TRADE AND WAGE INEQUALITY*

*Luca David Opromolla***

ABSTRACT

A classic question in international trade theory is how a change in a country's exposure to trade affects the distribution of resources across economic activities within a country and the distribution of incomes across factors of production. Classical trade theory predicts changes in wage inequality due to reallocation of resources among industries. However, the empirical labor literature points to the importance of within-industry wage inequality and the empirical trade literature emphasizes within-industry, across firms, heterogeneity. To reconcile theory and data, we present a number of recent theoretical developments in the trade literature that emphasize the consequences of a reduction in export and import barriers on within-industry wage inequality. These theories could prove useful to revisit the change in wage inequality in Portugal after the entrance into the EU and to explain more recent patterns.

1. Introduction

A classic question in international trade theory is how a change in a country's exposure to trade, and world markets more generally, affects the distribution of resources across economic activities within a country and the distribution of incomes across factors of production. A more specific and recurring question in the media is how globalization (intended as increased economic interdependence of countries) affects wages both in developed and in developing countries.[1]

Standard Heckscher-Ohlin trade theory predicts that when a country with a given ratio of skilled-to-unskilled workers integrates with a country with a higher ratio of skilled-to-unskilled workers production shifts, in the first country, towards unskilled- labor-intensive industries. The relative demand for unskilled workers, as well as their wages, rises. On the contrary, production shifts towards skill-intensive industries in the other country. Therefore, wage inequality will fall in an unskilled-labor abundant country when it integrates with a skilled-labor abundant country. However, the recent experience of developing countries seems to contradict this prediction. While globalization was expected to help the less skilled who are presumed to be the locally relatively abundant factor in developing countries, there is overwhelming evidence that these are generally not better off, at least not relative to workers with higher skills or education levels (Goldberg and Pavcnik (2007), Verhoogen (2008)). Similarly, the entry of Portugal into the EU in 1986 was expected to lower inequality through increased demand for low skill-intensive

* I am grateful to João Amador, Mário Centeno, and Pedro Portugal for their suggestions. I also thank Lucena Vieira for computational assistance. Luca David Opromolla acknowledges financial support from Portuguese national funds by *Fundação para a Ciência e a Tecnologia* (*FCT*). This article is part of the Strategic Project: PEst-OE/EGE/UI0436/2011. The opinions expressed in the article are those of the author and do not necessarily coincide with those of Banco de Portugal or the Eurosystem. Any errors and omissions are the sole responsibility of the author.

** Banco de Portugal, Economics and Research Department and *UECE* – Research Unit on Complexity and Economics.

1 For recent contributions, see the papers in Harrison (2007) and the surveys by Goldberg and Pavcnik (2007) and Feenstra and Hanson (2003).

products. However, wage inequality increased sharply in the second half of the 80s and slowed down in the mid-90s (Chart 1).

To be fair with classical trade theory, more sophisticated Heckscher-Ohlin-type models can account for a link between trade liberalization and rising wage inequality in a developing or less-developed country but because such models rely on between-industry shifts as the mechanism through which trade affects labor markets, they can only explain a rise in inequality if trade causes a shift in resources toward skilled-labor-intensive sectors. Empirical studies have typically failed to find evidence of such shifts. Moreover, the empirical labor economics literature shows that the bulk of wage inequality is due to within industry patterns instead of between industry differences. Wage inequality changes not so much because of the reallocation of resources across industries (*e.g.* from food production to basic metals) but mainly because of changes in the dispersion of wages paid by different firms belonging to the same industry (*e.g.* food exporters *vs*. food nonexporters) or because of changes in the dispersion of wages paid to different workers belonging to the same firm (*e.g.* white-collar *vs*. blue-collar workers). In section 2, we show that this pattern holds in Portugal, where about 91 per cent of wage inequality is due to within-industry differences.

How to reconcile the contrast between classical trade theory that predicts changes in wage inequality due to reallocation of resources among industries with data that point to a clear dominance of within-industry wage inequality? To this end, we present a number of recent developments in the trade literature that emphasize the consequences of greater trade liberalization on within-industry wage inequality.

A trait that is common to the new batch of international trade theories is their reliance on the role played by firm heterogeneity. This is justified by the clearly proved existence of large and persistent productivity differences among firms belonging to the same industry (*e.g.* Syverson (2004)), and among exporters, importers and firms that do not trade. For example, exporters are in the minority; they tend to be more productive and larger; yet they usually export only a small fraction of their output. Similar facts hold for importers.[2]

In the core of this paper, we review three categories of models that address, in different ways, the issue of how changes in the barriers to international trade can affect the distribution of wages across firms and workers within an industry. While all the models that we discuss strongly rely on firms' heterogeneity, in some cases firms' heterogeneity is merely taken as an exogenously given characteristic, in other cases it is the result of endogenous choices that lead some firms to recruit more skilled workers than others and to pay higher wages. The first model we discuss is the one of Amiti and Davis (2011) where firms are (exogenously) heterogeneous in terms of productivity and workers are homogeneous. Firms can either sell their product only on the domestic market or also export it. Besides using local inputs, they can import other inputs to produce more efficiently. Because of fairness concerns, more profitable firms pay higher wages. In this setting, trade affects the distribution of wages by affecting the distribution of profits across firms choosing different modes of globalization. Next, we consider the model of Verhoogen (2008) where, within each occupational category, there are workers of different "quality" (*ex-ante* heterogeneity). Firms are heterogeneous in the sense that, by combining the same kind of inputs, some of them are able to produce goods of higher quality. Higher quality goods are more appreciated in the foreign market. A reduction in export barriers therefore provides a stronger incentive for some firms to upgrade the quality of their product and workforce, and pay higher wages. Finally, we consider the model in Helpman *et al*., (2010) where workers are also of different quality but this reveals itself only after the match with a firm (*ex-post* heterogeneity). Helpman *et al*., (2010) assumes that some firms have a higher incentive to try to identify the quality of a potentially new employee before hiring her/him. Because replacing a "good" worker is more costly, these firms pay higher wages. A reduction in trade barriers reinforces this mechanism.

2 Bernard and Jensen (1995), Bernard and Jensen (1999a), Clerides *et al*., (1998), and Aw and Roberts (2000).

A complementary strand of the labor literature focuses on the role played by technological change. Autor *et al*., (2006) argue that the changing distribution of job task demands, spurred directly by advancing information technology and indirectly by its impact on outsourcing, goes some distance toward interpreting the recent polarization of the wage structure. Card and DiNardo (2002) claim instead that skill-biased technological change fails to explain the evolution of some dimensions of wage inequality, like the gender and racial wage gaps and the age gradient in the return to education. In this article we do not take a stand on these, equally relevant, lines of research, and we focus on a number of recent trade models that have implications for wage inequality.

The rest of the article is organized as follows. Section 2 shows new evidence about the evolution of wage inequality in the Portuguese manufacturing sector, emphasizing the role played by within-industry wage inequality. In section 3.1 we introduce a standard dynamic industry model with heterogeneous firms to analyze the intra-industry effects of international trade. Despite differences in productivity and profits, in this model all firms pay the same wage. However, this model is at the base of most of the recent studies on trade and wage inequality. Section 3.2 is the core of the article. We present in detail (employing a non-technical approach) three different theoretical frameworks, and discuss their empirical relevance, to study the impact of globalization on the distribution of wages. Section 3.3 briefly overviews other, even more recent, and promising theories that link trade and wages by considering on-the-job search and the organization of the firm. Section 4 concludes.

2. Wage inequality in Portugal: Between *vs*. Within-Industry Dispersion

In this section we analyze the evolution of dispersion in the distribution of wages in the Portuguese manufacturing sector from 1986, the year in which Portugal entered the EU, up to 2009, the latest year of data we have access to. We do so by exploiting the information contained in *Quadros de Pessoal*, a longitudinal dataset matching virtually all firms and workers based in Portugal.[3]

We explore how important is the dispersion in wages across industries with respect to the dispersion in wages across firms within an industry. The answer to this question justifies the choice of theoretical models discussed in section 3. Our measure of wage dispersion is the standard deviation of the (log) firm average hourly wage. Chart 1 shows the evolution over time of overall wage dispersion (solid line), and of its within-industry component (dashed line). Overall wage dispersion takes into account differences in the average wage paid by firms. The within-industry component of wage dispersion does the same, after controlling for the fact that firms belonging to different industries (or to the same industry in different years) pay wages that are on average different. In other words, the solid line represents the overall dispersion in wages (across firms) while the dashed line shows how much of the overall dispersion is due to differences in wages within industries; the vertical distance between the two lines represents the dispersion in wages due to systematic differences in pay across industries.[4]

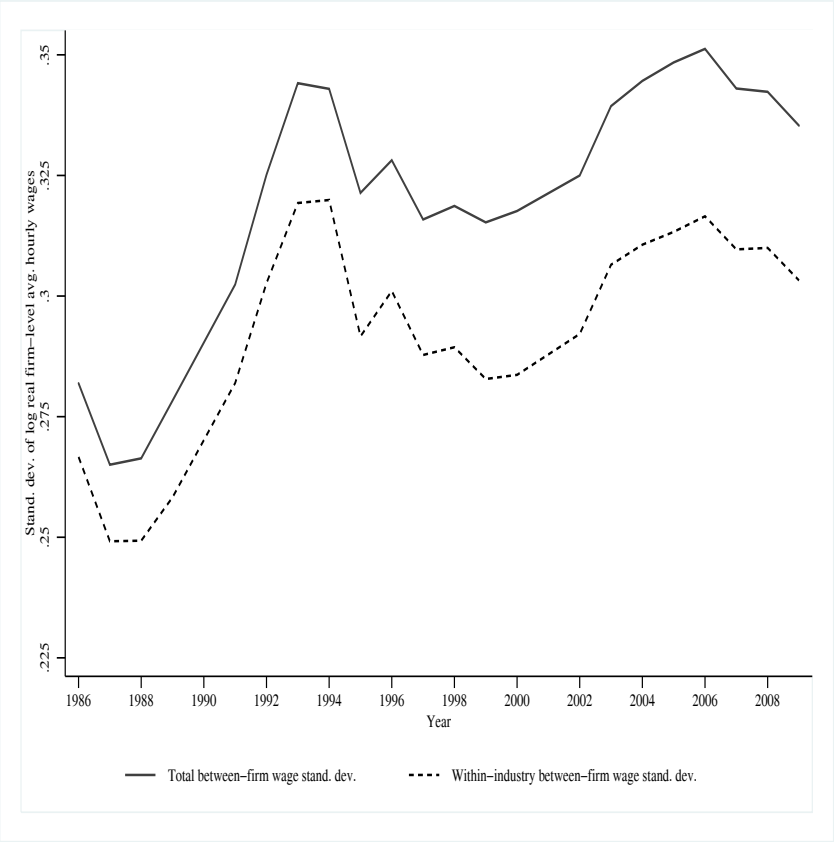
Chart 1 conveys three striking messages. First, the dispersion in wages has greatly increased from the mid 80s to the early 90s, remaining stable afterwards. Second, the within-industry component represents the large majority (about 91 per cent) of wage inequality. Third, the importance of the within-industry component is fairly stable over time, since it follows closely the evolution of the overall dispersion in

3 See the Annex for more details. *Quadros de Pessoal* has been used by, amongst others, Cabral and Mata (2003) to study the evolution of the firm size distribution; by Blanchard and Portugal (2001) to compare the U.S. and Portuguese labor markets in terms of unemployment duration and worker flows; by Cardoso and Portugal (2005) to study the determinants of both the contractual wage and the wage cushion (difference between contractual and actual wages); by Carneiro *et al*., (2012) who, in a related study, analyze how wages of newly hired workers and of existing employees react differently to the business cycle; by Martins (2009) to study the effect of employment protection on worker flows and firm performance. See these papers also for a description of the peculiar features of the Portuguese labor market.

4 See the Annex for more details about the construction of Chart 1. Table 1 in the Annex reports summary statistics for the hourly wages in 2009 by *CAE* (*Classificação Portuguesa de Actividades Económicas*) Rev.3 industries.

Chart 1

WAGE INEQUALITY, *QUADROS DE PESSOAL* 1986-2009 PANEL



Source: *Quadros de Pessoal*.

wages. The takeaway message is that changes in wage inequality in Portugal in the last two decades are due to changes in within-industry wage inequality. Chart 1 confirms the importance of considering models where trade can affect within-industry wage inequality.

A number of other papers have studied the evolution of wage inequality in Portugal. Cardoso (1997) and Cardoso (1998), using the same data used in this study, analyze the evolution of wage inequality between 1982 and 1993, reporting an increase in several measures of wage inequality during the period. Cardoso (1998) confirms that changes taking place within economic activities, are the main forces driving changes in the wage pattern.[5]

Centeno and Novo (2009), still using data from *Quadros de Pessoal*, link the evolution of wage inequality to changes in the supply of high-skilled workers and polarization of employment demand.

3. Theoretical Models of Trade and Wages

We turn now to the theoretical part of the paper. We present, in the next section, an overview of Melitz (2003), one of the two standard models of trade with heterogeneous firms.[6] This is the base for the models discussed in section 3.2, which largely extend the simple treatment of the labor market of Melitz (2003) to better address the impact of trade on wages.

5 Consistent with the approach in this paper, Cardoso (1998) dismisses explanations that rely on shifts in the demand for labor across economic activities. Curiously, this includes "old" international trade theories.

6 The other standard approach is Eaton and Kortum (2002). They develop a Ricardian trade model that incorporates realistic geographic features into general equilibrium.

3.1. The base of the pie: Melitz (2003)

Recent empirical research using longitudinal plant or firm-level data from several countries has established a number of robust stylized facts regarding the productivity distribution of firms, its relations with firms' trade status, and the effect of trade liberalization on aggregate productivity. A number of studies have overwhelmingly substantiated the existence of large and persistent productivity differences among firms belonging to the same industry. For example, Syverson (2004) reports that, within narrowly-defined industries in the U.S., the difference between the 90th and the 10th percentiles of the firm-level productivity distributions is about 99 log points for total factor productivity (TFP) and about 140 log points for labor productivity. This corresponds to a nearly 2.7-to-1 ratio in TFP and 4-to-1 ratio in value added per labor unit (employee or employee-hour).[7] Moreover, some studies have shown that productivity differences are systematically correlated with firms' export and/or import status. Exporters and, even more importers, are generally more productive than other firms. Bernard and Jensen (1999a) report plant labor productivity differentials 16 – 19 per cent higher for exporters in the same four-digit industry. An important observation, especially for policy purposes, is that while exporting plants have substantially higher productivity levels, there is little evidence that exporting increases plant productivity growth rates. The higher productivity of exporters largely predates their entry into exporting.

Finally, other studies find evidence that trade liberalization spurs productivity growth in the tradable sector and a large fraction of this growth is linked to within industry market share reallocations towards more productive exporting plants. Pavcnik (2002) finds that market share reallocations significantly contribute to productivity growth in the tradable sector following trade liberalization in Chile. In a related study, Bernard and Jensen (1999b) find that TFP at continuing manufacturing plants grew at an average annual rate of 1.42 per cent from 1983 to 1992 and 42per cent of aggregate TFP growth came about because of increasing output shares at more productive plants.

Based on the above facts, Melitz (2003) proposes a dynamic industry model with heterogeneous firms to study the role of international trade as a catalyst for inter-firm reallocations within an industry. Melitz (2003) considers an industry where firms are exogenously heterogeneous in terms of productivity. There is only one pure production input, called labor, and the more productive firms are able to produce more units of output for the same amount of inputs.[8] Given an isoelastic demand structure and monopolistic competition, more productive firms have higher revenues and are larger. Due to the presence of a fixed cost of participating in the domestic market, only firms that satisfy a minimum level of efficiency are able to make positive profits and stay in the market. Similarly, exporting requires the payment of a (higher) fixed cost and of a variable trade cost. As such, only the most productive, among the domestic producers, find it profitable to export.

Melitz (2003) shows how, when countries open to international trade, only the most productive firms– those that are able to cover the export fixed cost with their sales–enter the export market. The pressure on wages due to the higher labor demand by new exporters (and potential entrants) drives the least productive firms out of the market. Further exposure to trade, in the form of an additional reduction in tariffs or transport costs, implies further reallocation of resources towards the most productive firms within an industry. Overall, aggregate productivity grows when trade barriers are reduced. The main message from Melitz (2003) is that aggregate productivity grows thanks to a reallocation of resources (*i.e.* labor) from the least productive firms (*i.e.* exiting and surviving domestic producers) to the most productive ones (*i.e.* current and new exporters). However, reallocation of workers across firms does not affect wage inequality in the Melitz (2003) model since labor is homogeneous (*i.e.* all workers share

---

7 Syverson (2004) uses the 1977 Census of Manufactures to compute productivity distribution moments for 443 four-digit SIC (Standard Industrial Classification) manufacturing industries.

8 An isomorphic interpretation is that more productive firms are able to produce the same quantity of goods, but of higher quality, with the same amount of inputs.

the same characteristics) and the labor market is perfectly competitive. As such, all workers employed by firms belonging to the same industry receive exactly the same wage. In the next section, we show how extensions of the Melitz (2003) basic framework can shed light on interesting linkages between the extent of barriers to international trade and the dispersion in wages.

3.2. Filling the pie: three theories of trade and wages

The three theoretical mechanisms that we present in the next section rely on different combinations of firm and worker heterogeneity. Amiti and Davis (2011) assumes homogeneous labor and exogenous differences in firms' efficiency in the domestic and foreign markets. Verhoogen (2008) assumes that firms are heterogeneous in their capability of combining different inputs to reach a given quality level for the products that they sell. Because of that they have different incentives to attract observationally better workers and they end up with workforces that are heterogeneous in terms of skills. Helpman *et al*., (2010) shows that more productive firms have a higher incentive to screen and hire workers that are ex-ante equal but ex-post more able.

Both workers' and firms' heterogeneity play a role in the theory. This parallels what the data say. Addison *et al*., (2013), using matched employer-employee data for Portugal for more than two decades, provide a nice decomposition of the variation in log real hourly wage into components related to firms', workers', and job title's characteristics (both observed and unobserved). They find that worker permanent heterogeneity is the most important source of wage variation (36 per cent), and that the unobserved component plays a more important role (21 per cent) than the observed component (15 per cent). Firm permanent effects are less important but still quite sizable (28.7 per cent). Job title effects explain about 10 per cent of wage variation. In a related paper, Moxnes *et al*., (2013) study if exporters' superior performance is due to intrinsic firm quality or to more able workers. Using Norwegian matched employer-employee data, they show that the exporter wage premium falls by roughly 50 per cent after controlling for observed and unobserved worker characteristics, while the TFP premium falls by 25 – 40 per cent, suggesting that sorting explains up to half of these premia. Overall, workers' and firms' heterogeneity seem to play equally important roles. This confirms the importance of all the three theoretical mechanisms discussed next for addressing the impact of trade on wage inequality.

3.2.1. Exports, imports, and wage inequality

The first model we discuss is developed in Amiti and Davis (2011). They provide a simple extension of Melitz (2003) that introduces a link between a firm's performance and the wages it pays to its workers. Compared to Melitz (2003), Amiti and Davis (2011) consider a wider array of trade activities: besides selling its product on the domestic market and eventually exporting it to other countries, a firm can also import intermediate goods. Importing, like exporting, requires the payments of a fixed cost but the possibility of using foreign-produced intermediate inputs (and to combine them with local inputs) allows firms to reduce their marginal cost of production, thereby increasing their potential for sales both on the domestic and export markets. The decision to include an import choice into the model is motivated by the evidence on the large and growing importance of trade in intermediates (Yi (2003)) and by the goal of the authors to show the importance of distinguishing between the effects of changes in output and inputs tariffs. As in Melitz (2003), participation to the domestic and export markets requires the payment of a fixed cost. Due to the fixed costs, only firms that satisfy a minimum level of efficiency are able to make positive profits and stay in the market. Similarly, only firms that are efficient enough find it profitable to pay the fixed cost of exporting or importing.

If the description of the model ended now there would be a clear productivity ranking of firms according to their trade status. Domestic firms would be the least productive and exporter-importer would be the most productive firms. Intermediate firms would be either exporter-only (*i.e*. export but not import)

or importer-only depending on the relative magnitude of the fixed and variable costs of exporting and importing. For example if, all else equal, the fixed cost of importing were higher than the one of exporting there would be no import-only firms. However, Amiti and Davis (2011) allow for an extra layer of heterogeneity by making the variable export and import costs firm-specific: while a part of these costs is common to all firms, another part is specific to the firm so that some firms are more efficient than others at exporting and/or importing. Moreover, the size of the firm-specific component can be correlated with the overall efficiency of the firm. For example, some exporters that face relatively small variable export costs can be less efficient (in the domestic market) than some nonexporters.[9] The additional layers of heterogeneity imply that all types of firms (domestic, export-only, import-only, exporter-importer) can co-exist in equilibrium.

Amiti and Davis (2011) further assume that labor is homogeneous but labor markets are imperfect. They do that by assuming a fair-wage constraint (similarly to Egger and Kreickemeier (2009)). The wage is increasing in the profitability of the firm. Workers demand these wage premia as a condition of exerting effort because it is considered fair that a more profitable firm pays a higher wage (Akerlof (1982)). Firms are willing to pay these wages because it is necessary to elicit effort. The wages are not bid down because all workers are identical and once hired any other worker will likewise demand the fair wage. In practical terms, wages are a positive function of profits. All else equal, a firm that exports a larger share of its output or imports a higher share of its inputs will have higher profits and wages. This is consistent with the data: Martins and Opromolla (2012) show that in Portugal there is a wide difference between the average hourly wage paid by firms that trade and firms that do not trade. Using worker-level data for manufacturing firms from *Quadros de Pessoal* they find that the unconditional (*i.e.* not controlling for firms' and workers' characteristics) wage premium is 2.8 per cent for firms that export (but do not import), 27.5 per cent for firms that import (but do not export), and 33.8 per cent for firms that both export and import.

In this framework, trade affects wage inequality by affecting firms' profits and their mode of globalization. Therefore, to understand how a trade liberalization affects wage inequality within an industry we must understand how it affects the distribution of profits across the firms that operate in the industry. Amiti and Davis (2011) show that a decline in output tariffs reduces wages of workers at firms that sell only in the domestic market, but raises wages of workers at firms that export. Similarly, a decline in input tariffs raises the wages of workers at firms using imported inputs, but reduces wages at firms that do not import inputs. Variations in tariffs also drive some firms out of the market. The overall effect on wage inequality depends on the initial distribution of firms by productivity and trade status. Therefore, the effect of a reduction in output or input tariffs (or a combination of the two) on wage inequality varies across industries. The main theoretical result of Amiti and Davis (2011) is that the wage consequences of a particular tariff change depend on the mode of globalization of the firm.[10] It is important to note that the theoretical results in Amiti and Davis (2011) are not limited to the case of changes in tariffs: they carry through for any change in the relative marginal cost of serving final goods markets or sourcing inputs from foreign *vs*. domestic markets. This includes changes in transport costs, regulation, or other barriers that affect these relative marginal costs.

---

9 The empirical evidence confirms that the productivity distributions of exporters and nonexporters partly overlap. Impullitti *et al*., (2013) provide an extension of Melitz (2003) where firms are subject to idiosyncratic productivity shocks. The presence of sunk costs of exporting makes the decision to participate in the foreign market history--dependent. In this setting, the efficiency distributions of exporters and nonexporters overlap along the band of inaction: the most efficient nonexporters lie to the right of (*i.e.* are more efficient than) the least efficient exporters.

10 Amiti and Davis (2011) confirm the main predictions of their model using a rich data set covering the Indonesian trade liberalization of 1991-2000.

3.2.2 Trade, quality upgrading and wage inequality

The next model we discuss, Verhoogen (2008), focuses on shifts in the within-plant product mix between goods of different qualities destined for different markets as a mechanism linking trade and labor-market outcomes. Some firms pay higher wages than others because they recruit workers that are "better" in terms of some observable characteristics (*i.e.* education, experience). Verhoogen (2008) observes that, during the late-1994 Mexican peso crisis, initially more productive plants increased the export share of sales, wages, the wage premium paid to white-collar workers, and ISO 9000 certification (an international production standard commonly associated with product quality) more than initially less productive plants. Since these initially more productive plants were already paying higher wages, wage inequality considerably increased after the peso devaluation. Most of the increase was due to the within-industry component.

Verhoogen (2008) explanation for these concurrent changes is the following. Following Melitz (2003), the peso devaluation provided a stronger incentive to start exporting, or to increase exporting, to initially more productive firms. As suggested by Iacovone and Javorcik (2012), firms might need, before exporting, to make additional investments to make their product more desirable to foreign consumers.[11] Wealthier foreign consumers, in particular, might have a stronger preference for quality. Therefore, new exporters and current exporters increasing the export share of their sales should invest in increasing the quality of their product. Doing that might require, among other things, recruiting a more qualified labor force, and therefore paying higher wages.

More specifically, Verhoogen (2008) considers a two-country model where Northern (U.S., in his application) consumers value quality more than Southern (Mexican) consumers. All else equal, Northern consumers are willing to pay a higher price, than Southern consumers, to buy a product with the same quality level.

On the supply side, production technology is such that each unit of output carries fixed factor requirements: one white-collar worker, one blue-collar worker, and one machine. However, each of these inputs is available in different "qualities". Recruiting a more qualified blue-collar worker, for example, allows a firm to produce a higher quality product. Moreover, the contribution of the more qualified blue-collar worker depends on the "quality" of all the other inputs (white-collar workers and machines) that are currently used. This occurs because the production technology exhibits what is technically called "supermodularity" (as opposed to submodularity) or complementarities. Milgrom and Roberts (1990) explain that two tasks are complementary if performing one better raises the marginal product of better performance in the other. On the contrary, when a production function is submodular, superior performance of one task mitigates the need for superior performance in the others. Grossman and Maggi (2000) provide some examples: as an example of supermodularity, Japan tends to excel in industries requiring care and precision in a long sequence of production stages. Its exports include many sophisticated consumer goods, such as automobiles and high-end consumer electronics. Whereas the United States (as an example of submodularity) exports many goods and services whose value reflects disproportionately the input of a few very talented individuals. Its highly successful software industry is an example of this. The same applies to Italian innovative furniture styles, fashion designs, and movies.

Verhoogen (2008) assumes that the strength of the supermodularity "reinforcing mechanism" is heterogeneous across plants: some firms are more "productive" than others in the sense that (i) they can produce a higher quality product using a given set of inputs, and (ii) a marginal increase in the quality of one of the inputs (ex. blue-collar worker) marginally increase the quality of the product by more than in other firms. Obviously, these firms have a higher incentive of recruiting "better" workers and using

11 Iacovone and Javorcik (2012) provide anecdotal evidence from their August 2007 visit to a leading Mexican company producing fruit and vegetable juices. They explain that, 'while Mexican consumers prefer cartons, US buyers have a preference for plastic and glass containers. In the juice industry, package attractiveness plays a very important role. To improve the quality of its packaging, the company opted for a new technology where export-destined containers are covered with sleeves on which product labels are printed, as this produces a more attractive appearance than printing directly on a container.'

better machines. Higher quality inputs are, however, costlier. There are many reasons why this is true. Consider, for example, plants that face worker quality-wage schedules that are upward-sloping (*i.e.* recruiting higher quality workers implies the payment of a higher wage). This is consistent with: (i) a model in which worker quality represents general skill, workers are heterogeneous in skill levels within each occupational category, and plants must pay high wages to attract high-skill workers, as in Kremer (1993); a model in which worker quality represents effort and plants must offer efficiency wages in order to induce workers to supply it (Akerlof (1982); Shapiro and Stiglitz 1984; Bowles 1985); or a model in which worker quality represents plant-specific skills and workers bargain for a share of the gains to investments in those skills (Hashimoto 1981). For Verhoogen (2008) purposes, the important point is that worker quality improves product quality and is costly to the plant to acquire.

Each plant chooses the white-collar wage, the blue-collar wage, capital intensity, and output price to maximize profits, separately for each production line. The input decisions determine quality; quality and price pin down demand and hence output. Verhoogen (2008) shows that more productive plants produce higher-quality goods, pay higher wages to both white-collar and blue-collar workers, are more capital-intensive, and charge higher prices than less productive plants. Moreover, if a plant enters both the Southern and the Northern markets, it chooses greater quality, prices, wages, and capital intensity for goods sold in the North than for goods sold in the South because of the North stronger preference for quality. All else equal, plant size and wages are positively correlated: more productive plants hire more workers (because they sell more) and pay higher wages. The model thus provides a natural explanation for the employer size-wage effect, documented by Brown and Medoff (1989) and others.

In this context, an increase in the incentive to export to a more developed country generates differential quality upgrading: initially more-productive plants increase exports, produce a greater share of higher-quality goods, and raise wages relative to initially less-productive plants in the same industry. Since initially more-productive plants also tend to be initially higher-wage, this process increases within-industry wage dispersion. Verhoogen (2008) finds evidence consistent with an increase in wage inequality through trade and quality-upgrading mechanism for Mexican plants trading with the U.S. However, the insights from the theory are more general. The mechanism proposed in Verhoogen (2008) is relevant to understand the effects of trade on sectors where there is scope for significant quality-upgrading, and where the sensitivity of consumers to quality is highly heterogeneous across countries. Changes in the incentive to export can take different forms: for example, variations in exchange rates, transport costs, contract enforcement laws.

3.2.3. Trade, unobservable workers' characteristics, and wage inequality

Helpman *et al*., (2010) propose a framework for examining the determinants of wage inequality that emphasizes within-industry reallocation, labor market frictions, and differences in workforce composition across firms.

Like in Verhoogen (2008), firms can either produce for the domestic market or also export (but not import as in Amiti and Davis (2011)). As in Melitz (2003), the presence of fixed costs regulates the presence of firms on the domestic and export markets. Production requires workers and workers are heterogeneous in terms of their ability. How do firms match with workers then? Helpman *et al*., (2010) assume that the labor market is characterized by search and matching frictions a la Diamond-Mortensen-Pissarides: a firm pays a search cost to find and match with a worker. The magnitude of the search cost is endogenously determined by the tightness of the labor market: meeting a new worker is costlier if there are few workers searching for employment with respect to the firms' overall demand of new workers.

The authors assume that the output of each variety depends on the productivity of the firm, the measure of workers hired, and the average ability of these workers. However, unlike in Verhoogen (2008), worker ability cannot be costlessly observed when firms and workers are matched. More specifically, the ability

of a worker can be interpreted either as match-specific and independently distributed across matches or as a general talent of a worker that does not depend on his match, but is unobservable to both workers and firms. Of course, whatever the interpretation, a worker's ability affects production. The role of the workforce average ability can be interpreted either as capturing human capital complementarities (*e.g.* production in teams where the productivity of a worker depends on the average productivity of her team) or a managerial time constraint (*e.g.* a manager with a fixed amount of time who needs to allocate some time to each worker, as in Caliendo and Rossi-Hansberg (2012)). Whatever the interpretation, a key feature of the production technology is the presence, as in Verhoogen (2008), of complementarities in worker ability: the productivity of a worker is increasing in the abilities of other workers employed by the same firm. Therefore, a worker with a given ability can have a positive or negative marginal product, depending on the ability of his co-workers. Jin and Martins (2010) find evidence consistent with the presence of complementarities related to schooling in the Portuguese labor market. Using data from *Quadros de Pessoal*, they find that the firm-wide returns to education are higher than the private returns, and that less educated workers within a firm benefit from increases in their firm's average school level. Similarly to Verhoogen (2008), more productive firms have a higher incentive at recruiting workers that are, on average, more able. Since ability is not readily observable, firms have to undertake costly investments (see Barron *et al*., (1985)) to obtain an imprecise signal of a worker's ability. The access to the screening technology is the same for all firms but different degree of screening are possible (at a cost), and more productive firms have a higher incentive to screen.

After having observed its productivity, a firm chooses whether or not to produce, whether or not to export, the measure of workers to sample, and the screening ability threshold (and hence the measure of workers to hire). Once these decisions have been made, the firm and its hired workers engage in strategic bargaining with equal weights over the division of revenue from production in the manner proposed by Stole and Zwiebel (1996a) and Stole and Zwiebel (1996b): the firm and the workers receive (different) constant fractions of the firm's revenue. Anticipating the outcome of the bargaining game, the firm maximizes its profits. More productive firms have higher revenues, a higher incentive to sample more workers, screen to a higher ability threshold. Under the assumption that screen costs increase fast enough (with the ability threshold) and workers' abilities are dispersed enough, more productive firms are also bigger (hire more workers). The crucial implication of Helpman, Itskhoki, and Redding (2010)'s model is that (i) through the bargaining process (by adjusting employment) firms are able to push wages down to the replacement cost of a worker, and (ii) the latter is higher for larger firms since (iii) larger firms have workers of higher average ability. Replacing a worker is costlier for larger firms since high ability workers are scarcer. Given that the search technology is the same for all firms, larger firms pay higher wages.

When the economy is opened to trade, the selection of more productive firms into exporting increases their revenue relative to less productive firms, which further enhances their incentive to screen workers to exclude those of lower ability. This mechanism generates a wage-size premium and implies that exporting increases the wage paid by a firm with a given productivity.

3.3. On the job search and the organization of the firm

The choice of the models presented in the previous subsection is clearly, given space constraints, non-exhaustive. Other relevant theories of how trade affects within-industry wage inequality have been recently advanced. Two interesting strands of research include models that incorporate on-the-job search and that analyze the organization of the firm. Felbermayr *et al*., (2012) and Caliendo and Rossi-Hansberg (2012) are two important examples in these lines of research. Felbermayr *et al*., (2012) incorporate directed labor market search and convex adjustment costs into a model of international trade with heterogeneous firms and homogeneous workers á la Melitz to study how trade affects residual wage inequality. The latter is defined as inequality in wages after taking into account differences in workers' observable characteristics (*e.g.* education, experience, etc.). They show that trade liberalization increases real wages

of all employed workers. However, by changing the allocation of workers across firms, it may result in higher inequality and unemployment.

Caliendo and Rossi-Hansberg (2012) emphasize that a firm's productivity depends on how the firm is organized. They develop a theory of an economy where firms with heterogeneous demands use labor and knowledge to produce. Entrepreneurs decide the number of layers of management and the knowledge and span of control of each agent. In a companion paper, Caliendo *et al*., (2012), it is shown, using French data, that the effect of changes in firm size and firm export status on wages depends crucially on whether they trigger a change in organization. If they do not, wages rise while, if they do, wages in all pre-existing layers fall. Their results seem to be quite robust and extend to other countries: Mion and Opromolla (2013) show that all the main results contained in Caliendo *et al*., (2012) are also valid in the Portuguese case.

4. Conclusions

A classic question in international trade theory is how a change in a country's exposure to trade affects the distribution of resources across economic activities within a country and the distribution of incomes across factors of production. Recent advances in international trade empirical research have emphasized heterogeneity of firms belonging to the same, narrowly defined, industries. Trade theories have followed. A standard trade model, Melitz (2003), emphasizes the role of international trade as a catalyst for inter-firm reallocations within an industry. At the same time, labor market empirical evidence has identified the importance of within-industry wage inequality. The lessons from the new trade theories are potentially important for Portugal: we show that within-industry wage inequality (i) represents a dominant component of overall wage inequality and (ii) its evolution parallels that of overall wage inequality since the mid 80s. To reconcile theory and data, we present a number of recent theoretical developments in the trade literature that, relying on different combinations of firm and worker heterogeneity, emphasize the consequences of a reduction in export and import barriers on within-industry wage inequality. These theories could prove useful to revisit the change in wage inequality in Portugal after the entrance into the EU and to explain more recent patterns.

References

Addison, J. T., Guimarães, P., Portugal, P., and Torres, S. (2013), *The sources of wage variation: A three way high-dimensional fixed effects regression model*, *mimeo*.

Akerlof, G. (1982), "Labor contracts as partial gift exchange", *Quarterly Journal of Economics*, 97(4):543–569.

Amiti, M. and Davis, D. (2011), "Trade, firms, and wages: Theory and evidence", *Review of Economic Studies*, 79:1–36,

Autor, D. H. and Katz, L. F. and Kearney, M. S. (2006), "The Polarization of the U.S. Labor Market", *American Economic Review Papers and Proceedings*, 96(2), 189 - 194.

Aw, B. Y., C. S. and Roberts, M. J. (2000), "Productivity and turnover in the export market: Micro evidence from Taiwan and South Korea", *The World Bank Economic Review*, 14(1):65–90.

Barron, J., Bishop, J., and Dunkelberg, W. (1985), "Employer search: The interviewing and hiring of new employees", *Review of Economics and Statistics*, 67(1):43–52.

Bernard, A. B. and Jensen, J. B. (1995), "Exporters, jobs, and wages in u.s. manufacturing: 1976-1987", *Brookings Papers on Economic Activity: Microeconomics*, 1995:67–119.

Bernard, A. B. and Jensen, J. B. (1999a), "Exceptional exporter performance: Cause, effect, or both?", *Journal of International Economics*, 47(1):1–25.

Bernard, A. B. and Jensen, J. B. (1999b), "Exporting and productivity in the USA", *Oxford Review of Economic Policy*, 20(3):343–357.

Blanchard, O. and Portugal, P. (2001), "What hides behind an unemployment rate: Comparing Portuguese and U.S. labor markets", *American Economic Review*, 91(1):187–207.

Cabral, L. and Mata, J. (2003), "On the evolution of the firm size distribution: Facts and theory", *American Economic Review*, 93(4):1075–1090.

Caliendo, L., Monte, F., and Rossi-Hansberg, E. (2012), "The anatomy of french production hierarchies", *NBER Working Papers* 18259.

Caliendo, L. and Rossi-Hansberg, E. (2012), "The impact of trade on organization and productivity", *Quarterly Journal of Economics*, 127(3):1393–1467.

Card, D. and DiNardo, J. E. (2002), "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles", *Journal of Labor Economics*, vol. 20, no. 4

Cardoso, A. and Portugal, P. (2005), "Contractual wages and the wage cushion under different bargaining settings", *Journal of Labor Economics*, 23(4):875–902.

Cardoso, A. R. (1997), "Workers or employers: Who is shaping wage inequality?", *Oxford Bulletin of Economics and Statistics*, 59(4):523–547.

Cardoso, A. R. (1998), "Earnings inequality in Portugal: High and rising?", *Review of Income and Wealth*, 44(3):325–343.

Carneiro, A., Guimarães, P. G., and Portugal, P. (2012), "Real wages and the business cycle: Accounting for worker, firm and job-title heterogeneity", *American Economic Journal: Macroeconomics*, 4(2):133–152.

Centeno, M. and Novo, A. A. (2009), "When supply meets demand: Wage inequality in Portugal", *Iza discussion paper* no. 4592.

Clerides, S., Lach, S., and Tybout, J. R. (1998), "Is learning by exporting important? micro-dynamic evidence from Colombia, Mexico, and Morocco", *Quarterly Journal of Economics*, 113(3):903–947.

Eaton, J. and Kortum, S. (2002), "Technology, geography, and trade", *Econometrica*, 70(5):1741–1779.

Egger, H. and Kreickemeier, U. (2009), "Firm heterogeneity and the labor market effects of trade liberalization", *International Economic Review*, 50:187–216.

Feenstra, R. and Hanson, G. (2003), *Handbook of International Trade, chapter Global Production Sharing and Rising Inequality: A Survey of Trade and Wages*, Basil Blackwell.

Felbermayr, G., Impullitti, G., and Prat, G. (2012), "Firm heterogeneity, directed search, and wage dispersion in the global economy", *mimeo*.

Goldberg, P. and Pavcnik, N. (2007), "Distributional effects of globalization in developing countries", *Journal of Economic Literature*, 45(1):39–82.

Grossman, G. M. and Maggi, G. (2000), "Diversity and trade", *American Economic Review*, 90(5):1255–1275.

Harrison, A., editor (2007), *Globalization and Poverty*, University of Chicago Press. 15

Helpman, E., Itskhoki, O., and Redding, S. (2010), "Inequality and unemployment in a global economy", *Econometrica*, 78(4):1239–1283.

Iacovone, L. and Javorcik, B. S. (2012), "Getting ready: Preparation for exporting", University of Oxford, *mimeo*.

Impullitti, G., Irarrazabal, A., and Opromolla, L. (2013), "A theory of entry and exit in export markets", *Journal of International Economics*, *forthcoming*.

Jin, J. and Martins, P. (2010), "Firm-level social returns to education", *Journal of Population Economics*, 23(2):539–558.

Martins, P. S. (2009), "Dismissals for cause: The difference that just eight paragraphs can make", *Journal of Labor Economics*, 27(2):257–279.

Martins, P. S. and Opromolla, L. D. (2012), *Why ex(im)porters pay more: Evidence from matched firm-worker panels*, *Mimeo*.

Melitz, M. J. (2003), "The impact of trade on intra-industry reallocations and aggregate industry productivity", *Econometrica*, 71(6):1695–1725.

Milgrom, P. and Roberts, J. (1990), "The economics of modern manufacturing: Technology, strategy and organization", *American Economic Review*, 80(3):511–528.

Mion, G. and Opromolla, L. D. (2013), Reproducing results of Caliendo, Rossi-Hansberg, Monte (2012). mimeo.

Moxnes, A., Irarrazabal, A., and Ulltveit-Moe, K. H. (2013), "Heterogeneous firms or heterogeneous workers? implications for exporter premia and the gains from trade", *Review of Economics and Statistics*, *forthcoming*.

Pavcnik, N. (2002), "Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants", *The Review of Economic Studies*, 69(1):245–76.

Stole, L. and Zwiebel, J. (1996a), "Intra-firm bargaining under non-binding contracts", *Review of Economic Studies*, 63:375–410.

Stole, L. and Zwiebel, J. (1996b), "Organizational design and technology choice under intrafirm bargaining", *American Economic Review*, 86:195–222.

Syverson, C. (2004), "Product substitutability and productivity dispersion", *Review of Economics and Statistics*, 86(2):534–550.

Verhoogen, E. (2008), "Trade, quality upgrading and wage inequality in the mexican manufacturing sector", *Quarterly Journal of Economics*, 123(2):489–530.

Yi, K.-. (2003), "Can vertical specialization explain the growth of world trade?", *Journal of Political Economy*, 111:52–102.

Annex: *Quadros de Pessoal*

Currently, *Quadros de Pessoal* collects data on about 350,000 firms and 3 million employees. For this study, we were able to gain access to information from 1986 to 2009.[12]

The data are made available by the Ministry of Employment, drawing on a compulsory annual census of all firms in Portugal that employ at least one worker. Each year, every firm with wage earners is legally obliged to fill in a standardized questionnaire. Public administration and non-market services are excluded. Reported data cover the firm itself, each of its plants, and each of its workers. Variables available in the dataset include the firm's location, industry, total employment, sales, ownership structure (equity breakdown among domestic private, public or foreign), and legal setting. The worker-level data cover information on all personnel working for the reporting firms in a reference week. They include information on gender, age, occupation, schooling, hiring date, earnings, hours worked (normal and overtime), etc. The information on earnings includes the base wage (gross pay for normal hours of work), seniority-indexed components of pay, other regularly paid components, overtime work, and irregularly paid components.[13] It does not include employers' contributions to social security.

Each firm entering the database is assigned a unique, time-invariant identifying number which can be used to track firms over time. The Ministry of Employment implements several checks to ensure that a firm that has already reported to the database is not assigned a different identification number. Similarly, each worker also has a unique identifier, based on a worker's social security number, allowing to follow individuals over time. The administrative nature of the data and their public availability at the workplace–as required by the law–imply a high degree of coverage and reliability. The public availability requirement facilitates the work of the services of the Ministry of Employment that monitor the compliance of firms with the law (*e.g.*, illegal work).

(Log) hourly wage is computed adding base and overtime wages plus regular benefits (at the month-level) and dividing by the number of regular and overtime hours worked in the reference week multiplied by 4.3. In every year, we apply a trimming of the top and bottom 0.5 per cent. Regular and overtime hours worked are set to (i) missing if (individually) greater than 480 per month, (ii) to zero if negative. Wages were deflated using the Consumer price index (CPI - Base 2008) by Special aggregates provided by Statistics Portugal.

In Chart 1, we consider all the firms located in Continental Portugal, and all their, single-job, full- time employees, between 16 and 65 year old, and working between 25 and 80 hours (base plus overtime) per week. The (real) hourly wage in euros is based on the total number of hours worked (normal plus overtime) and is constructed as the sum of the base wage plus overtime wages and regular benefits. For each firm-year pair we compute the firm average hourly wage. For each year, we compute the standard deviation (across firms) of the average log hourly wage. We then regress the firm average log hourly wage on a full set of NACE2 industry dummies interacted with year dummies. The standard deviation of the residuals is our measure of within-industry wage dispersion. The CAE industrial activity classification used for the 1986-1994 period is Rev.1, for the 1995-2002 period is Rev. 2, for the 2003-2006 period is rev 2.1, and for the 2007-2009 period is Rev. 3. Due to imperfect consistency of the classification over the whole sample period we split the sample in three periods: 1986-1994, 1995-2006, and 2007-2009.

12 Information for the years 1990 and 2001 is only partly available due to issues arisen in the collection of the data.

13 It is well known that employer-reported wage information is subject to less measurement error than worker--reported data. Furthermore, the *Quadros de Pessoal* registry is routinely used by the inspectors of the Ministry of Employment to monitor whether the firm wage policy complies with the law.

Table 1

HOURLY WAGE BY CAE REV.3 INDUSTRY, 2009

CAE Rev. 3 2-digits Category	Mean	Min	Max	Median	Obs.
Food products	611.3232	418.7342	3758.958	558.3123	5259
Beverages	835.0713	418.7342	3112.882	743.5869	436
Textiles	621.8053	418.7342	2719.79	567.2627	1756
Wearing apparel	543.6384	418.7342	3152.675	500.5075	4274
Leather and related products	575.5218	418.7342	2842.74	524.7577	1609
Wood and products of wood and cork, except furniture; articles of straw and plaiting materials and plaiting	646.1517	418.7342	4652.602	587.8625	2522
Paper and paper products	766.2006	418.7342	4101.275	677.5777	335
Printing and reproduction of recorded media	762.844	418.7342	2700.017	702.4452	1539
Chemicals and chemical products	990.7746	418.7342	5502.539	809.8291	516
Basic pharmaceutical products and pharmaceutical preparations pharmaceutical preparations}	1635.047	418.7342	4203.867	1534.768	97
Rubber and plastic products	830.6631	418.7342	3719.723	783.8083	753
Other non-metallic mineral products	732.0034	418.7342	5102.788	656.8905	2464
Basic metals	855.3523	418.7342	3081.462	753.889	242
Fabricated metal products except machinery and equipment	745.774	418.7342	5332.813	655.5926	6067
Computer, electronic and optical products	1086.937	418.7342	3771.163	872.1747	136
Electrical equipment	870.5071	418.7342	3578.781	785.8571	400
Machinery and equipment n.e.c.	907.3269	418.7342	5201.302	831.4076	1043
Motor vehicles, trailers and semi-trailers	845.8602	418.7342	2907.048	776.5099	389
Other transport equipment	900.3931	418.7342	3344.354	787.7833	111
Furniture	573.0704	418.7342	2184.985	511.7862	2836
Repair and installation of machinery and equipment	725.0231	418.7342	3765.643	647.8442	1056

Source: *Quadros de Pessoal*.

Notes: Industries "Manufacture of tobacco products" and "Manufacture of coke and refined petroleum products" are not reported in this table due to confidentiality reasons related to the small number of observations.