bar{\lambda}\bar{w}_1\right)\left[2n_1(z)n_2(z) + 2n_2(z)^2 + 2n_1(z) + 3n_2(z) + 1\right]}{b\left[n_1(z) + n_2(z) + 1\right]\left[3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2\right]} \\ & + \frac{\left(\bar{\lambda}\bar{w}_2 - \bar{\lambda}\bar{w}_1\right)\left[n_1(z) + n_2(z)\right]\left[n_2(z) + 1\right]n_2(z)}{b\left[n_1(z) + n_2(z) + 1\right]\left[3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2\right]}. \end{aligned} \tag{4.68}$$

Solving (4.66) for $2A - \bar{\lambda}\bar{w}_1$, substituting the resulting expression into (4.68) and recollecting from above that $y_i(z) \equiv y(z)$ for $i = 1, 2$, we can calculate

$$y(z) = \frac{\left(\bar{\lambda}\bar{w}_2 - \bar{\lambda}\bar{w}_1\right)\left[n_1(z) + n_2(z)\right]\left[n_2(z) + 1\right]}{b\left[n_1(z) + n_2(z) + 1\right]\left[n_1(z) - 1\right]} \tag{4.69}$$

and substituting (4.67) finally gives

$$y(z) = \frac{\left(2A - \bar{\lambda}\bar{w}_2\right)\left[n_1(z) + n_2(z)\right]}{b\left[n_1(z) + n_2(z) + 1\right]^2}. \tag{4.70}$$

Noting from no arbitrage condition (ii) that $y(z)$ must be the same for all z, i.e. $y(z) = y$, we can infer from Eq. (4.70) that in a full diversification equilibrium the total number of competitors is the same in all industries z: $2n = n_1(z) + n_2(z) > 1$. According to (4.66), we can then define the implicit function

$$\zeta\left(n_1(z)\right) \equiv \left[(2A - \bar{\lambda}\bar{w}_1) + 2n\left(\bar{\lambda}\bar{w}_2 - \bar{\lambda}\bar{w}_1\right)\right]\left[n_1(z) - 1\right] - 2n(2n+1)\left(\bar{\lambda}\bar{w}_2 - \bar{\lambda}\bar{w}_1\right) = 0. \tag{4.71}$$

Noting that changes in $n_1(z)$ do not affect economy-wide variables $\bar{\lambda}\bar{w}_1$, $\bar{\lambda}\bar{w}_2$, we can conclude from inspection of (4.71) that $\zeta(\cdot)$ is a monotonic function of $n_1(z)$, so that a solution to $\zeta(\cdot) = 0$, if it exists, must be unique. This implies that if a full diversification equilibrium exists, the number of competitors in the two countries must be the same in all industries, i.e. $n_1(z) = n_1$

and $n_2(z) = 2n - n_1 = n_2$ for all z. However, if industries are symmetric in this respect, it follows from (4.23), (4.24) – and the previous insight that diversification requires factor price equalization – that $\bar{\lambda} w_i(z) = \bar{\lambda} w$ for $i = 1, 2$ and all z. This implies $\bar{\lambda}\bar{w}_i = \beta\bar{\lambda} w$ for $i = 1, 2$, and we can therefore calculate

$$W \equiv \bar{\lambda} w = \frac{2A\left(2n_1 + 2n_2 + 1\right)}{(1-\beta)\left(3n_1 n_2 + 2n_2^2 + 2n_1 + 2n_2 + 1\right) + \left(2n_1 + 2n_2 + 1\right)}, \tag{4.72}$$

$$W \equiv \bar{\lambda} w = \frac{2A\left(n_1 + 2n_2 + 2\right)}{(1-\beta)\left(3n_1 n_2 + 2n_2^2 + 3n_1 + 2n_2\right) + \left(n_1 + 2n_2 + 2\right)}, \tag{4.73}$$

according to (4.23) and (4.24). Accounting for $n_2 = 2n - n_1$, system (4.72) and (4.73) establishes an implicit relationship between n_1 and n:

$$\Gamma\left(n_1, n\right) \equiv \left(n_1 - 1\right)\left[2\left(2n_1 + 1\right) + \left(3n_1 + 4\right)\left(2n - n_1\right) + 2\left(2n - n_1\right)^2\right] = 0. \tag{4.74}$$

It is immediate that $\Gamma\left(n_1, n\right) = 0$ has a unique solution at $n_1 = 1$. Put differently, capital mobility establishes firm allocation $n_1 = 1$ and $n_2 = 2n - 1$ in a long-run open economy equilibrium with diversification. Wages and output corresponding to this firm allocation are given by W^{lr} and y^{lr}, according to (4.22) and system (4.72), (4.73).

Taking stock, we have so far shown that firm allocation $n_1(z) = 1$, $n_2(z) = 2n - 1$ is the only candidate for a long-run open economy equilibrium with diversification. However, we have not discussed whether respective firm allocation captures the capital owners' best responses to the investment decisions of their competitors and thus establishes an equilibrium at all. Showing that $n_1(z) = 1$, $n_2(z) = 2n - 1$ characterizes a best-response equilibrium in the investment game is the purpose of the subsequent analysis. Since capital owners foresee that their investment decision influences product market competition and thus union wage setting in the respective industry, we must evaluate $y_i(z)$, $i = 1, 2$ for asymmetric wages $\bar{\lambda} w_1 \neq \bar{\lambda} w_2$. However, since a single capital owner cannot influence the economy-wide average wage, we still have $\bar{\lambda}\bar{w}_i = \bar{\lambda}\bar{w}$ for $i = 1, 2$. Evaluating (4.23) and (4.24) at $\bar{\lambda}\bar{w}_i = \bar{\lambda}\bar{w}$, substituting the resulting expression into (4.22), and accounting for $w_j(z) = w(z)$ we get

$$y_1(z) = \frac{2A - \bar{\lambda}\bar{w}}{b}\,\frac{2n_1(z)n_2(z) + 2n_2(z)^2 + 2n_1(z) + 3n_2(z) + 1}{\left[n_1(z) + n_2(z) + 1\right]\left[3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2\right]}, \tag{4.75}$$

$$y_2(z) = \frac{2A - \bar{\lambda}\bar{w}}{b}\,\frac{3n_1(z)n_2(z) + n_1^2 + 2n_2(z)^2 + 2n_1(z) + 2n_2(z)}{\left[n_1(z) + n_2(z) + 1\right]\left[3n_1(z)n_2(z) + 2n_2(z)^2 + 4n_1(z) + 4n_2(z) + 2\right]}. \tag{4.76}$$

Differentiating $y_i(z)$ by $n_i(z)$ and evaluating the resulting expression at $n_1(z) = 1, n_2(z) = 2n - 1$, further implies

$$\frac{\partial y_1(z)}{\partial n_1(z)} = -\frac{2A - \bar{\lambda}\bar{w}}{b}\,\frac{12n^2}{\left(2n+1\right)^3\left(4n+1\right)}, \qquad \frac{\partial y_2(z)}{\partial n_2(z)} = -\frac{2A - \bar{\lambda}\bar{w}}{b}\,\frac{2n-1}{\left(2n+1\right)^3}. \tag{4.77}$$

It is straightforward that $dy_i(z)/dn_i(z) < 0$ and thus $d\Pi_i(z)/dn_i(z) < 0$. This implies that a capital owner cannot benefit from adjusting his/her investment if $n_1 = 1$ and $n_2 = 2n - 1$, which confirms that a unique full diversification equilibrium exists and completes the proof. *QED*

5 Wage Moderation and the German Export Miracle: Plant-level Evidence

5.1 Introduction

The recent surge of German exports is surrounded by a heated debate on the causes and consequences of this so-called "export miracle". Opponents argue that Germany has enforced a series of policy reforms that have led to wage moderation and thus have increased international competitiveness at the expense of its trading partners, especially within the Eurozone (cf. Lagarde, 2010).[1] While the broader political debate focused on the role of diverging unit labor costs for growing current account imbalances, the "export miracle" also provokes the question about driving forces for export activity. It is commonly acknowledged that exporting firms are distinctively different from their non-exporting competitors. Bernard and Jensen (1995) and Bernard and Jensen (1999) documented for the US manufacturing industry that exporting firms are larger, more productive and pay higher wages than their national counterparts.[2] The seminal work by Melitz (2003) provides a tractable theoretical model that is able to explain these stylized facts by allowing for firm heterogeneity due to firm-specific productivity levels. While there is broad empirical support for this mechanism,[3] the economic profession is surprisingly quiet about the role of competitiveness for sorting into exporting.

It is the purpose of this paper to fill this gap by investigating the role of unit labor costs as measure of competitiveness for the export activity of German plants. Therefore, we construct a proxy for competitiveness that comprises both productivity and labor costs. Higher productivity and/or lower labor costs make plants more efficient, indicated by a higher level of competitiveness. Moreover, we argue that the export promoting effect of competitiveness may be driven at two different margins. A rise in competitiveness may increase the probability of a plant to switch from the sole domestic supply regime to the exporter regime (extensive margin), or it may also be associated with a surge in export-intensity of already exporting plants (intensive margin). In our view, German plants are highly interesting in analyzing these questions mainly for two reasons. First, German firms and plants have been particularly active in exporting in the recent past. In the period 2000 to 2010, the German export volume has increased by about 60 percent and has for the first time surpassed the level of one trillion Euro in 2012 (cf. Statistisches

[1] During an interview with Financial Times, Lagarde stated: "The issue at hand is really one of competitiveness. Clearly Germany has done an awfully good job in the last 10 years or so, improving competitiveness, putting a very high pressure on its labor costs. When you look at unit labor costs to Germany, they have done a tremendous job in that respect. I'm not sure it is a sustainable model for the long term and for the whole of the group."

[2] Similar results were found for other countries, like Germany (cf. Bernard and Wagner, 1997) and Taiwan (cf. Aw and Hwang, 1995).

[3] For an excellent survey on this topic see e.g. Bernard, Jensen, Redding, and Schott (2011).

Bundesamt, 2012). Second, at the same time, a number of structural reforms had been initiated on the German labor market. It is therefore often argued that these labor market reforms have increased the competitiveness of German firms and plants on international markets relative to their competitors from abroad.

In a first step of our analysis, we construct two measures of competitiveness. The first is at the plant-level and uses data from the IAB establishment panel. We compute unit labor costs per plant and put it in relation to the foreign trade-weighted average unit labor costs in the corresponding industry. Similarly, we derive a measure of competitiveness at the sectoral level by using OECD STAN data. Our analysis is closely linked to studies by Davis and Harrigan (2011) and Harrigan and Reshef (2011) that extend the Melitz framework by considering the sorting into exporting decision not only according to productivity costs but also according to labor costs, whereby both variables are drawn from a joint distribution. We regress the export share of German plants on our two measures of competitiveness. Since our endogenous variable is a fractional variable with a probability mass at zero it is not appropriate to model this variable by OLS or a variant of it. This issue is extensively discussed in Papke and Wooldridge (1996) and has been applied to international trade by Wagner (2001). These papers suggest to use a fractional logit/probit model. On the other hand, people also suggest the use of a Tobit model. Given these discussions we chose to follow both approaches. Irrespective of the choice of model, our results show a positive and significant relationship between plant-level competitiveness and export activity. Plants that are characterized by lower unit labor costs relative to their average foreign competitors export more. To the best of our knowledge, our paper provides the first plant-level evidence on the role of both productivity and average wages as export determinants. Moreover, we use Tobit regressions in the spirit of Felbermayr and Kohler (2006b) in order to disentangle the total effect into its effects at the extensive and intensive margin of trade. The Tobit model has the crucial advantage that both effects can be estimated simultaneously. Of course, the Tobit model is appropriate only if we believe that the data generating process is the same at both margins. Put differently, we are postulating that the forces that drive firms exporting behavior at both margins are identical. Following this approach we are able to report robust evidence on the export-promoting effects of competitiveness at both margins. Our results show that a one standard deviation of plant-competitiveness is associated with a approximately three percent higher probability of being an exporter at the extensive margin and 0.7 percentage points higher export intensity at the intensive margin. The results are robust to different estimators. Our industry-level competitiveness is insignificant in all specifications and models. Measuring competitiveness in terms of low labor costs reveals a negative relationship. Low-wage firms tend to export less. This result is in line with a huge literature that demonstrates that exporters pay higher wages. Schank, Schnabel, and Wagner (2007b) were the first using matched employer-employee data from Germany in order to show that the exporter wage premium is of the residual type. Controlling for observed and unobserved worker characteristics they *ceteris paribus* find that German exporters in manufacturing industries pay higher wages than plants that solely serve the domestic market. Klein, Moser, and Urban (2010) further distinguish between low- and high-skill workers and show that the positive premium is mainly driven by a premium paid to the high-skilled, where low-skilled even suffer from a wage discount. Including both plant-level competitiveness measures reveals that ignoring the relative wage payments leads to lower point estimates of the competitiveness measures. We find a much stronger link between competitiveness and exports when controlling for the exporter wage premium through our labor cost competitiveness measure.

As an additional exercise, we separate regressions into the pre- and post-Euro era. Our results show that competitiveness was indeed important only after the Euro was introduced in the year 1999, which is in line with the critique by Lagarde and the accompanying hypothesis of wage moderation driving export activity. In that perspective, our paper can be related to a recent work by Hogrefe, Jung, and Kohler (2012) who argue that the introduction of the Euro gave rise to currency misalignments. In line with their study we find at least weak evidence for an interaction between the introduction of a common currency union, competitiveness and trade.

Finally, random effects Tobit regressions are used as a robustness test. The findings further support the importance of wages in determining sorting into exporting. Competitiveness turns out insignificant but the negative link between wage competitiveness and exports is not affected. However, higher plant-competitiveness significantly increases exports at both margins when average wages are included in the regression.

The remainder of the paper is organized as follows. Section 2 describes the data source and provides first descriptive evidence. Section 3 introduces the empirical strategy. The results are presented in Section 4. Section 5 concludes.

5.2 Data and first descriptives

5.2.1 The IAB establishment panel

Our main data source is the IAB establishment panel, which is a stratified annual sample that surveys about 16,000 German plants with at least one employee subject to social security contributions. We focus on manufacturing industries where trade in goods is much more important compared to the service sector. East German plants were firstly surveyed in the wave 1996 so that we focus on the period 1996-2008.[4]

Within each wave we have information about the share of revenues generated through exports. Unfortunately, we have only very little information about the destination of exports. More precise information would allow us to run gravity-like regressions on the plant-level by taking distance into account.[5] We however argue, that most of the German trade is within Europe where distance is less important.[6] Besides export intensity there is a large set of additional information, such as establishment size, measured as the total number of employees, revenue, usage of intermediate inputs and investments. This data set has been based on the needs of the German Federal

[4] The panel comprises newer data that reach to the year 2010 and it would be very interesting to exploit them, especially from the background of the financial and economic crisis. However, due to a structural break in the data, many of our control variables cannot be computed after 2008. Therefore, we decided to use the data set only up to the year 2008.

[5] For some waves there exists some limited information about export destinations. Schmillen (2011) shows how the broader information about two different areas can be used to construct distance proxies to the export destination for the IAB establishment panel. However, since it does not cover our whole sample period and consists just of three very broad regional categories, we do not utilize this measure.

[6] The Federal Statistic Office of Germany reports that in 2012 almost 70 percent of exports of goods made in Germany were shipped to European countries. Asia and America rank second and third by far behind Europe.

Employment Agency so that it comprises additionally a large set of workforce characteristic controls. For instance information about the recognition of a collective agreement, the share of female, part-time, short-term or qualified employees is available or can be constructed. See Felbermayr, Hauptmann, and Schmerer (2012) for a detailed discussion on the data used. More comprehensive information on the IAB establishment can be found in Fischer, Janik, Müller, and Schmucker (2009) and Kölling (2000).

There is no capital information in the data. As proxy we apply the perpetual inventory method proposed by Müller (2008, 2010). Based on the information about the amount and type of expansion investments by plant we construct proxies for plant's capital stocks by summing over all periods. Type-specific depreciation rates are used as discount factors.

The industry-level data on labor costs, total value, and bilateral trade flows are taken from the STAN-database of the OECD.

5.2.2 First glimpse at the data

Figure 5.1 graphs the variables of interest over time. The left panel compares the share of exporters (*extensive margin*), the export intensity of exporting plants (*intensive margin*) and the average level of competitiveness in German manufacturing industries.[7] The latter measures competitiveness of Germany relative to its trading partners through production costs per unit of output.[8] Hence, a lower index for competitiveness implies that Germany has a relative cost advantage compared to its trading partners. To make this more illustrative and intuitive we decided to use the inverse of the index such that a higher measure corresponds to higher competitiveness.

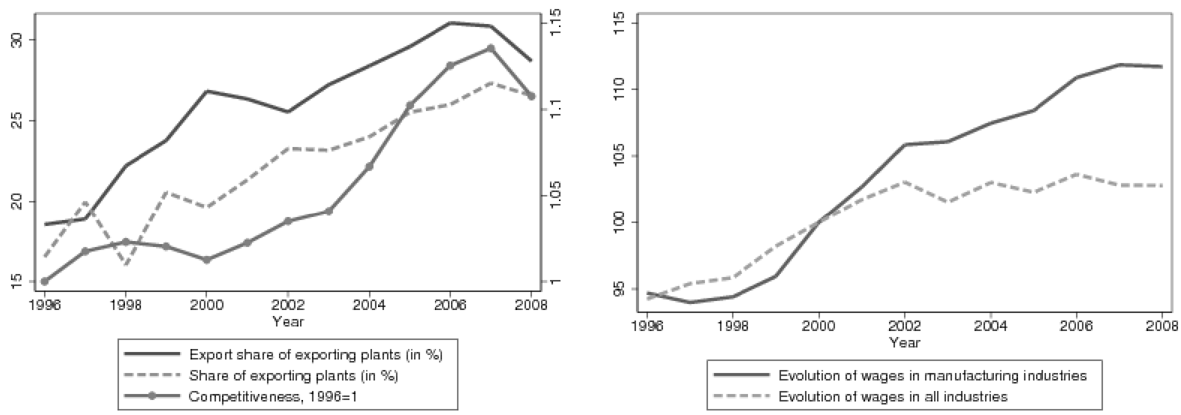


Figure 5.1: The evolution of exports, competitiveness, and wages

The first glimpse at the data reveals that the export intensity of German manufacturers and the relative cost advantage were increasing over time, as displayed in the left panel. Except of a short but sharp dip in 1998 for the share of exporting plants and a brief period of decreasing export intensity of exporting plants (2000-2002), both the extensive and intensive margin have risen in the period under consideration. The end of the timeline indicates the downturn in exporting that is due to the begin of the economic and financial crisis that sparked off in 2008. Despite the

[7]All plant-level means are constructed using propability weights.

[8]See the methodology section for more details on the construction of the index.

downturn, the export activity at both margins is still about 10 percentage points higher than in 1996. Our measure of competitiveness indicates no clear cost advantage for Germany until 2000. From then on, we first observe a moderate increase in competitiveness between 2000 and 2003 before German plants managed to push up their relative cost advantage more significantly. Interestingly, the emerging crisis seems to dampen the competitiveness of German plants relative to its foreign rivals.

The right panel plots average individual wages over time. Without making the distinction between manufacturing and non-manufacturing sectors, we find the well-known picture that wage growth in Germany was stagnant after 2000, which is often associated with "wage moderation". If we focus on manufacturing industries, which are characterized by their high degree of export participation, we find a considerable increase in wages since 1998. Thereby, the picture at least challenges the proposed nexus between wage moderation and export status. Moreover, it also provokes the question how rising wages and increasing competitiveness fit together. Two potential explanations consistent with these stylized facts are an increase in labor productivity and/or soaring labor costs of Germany's trading partners.

5.3 Empirical strategy

Our empirical strategy is twofold. In a first step we construct various measures of competitiveness for Germany. We then regress the plant's export intensity on the competitiveness measures. We try to put as many plant controls as possible in order to account for the omitted variable bias. Different estimators are used to address potential concerns about unobserved heterogeneity and in order to disentangle the overall effect into its effect at different margins.

5.3.1 The competitiveness measures

Measuring plant-competitiveness. We construct plant-level competitiveness measures that allow to relate a plant's unit labor costs to its international engagement through the variable

$$C_{it} = V_{it}/W_{it} \quad , \tag{5.1}$$

where V_{it}/W_{it} measures plant i's value added over its wage sum at time t. In this sense our competitiveness measure mirrors the inverse of nominal unit labor costs. A higher competitiveness may be due to higher productivity and/or lower labor costs. Hence, we also shed light on the role of wages on unit labor costs as further plant-level evidence in order to asses the role of wage moderation on competitiveness by running all regressions including the average plant-wage or/and the unit labor costs. Higher export intensity may be positively correlated with the average plant-wage as long as unit labor costs are falling. Firms that become more productive can pay higher wages but still have relatively low unit labor costs. We expected a negative relationship between unit labor costs and plant-exports. The effect of wages and exports may go in both directions.

Measuring industry-competitiveness. We use data from the OECD STAN database to construct a proxy for Germany's international competitiveness at the industry level as

$$C_{jt} = \frac{V_{Djt}/W_{Djt}}{\sum_k a_{kjt} V_{kjt}/W_{kjt}} \quad , \tag{5.2}$$

where W_{Djt}/V_{Djt} denotes real unit labor costs in industry j at time t in Germany (indicated by subscript D) computed as labor cost (W_{Djt}) over value added (V_{Djt}). The denominator in (5.2) is a sum of unit labor costs of Germany's trading partners, weighted by each partner's trade share a_{kjt}.[9] Competitiveness increases if German unit labor costs increase (decrease) less (more) compared to its trading partners' average unit labor costs. Therefore, lower levels of C_{jt} are associated with a higher level of competitiveness in industry j. We use the predetermined trade share from the wave 1995 for all waves. Thus, the weights are constant over all waves included in our study (1996 to 2008).

5.3.2 Econometric setup

To estimate the export intensity and competitiveness nexus we run the following model

$$EXP_{it} = \alpha + C_{it}\gamma_1 + C_{jt}\gamma_2 + X_{it}\beta + \theta_j + \theta_t + \theta_r + \varepsilon_{it}, \tag{5.3}$$

where EXP_{it} is the export share of plant i in year t. C_{it} denotes our plant-level competitiveness measure. C_{jt} is competitiveness of plant i's industry j at time t. X_{it} is a vector of plant characteristics. Finally, ε_{it} represents a stochastic error term. We always include controls for year-specific fixed effects, θ_t, industry-specific fixed effects, θ_j, and regional-specific fixed-effects, θ_r.

As suggested in Wagner (2001) and Wagner (2011) the preferred model is a fractional Probit/Logit estimator as proposed by Papke and Wooldridge (1996). Their major contribution was to establish an estimator that fits a distribution that accounts for the proportions 0 and 1.

Our sample contains both single- and multi-plant firms, which may cause problems with the export variable. It may well be that part of the production is indirectly exported through the firm rather than the plant. We tackle this issue by including only single-plant firms in the sample, which is the majority.

Exploring the intensive and extensive margins of German export success. Felbermayr and Kohler (2006a) use a corner solutions approach in order to disentangle the effect of distance on bilateral trade into its effects at the intensive and extensive margin.[10] They propose a Tobit regression approach which allows them to estimate both effects simultaneously. We employ the same estimator

$$\begin{cases} EXP^* &= x'\beta + u \\ EXP &= \max(0, EXP^*) \end{cases}$$

[9] The weights are constructed such that $a_{kjt} = T_{kjt}/\sum_k T_{kjt}$, where T_{kjt} denotes the trade between Germany and its partner country k in industry j. The weights therefore sum up to unity.

[10] Galiani (2008) provides a comprehensive overview over the corner solutions approach and its implementation into STATA.

The dependent variable takes the value zero with a certain probability $p(EXP = 0|x)$. Certain values above zero, observations for exporters, happen with zero probability. Put differently, the export intensity is partly continuous over a certain interval. The model can be estimated using a consistent maximum-likelihood estimator

$$L(\beta) = \prod_{i=1}^{n} \left[P(EXP_i = 0)^{1-w_i} f(EXP_i|x_i, EXP_i > 0)^{w_i} \right] \quad , \tag{5.4}$$

where w_i is an indicator variable that takes the value one if $EXP > 0$. The solution to the maximization problem yields the coefficients β with the following interpretation

$$\frac{\partial E(EXP^*|x)}{\partial x} = \beta \quad . \tag{5.5}$$

However, besides the partial derivatives on the "latent" variable EXP^* the non-linear estimates obtained from the maximization of equation (5.4) can be used to compute the effects at the extensive and intensive margin through

$$\underbrace{\frac{\partial P(EXP > 0|x)}{\partial x}}_{Extensive} \quad , \quad \underbrace{\frac{\partial E(EXP|x, EXP > 0)}{\partial x}}_{Intensive} \quad , \underbrace{\frac{\partial E(EXP|x)}{\partial x}}_{Total} \quad , \tag{5.6}$$

which can be predicted based upon the estimates obtained from solving 5.4.[11] All marginal effects are evaluated at the sample means. The effects at the intensive margin can be interpreted as the marginal effect of variable x on the expected export intensity of firms that already export. The effect at the extensive margin is the change in probability of becoming an exporter if x changes.

The two-step approach: Probit. There is also a heated discussion about whether to use a two-step approach to estimate the sorting into export using a Probit model. Hence, we also rerun our empirical specification presented in equation (5.3) based on a Probit model. A plant's export performance is measured by a dummy that takes the value one if the plant has a positive export-share. However, the export intensity itself is not taken into account so that the marginal effect of competitiveness gives us the change in the propability of being an exporter.

5.4 Results

Table 5.1 reports coefficients obtained from estimating (5.3), where both plant- and industry-level competitiveness are included. Plant-level competitiveness is included in logs in order to account for the huge variation of unit labor costs.[12] Coefficients are reported in the first row of Table 5.1. Overall we find that firms that are more competitive due to lower unit labor costs

[11] We use the Stata commands *mfx compute, predict(p(0,.))*, *mfx compute, predict(e(0,.))*, *mfx compute, predict(ys(0,.))* in order to predict the marginal effects in equations (5.6). See Galiani (2008) for more information.

[12] The standard deviation of plant-competitiveness in logs is 0.7, the minimum is around -7.57 and the maximum is around 3.335. Unit labor costs capture a plants cost efficiency which has a relatively large standard deviation compared to the industry-level measures.

export more. However, the magnitude of the effect changes with different models and the level of significance varies systematically over different samples. All coefficients reported are marginal effects.

The role of unit labor costs. As a first step we distinguish between a Fractional Probit (column 1) and Fractional Logit estimator (column 2). The coefficients measure the total effect of competitiveness on exports so that a further decomposition into the effects at the extensive and intensive margin is not possible based on the Fractional Probit/Logit model. The descriptives in the appendix show that the standard deviation of plant-competitiveness is approxemately 0.7. Exploiting this information helps us to evaluate the magnitude of the effects. Competitiveness is measured in logs so that the 0.7 standard deviation translates into a 70 percent standard deviation from the mean in both directions. A two-standard deviation increase in competitiveness is associated with a 1.4 to 1.26 percent higher export-intensity, depending on whether we assume a Probit or Logit distribution, reported in columns (1) and (2) respectively.[13]

However, the results may be biased due to the presence of a corner solution problem that plagues our dependent variable. Zero export intensity is observed at a positive probability, whereas a certain export intensity above zero has zero mass in a continuous distribution. Linear models yield biased results, which can be addressed using a simple Tobit regression approach.

The solution to the maximum likelihood function yields a one-step estimator for both the probability of being a corner solution (non-exporter) and the density of the export intensity conditional on our variables of interest. Coefficients of the latent variable EXP^* ($\frac{\partial E(EXP^*|x)}{\partial x} = \beta$) are omitted. The interpretation would be meaningless in our application.[14] The McDonald and Moffitt (1980) decomposition allows to compute the marginal effects for different regions of the non-linear Tobit regression results. At the extensive margin, we are interested in the effects of competitiveness on the probability of being an exporter, $\frac{\partial P(EXP>0|x)}{\partial x}$, reported in column (3) as Tobit I. Coefficients are evaluated at the mean of all other regressors. At the intensive margin, we are mainly interested in the effects of competitiveness on the export intensity of plants that already export, $\frac{\partial E(EXP>0|x)}{\partial x}$, reported in column (4) as Tobit II. Again, all marginal effects are evaluated at the sample means of all other regressors.

At the intensive margin we find that plants that increase their competitiveness relative to their foreign "rival" by the same two standard deviations have a 4.2 percent higher probability of being an exporter. Conditional on already being an exporter, plants that increase competitiveness by two standard deviations can increase their export intensity by 1.12 percentage points. The combined total effect at both margins (labeled TOBIT III) is reported in column (5). The same two standard deviation increase in plant-competitiveness is associated with an increase in exports of roughly 1.54 percentage points.

This last coefficient is the counterpart to the coefficient reported in column (1) and (2), where we used the Fractional Probit/Logit estimator to estimate the total effect of competitiveness on exports. It turns out that both the fractional models and the Tobit model yield results that are remarkably close to each other with coefficients between 0.008 and 0.01. Given the huge standard

[13] We compute the effect as $1.4 \times 0.009 = 1.26$.

[14] Plants that report zero trade are non-exporters so that there is no latent trade variable as it is the case in the famous textbook example on expenditure and consumption.

Table 5.1: The extensive and intensive margin I

Dependent variable: Export intensity (share)

	(1) FRACP	(2) FRACL	(3) TOBIT I	(4) TOBIT II	(5) TOBIT III	(6) PROBIT
Plant-comp. (ln)	0.008***	0.007***	0.028***	0.007***	0.009***	0.027***
	(0.003)	(0.002)	(0.006)	(0.001)	(0.002)	(0.010)
Industry-comp.	0.010	0.005	0.064	0.015	0.020	0.075
	(0.025)	(0.023)	(0.081)	(0.019)	(0.025)	(0.095)
Employment (ln)	0.025***	0.022***	0.101***	0.024***	0.031***	0.137***
	(0.003)	(0.003)	(0.005)	(0.001)	(0.002)	(0.012)
Capital (ln)	0.011***	0.010***	0.038***	0.009***	0.012***	0.040***
	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)	(0.007)
Female workers (share)	0.058***	0.054***	0.199***	0.047***	0.061***	0.234***
	(0.014)	(0.013)	(0.023)	(0.005)	(0.007)	(0.050)
Part-time workers (share)	−0.082***	−0.086***	−0.239***	−0.056***	−0.073***	−0.224***
	(0.020)	(0.018)	(0.031)	(0.007)	(0.010)	(0.063)
Short-term workers (share)	0.050**	0.047**	0.102*	0.024*	0.031*	0.012
	(0.024)	(0.021)	(0.052)	(0.012)	(0.016)	(0.080)
Apprentices (share)	−0.238***	−0.222***	−0.739***	−0.174***	−0.227***	−0.793***
	(0.042)	(0.040)	(0.065)	(0.015)	(0.020)	(0.124)
Qualified tasks (share)	0.021**	0.025***	0.045**	0.011**	0.014**	−0.024
	(0.010)	(0.009)	(0.018)	(0.004)	(0.006)	(0.035)
Multi-empl. barg. (dummy)	−0.024***	−0.021***	−0.097***	−0.023***	−0.029***	−0.127***
	(0.005)	(0.004)	(0.009)	(0.002)	(0.003)	(0.018)
Single-empl. barg. (dummy)	−0.012**	−0.010*	−0.054***	−0.012***	−0.016***	−0.068***
	(0.006)	(0.005)	(0.013)	(0.003)	(0.004)	(0.025)
Workers council (dummy)	0.028***	0.024***	0.099***	0.024***	0.032***	0.115***
	(0.007)	(0.007)	(0.011)	(0.003)	(0.004)	(0.024)
West Germany (dummy)	0.012	0.010	0.026	0.006	0.008	−0.053
	(0.031)	(0.029)	(0.051)	(0.012)	(0.016)	(0.088)
Foreign ownership (dummy)	0.094***	0.076***	0.251***	0.071***	0.098***	0.225***
	(0.013)	(0.012)	(0.016)	(0.005)	(0.008)	(0.051)
Ownership n.a. (dummy)	0.019**	0.016**	0.081***	0.020***	0.026***	0.151***
	(0.008)	(0.007)	(0.017)	(0.004)	(0.006)	(0.030)
Capital company (dummy)	0.025***	0.026***	0.098***	0.023***	0.029***	0.105***
	(0.006)	(0.005)	(0.011)	(0.002)	(0.003)	(0.020)
Founded before 1990 (dummy)	−0.004	−0.002	−0.011	−0.003	−0.003	0.007
	(0.006)	(0.006)	(0.009)	(0.002)	(0.003)	(0.022)
Observations	18620	18620	18620	18620	18620	18620

Notes: Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors clustered at establishment-level in columns (1), (2) and (6). Bootstraped standard errors in columns (3)-(5) using 200 repetitions. Constant, year-, industry-, and regional-dummies included in all models but not reported. All coefficients are marginal effects evaluated at the means of the other regressors. FRACP denotes fractional-probit, FRACL denotes fractional-logit estimator. TOBIT I reports $\partial P(T > 0|x)/\partial x$, TOBIT II reports $\partial E(T > 0|x)/\partial x$, TOBIT III reports $\partial E(T|x)/\partial x$. PROBIT denotes probit model with dependent variable equal to one if export share larger than zero. Only single plants included in the regressions.

deviation of competitiveness the difference between the coefficients is not significant.

The role of wages in determining competitiveness. As a second step we analyze the role of wages for exports in Germany. Higher wages may reduce competitiveness through higher production costs. On the other hand, higher wages may be one of the crucial determinants of high quality. Both arguments have opposing effects on competitiveness but equally explain the observable surge in exports observed in Germany. We thus analyze the role of wages and competitiveness separately by first including only the inverse average wage measure (Table 5.2) before we include both, the wage and the unit labor costs variable, into the same regression as reported in Table (5.3). Notice that we focus on the inverse wage rate so that higher wages are associated with lower wage competitiveness. We compare the same models as before.

There is already a large literature on the exporter wage premium that states that exporting firms pay higher wages, which would be consistent with a negative sign of the competitiveness measure. The hypothesized wage moderation to export promotion effect would be validated by a positive sign of the wage competitiveness measure.

However, despite the higher labor costs exporting firms may still be more efficient through their higher productivity. Our results confirm the hypothesized negative relationship. The export promoting effect of competitiveness reported in Table (5.2) hardly stems from firms' low wage payments. On average, higher wages are associated with more intensified trade at both margins.

Slicing the sample into a pre- and a post-Euro era. Tables 5.4 to 5.6 report the results obtained from the post-Euro sample that goes from 1996 (the earliest wave that covers all regions in Germany) and 1999, the year the exchange rates were officially fixed within the Euro area. Again we compare fractional Probit, Tobit and Probit models. Except of the Tobit model results competitiveness is insignificant before the year of the introduction of the common currency in 1999. We compare those results to the estimates obtained from regressions based on the post-Euro sample, which are reported in Table 5.5 and 5.6, where we slice the post-Euro sample into a pre- and post-Hartz 4 sample. The advantage of slicing the post-Euro period into two sub-periods is that the different samples are roughly comparable in its time length. However, the results have to be treated cautiously, at least for the Tobit estimators. There is a discussion that nonlinear estimators yield results that are not comparable across different samples. Nevertheless, we are mainly interested in the inference of statistical significance. The magnitude of the effects can be compared based on the outcomes of the linear models. We obtain significant estimates for the period after the Euro was introduced.

Estimates for the period 2005 to 2008 are significant only for the Tobit model. Competitiveness is insignificant for the Probit model. For Fractional-Probit/Logit we obtain coefficients that are significant only on the 10 and 5 percent level. This supports the hypothesized link between the establishment of a common currency union and competitiveness.

The random effects Tobit model. Including factor variables when estimating Tobit regressions is not appropriate due to the non-linearity of the Tobit model. We therefore use a random-effects estimator in order to purge the regressions from unobserved heterogeneity at the plant-level.

Table 5.2: The extensive and intensive margin II

Dependent variable: Export intensity (share)

	(1) FRACP	(2) FRACL	(3) TOBIT I	(4) TOBIT II	(5) TOBIT III	(6) PROBIT
Plant-comp. wage (ln)	−0.048***	−0.046***	−0.153***	−0.036***	−0.046***	−0.134***
	(0.008)	(0.007)	(0.014)	(0.003)	(0.004)	(0.023)
Industry-comp.	0.007	−0.001	0.059	0.014	0.018	0.081
	(0.025)	(0.022)	(0.072)	(0.017)	(0.022)	(0.095)
Employment (ln)	0.024***	0.020***	0.096***	0.022***	0.029***	0.131***
	(0.003)	(0.003)	(0.005)	(0.001)	(0.001)	(0.012)
Capital (ln)	0.010***	0.008***	0.035***	0.008***	0.011***	0.036***
	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)	(0.007)
Female workers (share)	0.066***	0.063***	0.225***	0.053***	0.068***	0.256***
	(0.014)	(0.013)	(0.022)	(0.005)	(0.007)	(0.050)
Part-time workers (share)	−0.050**	−0.056***	−0.135***	−0.032***	−0.041***	−0.127**
	(0.020)	(0.019)	(0.035)	(0.008)	(0.011)	(0.063)
Short-term workers (share)	0.051**	0.050**	0.111**	0.026**	0.034**	0.012
	(0.023)	(0.020)	(0.053)	(0.012)	(0.016)	(0.082)
Apprentices (share)	−0.205***	−0.185***	−0.642***	−0.150***	−0.195***	−0.709***
	(0.041)	(0.040)	(0.070)	(0.016)	(0.021)	(0.125)
Qualified tasks (share)	0.006	0.011	−0.004	−0.001	−0.001	−0.068*
	(0.010)	(0.009)	(0.019)	(0.004)	(0.006)	(0.035)
Multi-empl. barg. (dummy)	−0.026***	−0.022***	−0.104***	−0.024***	−0.031***	−0.135***
	(0.005)	(0.004)	(0.009)	(0.002)	(0.003)	(0.018)
Single-empl. barg. (dummy)	−0.013**	−0.011**	−0.058***	−0.013***	−0.017***	−0.072***
	(0.006)	(0.005)	(0.011)	(0.003)	(0.003)	(0.024)
Workers council (dummy)	0.025***	0.020***	0.091***	0.022***	0.029***	0.110***
	(0.007)	(0.006)	(0.011)	(0.003)	(0.003)	(0.024)
West Germany (dummy)	0.007	0.004	0.010	0.002	0.003	−0.066
	(0.031)	(0.028)	(0.044)	(0.010)	(0.013)	(0.089)
Foreign ownership (dummy)	0.090***	0.071***	0.249***	0.069***	0.096***	0.223***
	(0.013)	(0.011)	(0.013)	(0.005)	(0.007)	(0.052)
Ownership n.a. (dummy)	0.018**	0.016**	0.080***	0.020***	0.026***	0.148***
	(0.008)	(0.007)	(0.016)	(0.004)	(0.005)	(0.030)
Capital company (dummy)	0.017***	0.019***	0.071***	0.016***	0.021***	0.078***
	(0.006)	(0.005)	(0.011)	(0.002)	(0.003)	(0.021)
Founded before 1990 (dummy)	−0.004	−0.002	−0.013	−0.003	−0.004	0.006
	(0.006)	(0.005)	(0.009)	(0.002)	(0.003)	(0.022)
Observations	18620	18620	18620	18620	18620	18620

Notes: Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors clustered at establishment-level in columns (1), (2) and (6). Bootstraped standard errors in columns (3)-(5) using 200 repetitions. Constant, year-, industry-, and regional-dummies included in all models but not reported. All coefficients are marginal effects evaluated at the means of the other regressors. FRACP denotes fractional-probit, FRACL denotes fractional-logit estimator. TOBIT I reports $\partial P(T > 0|x)/\partial x$, TOBIT II reports $\partial E(T > 0|x)/\partial x$, TOBIT III reports $\partial E(T|x)/\partial x$. PROBIT denotes probit model with dependent variable equal to one if export share larger than zero. Only single plants included in the regressions.

Table 5.3: The extensive and intensive margin III

Dependent variable: Export intensity (share)

	(1) FRACP	(2) FRACL	(3) TOBIT I	(4) TOBIT II	(5) TOBIT III	(6) PROBIT
Plant-comp. (ln)	0.014***	0.012***	0.048***	0.011***	0.015***	0.046***
	(0.003)	(0.003)	(0.006)	(0.001)	(0.002)	(0.010)
Plant-comp. wage (ln)	−0.055***	−0.052***	−0.177***	−0.041***	−0.054***	−0.157***
	(0.008)	(0.007)	(0.015)	(0.003)	(0.004)	(0.024)
Industry-comp.	0.006	−0.001	0.052	0.012	0.016	0.070
	(0.025)	(0.023)	(0.068)	(0.016)	(0.021)	(0.095)
Employment (ln)	0.025***	0.021***	0.100***	0.023***	0.030***	0.135***
	(0.003)	(0.003)	(0.005)	(0.001)	(0.001)	(0.012)
Capital (ln)	0.008***	0.007***	0.030***	0.007***	0.009***	0.032***
	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)	(0.007)
Female workers (share)	0.069***	0.065***	0.236***	0.055***	0.071***	0.267***
	(0.014)	(0.013)	(0.023)	(0.005)	(0.007)	(0.050)
Part-time workers (share)	−0.044**	−0.050***	−0.114***	−0.027***	−0.035***	−0.107*
	(0.020)	(0.019)	(0.037)	(0.009)	(0.011)	(0.062)
Short-term workers (share)	0.058**	0.056***	0.135**	0.032**	0.041**	0.037
	(0.023)	(0.020)	(0.058)	(0.014)	(0.018)	(0.081)
Apprentices (share)	−0.193***	−0.175***	−0.606***	−0.141***	−0.183***	−0.674***
	(0.041)	(0.039)	(0.069)	(0.016)	(0.021)	(0.125)
Qualified tasks (share)	0.005	0.010	−0.009	−0.002	−0.003	−0.072**
	(0.010)	(0.009)	(0.018)	(0.004)	(0.005)	(0.035)
Multi-empl. barg. (dummy)	−0.026***	−0.022***	−0.106***	−0.025***	−0.031***	−0.137***
	(0.005)	(0.004)	(0.008)	(0.002)	(0.002)	(0.018)
Single-empl. barg. (dummy)	−0.012**	−0.010**	−0.056***	−0.013***	−0.016***	−0.070***
	(0.006)	(0.005)	(0.012)	(0.003)	(0.003)	(0.024)
Workers council (dummy)	0.024***	0.019***	0.087***	0.021***	0.027***	0.106***
	(0.007)	(0.006)	(0.011)	(0.003)	(0.003)	(0.024)
West Germany (dummy)	0.004	0.002	0.000	0.000	0.000	−0.075
	(0.031)	(0.028)	(0.043)	(0.010)	(0.013)	(0.088)
Foreign ownership (dummy)	0.088***	0.069***	0.244***	0.067***	0.093***	0.218***
	(0.013)	(0.011)	(0.015)	(0.005)	(0.007)	(0.052)
Ownership n.a. (dummy)	0.016**	0.014**	0.075***	0.018***	0.024***	0.144***
	(0.008)	(0.007)	(0.018)	(0.005)	(0.006)	(0.030)
Capital company (dummy)	0.017***	0.018***	0.068***	0.016***	0.020***	0.076***
	(0.006)	(0.005)	(0.010)	(0.002)	(0.003)	(0.021)
Founded before 1990 (dummy)	−0.004	−0.002	−0.012	−0.003	−0.004	0.007
	(0.006)	(0.005)	(0.009)	(0.002)	(0.003)	(0.022)
Observations	18620	18620	18620	18620	18620	18620

Notes: Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors clustered at establishment-level in columns (1), (2) and (6). Bootstraped standard errors in columns (3)-(5) using 200 repetitions. Constant, year-, industry-, and regional-dummies included in all models but not reported. All coefficients are marginal effects evaluated at the means of the other regressors. FRACP denotes fractional-probit, FRACL denotes fractional-logit estimator. TOBIT I reports $\partial P(T>0|x)/\partial x$, TOBIT II reports $\partial E(T>0|x)/\partial x$, TOBIT III reports $\partial E(T|x)/\partial x$. PROBIT denotes probit model with dependent variable equal to one if export share larger than zero. Only single plants included in the regressions.

Table 5.4: The extensive and intensive margin 1996-1999

Dependent variable: Export intensity (share)

	(1) FRACP	(2) FRACL	(3) TOBIT I	(4) TOBIT II	(5) TOBIT III	(6) PROBIT
Plant-comp. (ln)	0.006	0.004	0.029**	0.006**	0.007**	0.025
	(0.004)	(0.003)	(0.015)	(0.003)	(0.003)	(0.020)
Industry-comp.	−0.064	−0.057	−0.028	−0.005	−0.007	0.045
	(0.056)	(0.047)	(0.268)	(0.052)	(0.064)	(0.331)
Employment (ln)	0.014***	0.011***	0.077***	0.015***	0.018***	0.119***
	(0.004)	(0.004)	(0.013)	(0.002)	(0.003)	(0.021)
Capital (ln)	0.012***	0.010***	0.054***	0.011***	0.013***	0.050***
	(0.003)	(0.003)	(0.009)	(0.002)	(0.002)	(0.012)
Female workers (share)	0.032*	0.026*	0.173***	0.034***	0.041***	0.245***
	(0.017)	(0.015)	(0.053)	(0.010)	(0.013)	(0.085)
Part-time workers (share)	−0.088***	−0.082***	−0.444***	−0.086***	−0.105***	−0.538***
	(0.026)	(0.023)	(0.086)	(0.017)	(0.020)	(0.119)
Short-term workers (share)	0.028	0.026	0.026	0.005	0.006	−0.165
	(0.031)	(0.026)	(0.116)	(0.023)	(0.027)	(0.168)
Apprentices (share)	−0.289***	−0.275***	−1.045***	−0.203***	−0.248***	−1.096***
	(0.053)	(0.050)	(0.173)	(0.035)	(0.041)	(0.244)
Qualified tasks (share)	0.015	0.016	0.038	0.007	0.009	0.002
	(0.013)	(0.011)	(0.042)	(0.008)	(0.010)	(0.066)
Multi-empl. barg. (dummy)	−0.014*	−0.012**	−0.072***	−0.014***	−0.017***	−0.096***
	(0.007)	(0.006)	(0.024)	(0.005)	(0.006)	(0.035)
Single-empl. barg. (dummy)	−0.006	−0.007	−0.040	−0.008	−0.009	−0.064
	(0.008)	(0.006)	(0.030)	(0.006)	(0.007)	(0.042)
Workers council (dummy)	0.017*	0.015*	0.085***	0.017***	0.021***	0.106**
	(0.009)	(0.008)	(0.025)	(0.005)	(0.006)	(0.042)
West Germany (dummy)	0.053	0.063	0.140	0.028	0.034	−0.029
	(0.042)	(0.042)	(0.117)	(0.024)	(0.030)	(0.149)
Foreign ownership (dummy)	0.101***	0.082***	0.347***	0.085***	0.117***	0.328***
	(0.030)	(0.026)	(0.054)	(0.019)	(0.027)	(0.098)
Ownership n.a. (dummy)	−0.022	−0.028	−0.036	−0.007	−0.009	0.022
	(0.018)	(0.017)	(0.069)	(0.013)	(0.016)	(0.082)
Capital company (dummy)	0.015*	0.016**	0.077***	0.015***	0.018***	0.059
	(0.008)	(0.007)	(0.024)	(0.005)	(0.005)	(0.037)
Founded before 1990 (dummy)	−0.007	−0.005	−0.031	−0.006	−0.007	−0.012
	(0.008)	(0.007)	(0.023)	(0.005)	(0.006)	(0.037)
Observations	3150	3150	3150	3150	3150	3150

Notes: Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors clustered at establishment-level in columns (1), (2) and (6). Bootstraped standard errors in columns (3)-(5) using 200 repetitions. Constant, year-, industry-, and regional-dummies included in all models but not reported. All coefficients are marginal effects evaluated at the means of the other regressors. FRACP denotes fractional-probit, FRACL denotes fractional-logit estimator. TOBIT I reports $\partial P(T > 0|x)/\partial x$, TOBIT II reports $\partial E(T > 0|x)/\partial x$, TOBIT III reports $\partial E(T|x)/\partial x$. PROBIT denotes probit model with dependent variable equal to one if export share larger than zero. Only single plants included in the regressions.

Table 5.7 reports the results. The coefficient indicates a rather low relationship between unit labor costs and exports once we control for the random effects.

Table 5.5: The extensive and intensive margin 2000-2004

Dependent variable: Export intensity (share)

	(1) FRACP	(2) FRACL	(3) TOBIT I	(4) TOBIT II	(5) TOBIT III	(6) PROBIT
Plant-comp. (ln)	0.008**	0.007**	0.031***	0.007***	0.010***	0.038***
	(0.003)	(0.003)	(0.008)	(0.002)	(0.003)	(0.012)
Industry-comp.	0.006	−0.007	0.096	0.023	0.030	0.204
	(0.052)	(0.047)	(0.220)	(0.052)	(0.068)	(0.224)
Employment (ln)	0.027***	0.023***	0.108***	0.026***	0.033***	0.144***
	(0.004)	(0.004)	(0.007)	(0.002)	(0.002)	(0.015)
Capital (ln)	0.013***	0.011***	0.039***	0.009***	0.012***	0.036***
	(0.003)	(0.002)	(0.005)	(0.001)	(0.001)	(0.008)
Female workers (share)	0.058***	0.056***	0.178***	0.042***	0.055***	0.185***
	(0.018)	(0.016)	(0.037)	(0.009)	(0.011)	(0.059)
Part-time workers (share)	−0.067***	−0.069***	−0.153***	−0.036***	−0.048***	−0.102
	(0.024)	(0.022)	(0.045)	(0.011)	(0.014)	(0.081)
Short-term workers (share)	0.020	0.017	0.020	0.005	0.006	−0.021
	(0.033)	(0.029)	(0.084)	(0.020)	(0.026)	(0.105)
Apprentices (share)	−0.255***	−0.244***	−0.715***	−0.170***	−0.222***	−0.668***
	(0.054)	(0.051)	(0.101)	(0.024)	(0.031)	(0.161)
Qualified tasks (share)	0.007	0.012	0.002	0.001	0.001	−0.065
	(0.013)	(0.011)	(0.025)	(0.006)	(0.008)	(0.043)
Multi-empl. barg. (dummy)	−0.024***	−0.020***	−0.101***	−0.024***	−0.031***	−0.138***
	(0.006)	(0.005)	(0.013)	(0.003)	(0.004)	(0.023)
Single-empl. barg. (dummy)	−0.010	−0.007	−0.054***	−0.012***	−0.016***	−0.071**
	(0.009)	(0.008)	(0.019)	(0.004)	(0.005)	(0.031)
Workers council (dummy)	0.024***	0.019**	0.089***	0.021***	0.028***	0.117***
	(0.009)	(0.008)	(0.015)	(0.004)	(0.005)	(0.029)
West Germany (dummy)	0.028	0.023	0.082	0.020	0.026	0.015
	(0.037)	(0.034)	(0.061)	(0.015)	(0.019)	(0.113)
Foreign ownership (dummy)	0.075***	0.061***	0.212***	0.058***	0.080***	0.228***
	(0.014)	(0.012)	(0.021)	(0.007)	(0.010)	(0.059)
Ownership n.a. (dummy)	0.021	0.018	0.098***	0.025**	0.033**	0.173**
	(0.017)	(0.015)	(0.038)	(0.010)	(0.014)	(0.078)
Capital company (dummy)	0.024***	0.024***	0.098***	0.023***	0.030***	0.113***
	(0.007)	(0.007)	(0.013)	(0.003)	(0.004)	(0.025)
Founded before 1990 (dummy)	−0.003	−0.002	−0.005	−0.001	−0.001	0.023
	(0.008)	(0.007)	(0.012)	(0.003)	(0.004)	(0.026)
Observations	8586	8586	8586	8586	8586	8586

Notes: Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors clustered at establishment-level in columns (1), (2) and (6). Bootstraped standard errors in columns (3)-(5) using 200 repetitions. Constant, year-, industry-, and regional-dummies included in all models but not reported. All coefficients are marginal effects evaluated at the means of the other regressors. FRACP denotes fractional-probit, FRACL denotes fractional-logit estimator. TOBIT I reports $\partial P(T > 0|x)/\partial x$, TOBIT II reports $\partial E(T > 0|x)/\partial x$, TOBIT III reports $\partial E(T|x)/\partial x$. PROBIT denotes probit model with dependent variable equal to one if export share larger than zero. Only single plants included in the regressions.

Table 5.6: The extensive and intensive margin 2005-2008

Dependent variable: Export intensity (share)

	(1) FRACP	(2) FRACL	(3) TOBIT I	(4) TOBIT II	(5) TOBIT III	(6) PROBIT
Plant-comp. (ln)	0.009*	0.009**	0.023**	0.006**	0.008**	0.008
	(0.005)	(0.004)	(0.010)	(0.002)	(0.003)	(0.015)
Industry-comp.	0.001	−0.002	0.020	0.005	0.007	0.103
	(0.032)	(0.031)	(0.123)	(0.031)	(0.041)	(0.105)
Employment (ln)	0.030***	0.026***	0.107***	0.027***	0.035***	0.141***
	(0.005)	(0.004)	(0.009)	(0.002)	(0.003)	(0.016)
Capital (ln)	0.008***	0.007***	0.029***	0.007***	0.010***	0.037***
	(0.003)	(0.003)	(0.005)	(0.001)	(0.002)	(0.010)
Female workers (share)	0.068***	0.063***	0.224***	0.056***	0.074***	0.279***
	(0.020)	(0.018)	(0.037)	(0.009)	(0.012)	(0.068)
Part-time workers (share)	−0.098***	−0.107***	−0.276***	−0.069***	−0.091***	−0.286***
	(0.030)	(0.028)	(0.058)	(0.014)	(0.019)	(0.084)
Short-term workers (share)	0.084**	0.077**	0.211**	0.053**	0.069**	0.151
	(0.038)	(0.033)	(0.087)	(0.022)	(0.029)	(0.112)
Apprentices (share)	−0.186***	−0.161***	−0.638***	−0.159***	−0.210***	−0.786***
	(0.057)	(0.054)	(0.101)	(0.025)	(0.034)	(0.162)
Qualified tasks (share)	0.044***	0.046***	0.103***	0.026***	0.034***	0.017
	(0.015)	(0.014)	(0.029)	(0.007)	(0.010)	(0.051)
Multi-empl. barg. (dummy)	−0.029***	−0.026***	−0.108***	−0.026***	−0.034***	−0.137***
	(0.006)	(0.006)	(0.014)	(0.003)	(0.004)	(0.026)
Single-empl. barg. (dummy)	−0.017**	−0.014*	−0.062***	−0.015***	−0.019***	−0.067*
	(0.008)	(0.007)	(0.019)	(0.005)	(0.006)	(0.037)
Workers council (dummy)	0.039***	0.031***	0.111***	0.029***	0.038***	0.108***
	(0.010)	(0.009)	(0.015)	(0.004)	(0.006)	(0.033)
West Germany (dummy)	−0.022	−0.020	−0.060	−0.015	−0.020	−0.085
	(0.039)	(0.035)	(0.100)	(0.025)	(0.033)	(0.128)
Foreign ownership (dummy)	0.121***	0.100***	0.276***	0.085***	0.119***	0.195***
	(0.020)	(0.018)	(0.024)	(0.010)	(0.014)	(0.065)
Ownership n.a. (dummy)	0.016	0.012	0.077*	0.020*	0.027*	0.140*
	(0.019)	(0.016)	(0.040)	(0.011)	(0.015)	(0.079)
Capital company (dummy)	0.032***	0.036***	0.111***	0.027***	0.035***	0.117***
	(0.010)	(0.009)	(0.019)	(0.005)	(0.006)	(0.030)
Founded before 1990 (dummy)	−0.002	0.001	−0.011	−0.003	−0.004	−0.003
	(0.008)	(0.007)	(0.016)	(0.004)	(0.005)	(0.028)
Observations	6873	6873	6873	6873	6873	6873

Notes: Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors clustered at establishment-level in columns (1), (2) and (6). Bootstraped standard errors in columns (3)-(5) using 200 repetitions. Constant, year-, industry-, and regional-dummies included in all models but not reported. All coefficients are marginal effects evaluated at the means of the other regressors. FRACP denotes fractional-probit, FRACL denotes fractional-logit estimator. TOBIT I reports $\partial P(T > 0|x)/\partial x$, TOBIT II reports $\partial E(T > 0|x)/\partial x$, TOBIT III reports $\partial E(T|x)/\partial x$. PROBIT denotes probit model with dependent variable equal to one if export share larger than zero. Only single plants included in the regressions.

Table 5.7: Robustness checks

Dependent variable: Export intensity (share)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	XTTOBIT Ext. mar.	XTTOBIT Int. mar.	XTTOBIT Both mar.	XTTOBIT Ext. mar.	XTTOBIT Int. mar.	XTTOBIT Both mar.	XTTOBIT Ext. mar.	XTTOBIT Int. mar.	XTTOBIT Both mar.
Plant-comp. (ln)	0.002	0.001	0.001				0.009**	0.002**	0.003**
	(0.005)	(0.001)	(0.001)				(0.004)	(0.001)	(0.001)
Wage Comp. wage (ln)				−0.037***	−0.009***	−0.012***	−0.044***	−0.011***	−0.014***
				(0.010)	(0.003)	(0.003)	(0.010)	(0.002)	(0.003)

Notes: Bootstrapped standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Bootstraped standard errors computed based on 200 repetitions. Included controls identical to those in Table (1) - (6) but coefficients are not reported. All coefficients are marginal effects evaluated at the means of the other regressors. Only single plants included in the regressions.

Moreover, the unit labor costs measure is insignificant in columns (1) to (3). Thus, the exporting promoting effects seems to be driven by some unobservable factors omitted in the regressions above. Columns (4) to (6) report regression results where only wage competitiveness is included. Again, we find a significant relationship between higher wages and higher exports. Most interestingly, columns (7) to (9) report regression results where we include both plant-competitiveness measures. Finally, plant-competitiveness is significantly associated with exports at both margins.

5.5 Conclusion

Our paper contributes to the discussion about potential explanations for Germany's recent export success. We are able to show that higher plant-level competitiveness due to higher productivity and/or lower wages is positively correlated with its export intensity at the intensive and extensive margin. Moreover, the effect is not driven by lower wage payments as exports are associated with higher wages. There are two explanations: firms are more efficient in producing goods, or real exchange rate movements in the Euro area led to higher export demand for relatively cheaper German exports. The latter equally affects all industries. Moreover, both arguments still are consistent with higer wage payments in exporting plants. Our regressions support this view in so far that separate regressions for pre- and post-Euro periods reveal that the export promoting effect of competitiveness is strongest shortly after the Euro was introduced. Some of the models yield insignificant coefficients of competitiveness before 1999 or after 2004. Future research has to be done in quantifying the effects at work based on a structural estimation of a macro-economic model. However, this is beyond the scope of our paper.

6 Summary

It was the purpose of this book to investigate the impact of different forms of globalization on inequality, unemployment and welfare in unionized labor markets and to examine the role of (unit) labor costs as a potentially crucial determinant of international competitiveness in the export activity of plants and firms. Chapter 2 provided an extended review of important contributions to the literature on labor market imperfections in open economies. Hereby, different forms of labor market imperfections have been distinguished, with particular emphasis given to the role of labor unions.

Chapter 3 analyzed the impact of trade on welfare, income distribution, and employment in a model of general oligopolistic equilibrium with unionized labor markets. In the benchmark scenario of two symmetric countries, the study showed that trade reduces the wage claims of unions which stimulates employment and leads to an increase in aggregate welfare. The consequence for income distribution between workers and firm owners is ambiguous and depends on the competitive environment. With respect to intra-group inequality, the study revealed that trade between symmetric countries does not impact the distribution of income between firm owners, while at the same reducing inequality among workers. Moreover, the study investigated the robustness of the results when relaxing the assumption of two fully symmetric countries. Two different types of asymmetry were analyzed: country size differences and technology differences à la Ricardo. It was shown that country size differences do not have a qualitative impact on the variables of interest but only change the volume of the effects. By contrast, differences in technology may change some of the results in a complex way depending on the size of the technological dissimilarity.

The aim of chapter 4 was to study the impact of openness on macroeconomic performance measures when countries differ in the centralization of union wage setting. Abstracting from inter-sectoral productivity differences, this study was not able to address the issue of intra-group inequality but shed new light on employment and welfare consequences of openness. The analysis allowed for two different forms of openness. The first one assumed that goods markets are integrated while capital markets remained segmented. This scenario was associated with the short run since entrepreneurs cannot immediately change their investment decisions in response to a globalization shock. In this scenario, trade reduced wage claims of unions and increased employment and welfare in both countries, and the economic rents of entrepreneurs as well as workers. For plausible parameter domains it was shown that the country-specific wage-setting institutions become 41less important when opening up for trade as differences in the variables of interest are reduced. In the long run, however, this needs no longer be true. When entrepreneurs can adjust their investment decisions to the shock of globalization they will search for the most profitable investment opportunities. Hence, capital flows from the country with the more centralized wage setting to the country with firm-level unions. These capital flows aggravate the differences in macroeconomic performance measures between the two countries and create winners and losers in both economies. Finally, the study also discussed potential consequences of a unilateral policy-induced shift towards a less-centralized wage bargaining regime.

The contribution of chapter 5 was to investigate the role of unit labor costs for the export activity of firms and plants. Thereby, we constructed an appropriate measure of international competitiveness of German plants combining panel data from the German Institute for Employment Research with OECD data. The study showed that higher plant-level competitiveness due to higher productivity and/or higher wages is positively correlated with its export intensity at both, the intensive and extensive margin of trade. However, as exports are associated with higher wages, this effect is not driven by lower wage payments. When slicing the sample into pre- and post-Euro periods, our regression results reveal that the export-promoting effect of competitiveness was strongest shortly after the introduction fo the Euro.

As indicated in chapter 1 this book does not provide a comprehensive picture of all possible consequences of international trade on unemployment and the distribution of income. Important aspects that were out of the picture in the three essays conducted here include the adjustment of firms via firm-internal labor markets, the possibility of unions to cooperate internationally, and also the role of migration. The empirical section does not provide an assessment of the theoretical hypotheses, but rather aimed at shedding some basic insights on what can explain exporting activity. This is, of course, at best a first step towards a better understanding on how wage costs can influence competitiveness and then trade. Although the book can not give an answer to all relevant questions that can be raised in the context of trade and labor market imperfections, I still hope that the study of this book has led to some additional insights into the role and consequences of wage policy in an open world and has stimulated the reader's interest in this topic.

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