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Andrey V. Ivanov

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Abteilungssprecher: Prof. Dr. Hans Peter Grüner
Referent: Prof. Konrad Stahl, PhD.
Korreferent: Prof. Dr. Eckhard Janeba
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Chapter 1

Introduction

1.1 General introduction

This dissertation consists of four self-contained papers, related in spirit by an interest in applied issues in the economy. There is a certain other connection between all chapters: Chapter 2 is about immigrants in the German labour market, Chapter 3 about immigrants and international trade, Chapter 4 about international trade and differentiated products, and Chapter 5 about differentiated products and abnormal price behaviour.

Each chapter contains a detailed introduction and a literature review; in what follows immediately, I will only provide a terse descriptions of each contribution.

1.1.1 Labour market discrimination

In Chapter 2, I investigate wage discrimination of immigrant women in a German labour market. It is true that immigrant women receive lower wages than their native counterparts. It is not a priori clear what part of this wage gap can be attributed to objective labour market characteristics, such as education.

The part that cannot be attributed to objective labour market characteristics might be called "discrimination". It is because this part comes from differences in how the market treats (through wages) each unit of objective characteristics, and this treatment can be different for immigrants and natives.

Starting with Oaxaca [1973], there exists a vast literature that attempts to find out the effective size of this "discrimination", with the job becoming more complex when trying to account for sample selection. That is, that a woman might self-select into the labour force, and we as scientists would have no way of telling the woman's outside option (i.e., an offered wage). This problem and its implications are well presented in Heckman [1979].

In this chapter, I implement various ways to decompose the wage gap that were developed for OLS regressions, in the context of quantile regressions. That is, instead of looking at the means wage gap, I look at the wage gap at different quantiles of wage distributions, in the context of German labour market. Furthermore, I correct for sample selection bias.

One empirical result stands out from this approach: endowment effects account for almost all of the observed wage gap between the native and immigrant women in Germany.

My contribution fits into a growing literature that utilises quantile regression approach to study how the wage distribution behaves over time [e.g., Buchinsky, 1998, 2001, Machado and Mata, 2005] or how the male-female wage gap behaves across the wage distribution [e.g., García et al., 2001, Albrecht et al., 2003]. There are only two papers that correct for selectivity [García et al., 2001, Albrecht et al., 2004], and only one mentioning[1] the native/immigrant wage gap [Albrecht et al., 2003]. All the papers concentrate on the gender wage gap. No paper besides Neuman and Oaxaca [2004] deals in-depth with the native/immigrant wage gap.

1.1.2 Migration and trade

In Chapter 3, I again look at migration. Migration is able to facilitate international trade through cross-border transfer of information. Migrants know about their host and home markets, and thus can be intermediaries to inter-regional trade. In broad terms, the effect of migrants on trade has been studied before [see, e.g., Rauch, 2001, Wagner et al., 2002]. However, the results of previous studies are open to different interpretations.

In this chapter, I investigate the intermediary effect of migrants on trade using the data for Germany on immigrant labour market involvement, to disentangle alternative explanations for the correlation between migration and trade. I find evidence for the importance of white-collar over blue-collar

[1] without decomposition or deeper investigation of any kind

immigrants, and for products that are relatively more complex, as expected. However, when trying to control for endogeneity, the size of the coefficients decreases by up to 16 percent.

1.1.3 Free Trade Agreements and third-country welfare

Staying with the issues of international trade, Chapter 4 looks at the welfare effect that a Free Trade Agreement between several countries can have on non-participating countries; this chapter is joint work with Frank Wachtler.

The literature related to the "innocent bystander problem" [Krugman, 1991] predicts that when a subset of countries enters into a free trade agreement (FTA), the rest of the world suffers in welfare. We present a trade model with horizontally differentiated goods, in which in contrast to the literature, we show that under some conditions the non-FTA-participating countries can also *gain* in welfare. The main drivers behind this positive result are the size asymmetry of the countries and the inability of firms to perfectly price-discriminate across countries.

1.1.4 "Ineffective" competition

Chapter 5 is again about horizontal differentiation, in which Florian Müller and I show that a duopoly market can have higher equilibrium prices than a single-product monopoly.

Conventionally, we think of an increase in competition as weakly decreasing prices, increasing the number of consumers served, thus increasing consumer surplus, decreasing firms profits, etc. Here, we revisit the Hotelling model to discuss how, under some tame circumstances, an increase in competition may lead to a price increase.

More importantly, we show this relationship empirically for the petrol market in German cities.

Chapter 2

Labour market discrimination in Germany? Quantile regression decomposition of the wage gap

2.1 Introduction

Suppose that for two groups in the labour market, we observe markedly different wages (e.g., immigrants and natives). It is possible to decompose this gap in different ways into the part explained by labour market characteristics (e.g., education, tenure) and the unexplained part [à la Neuman and Oaxaca, 2004]. The unexplained part can sometimes be viewed as discrimination.

In this paper, I investigate the possibility of implementing these wage gap decompositions in the context of wage distributions (via quantile regressions), and I augment the classification of the decompositions given in Neuman and Oaxaca [2004] with a new way to decompose the wage gap.

Furthermore, I decompose the wage gap of native and immigrant women in Germany, while taking account of sample selection (selectivity) problem.

One empirical result stands out from all but one decomposition: endowment effects account for almost all of the observed wage gap between the native and immigrant women in Germany.

There is a growing literature that utilises quantile regression approach to study how the wage distribution behaves over time [e.g., Buchinsky, 1998, 2001, Machado and Mata, 2005] or how the male-female wage gap behaves across the wage distribution [e.g., García et al., 2001, Albrecht et al., 2003]. There are only two papers that correct for selectivity [García et al., 2001, Albrecht et al., 2004], and only one mentioning[1] the native/immigrant wage gap [Albrecht et al., 2003]. All the papers concentrate on the gender wage gap. No paper, to the best of my knowledge, investigates the multiple ways to incorporate the differences in selectivity (in the spirit of Neuman and Oaxaca [2004]) into the quantile regression wage gap decompositions. No paper besides Neuman and Oaxaca [2004] deals in-depth with the native/immigrant wage gap.

The following section overviews the related literature. Section 2.3 presents the theory of the mean and distribution wage gap decompositions, with the following novelties: section 2.3.1 presents new decomposition, to augment the four given in Neuman and Oaxaca [2003]; section 2.3.2 provides some discussion of identification of various decompositions in the quantile regression context; section 2.3.2 provides the results from implementing own decomposition with quantile regressions; section 2.3.2 discusses the merits of selectivity-adjusted decomposition; and the rest of the section 2.3 provides the known theory of wage-gap decomposition. Section 2.4 describes the data. Section 2.5 presents the results. Section 2.6 concludes.

2.2 Related literature

2.2.1 Kuhn (1987)[2] and García et al. (2001)

Kuhn [1987] compares the strength of visible and invisible information in determining discrimination. The visible information comes in the form of wage information, visible to the outsiders and the basis for statistical studies, while the invisible information is inferred from the self-reported measure of discrimination from confidential surveys. This self-reported measure carries

[1] without decomposition or deeper investigation of any kind

[2] Kuhn [1987] does not use quantile regressions, but the study is related to García et al. [2001].

both types of information, which go into the decision of a person to report some or no discrimination. The latter type of information is invisible to the researcher, but visible to the person experiencing it, and may take forms of on-work attitudes, perks, etc.

Kuhn [1987] finds that if the visible discrimination disappears, the "percentage of women with median characteristics who report discrimination" would fall only by one third (from 15 to 10 percent for Canada, or from 10 to 6 for the US).[3]

García et al. [2001] pick up where Kuhn [1987] leaves off, trying to reconcile the statistical measures of discrimination with (potential) reported discrimination by women. García et al. [2001] suggest this can be done with the help of quantile regressions: their wage equation specification includes an error due to unobserved characteristics, which can shift the wage above or below that which would otherwise have obtained due only to observed characteristics. It is assumed that "women with unobserved characteristics that situate their wage above the expectation of wages based on their observed characteristics will compare themselves with men whose wage would be situated above the expectation of male wages conditional on the same observed characteristics" [García et al., 2001]. This suggests comparing the wages of women and men at different slices of the wage distribution conditional on observed characteristics.

The authors estimate their measure of discrimination, which is essentially the difference in the coefficients attributed to the labour market characteristics possessed by women. The authors find that at the top of the wage distribution, the differences in characteristics account for less of the wage gap than at the bottom of the distribution, which is consistent with the findings in Kuhn [1987] that women in higher paying positions report more discrimination.

The authors also account for endogeneity of education and selectivity into the labour force by women. The authors use the approach of Buchinsky [2001] for adjustment to selectivity in a quantile regression model. The selectivity's contribution to decomposition is treated similar to Selectivity 2 in Neuman and Oaxaca [2004], where the differences due to selectivity are recorded mostly into the discrimination part.

[3] There exists a question on the self-reported discrimination in the SOEP dataset that perhaps could be put to a good use?

2.2.2 Machada and Mata (2005) and Buchinsky (1998,2001)

Machado and Mata [2005] investigate the wage inequality in Portugal over time, and which factors contributed to the change in this wage inequality. More importantly, the authors develop a technique for creating counterfactual wage distributions with quantile regressions, in order to isolate the effects of different factors contributing to the wage inequality.

Like Machado and Mata [2005], Buchinsky [1998, 2001] focuses on the changes to the distribution of (in this case, female) wages and the returns to education over time. Buchinsky [1998, 2001] develops and applies the quantile regression techniques with sample selection bias, but does not study the male-female wage gap. The techniques developed in these papers are similar in spirit to the procedure of Heckman [1979] as applied in a standard (mean wage) Blinder-Oaxaca decomposition [see, e.g., Neuman and Oaxaca, 2004].

2.2.3 Albrecht and co-authors (2003,2004)

Albrecht et al. [2003] use quantile regressions to investigate how the gender gap differs across the wage distribution in Sweden, and in particular, whether there is a "glass ceiling" at the top of the distribution for women, with finding positive answer to this question. The authors apply the technique from Machado and Mata [2005] to create two counterfactual log wage densities (the one for female wages with women's own characteristics but "paid like men", and the other for the case in which women were given men's characteristics but were still paid "like women") to decompose the gender wage gap à la Blinder-Oaxaca.

For the secondary focus of the paper, Albrecht et al. [2003] look at the recent immigrants into Sweden and find that the native–immigrant wage gap is almost constant across the wage distribution.[4] However, there is no decomposition for the immigrants.

Albrecht et al. [2004] apply the Machado and Mata [2005] approach further by accounting for the sample selection bias, using the techniques from Buchinsky [1998].

[4] I find different results for the German labour market.

2.3 Wages and the wage gap decomposition

2.3.1 Mean regression

This section is essentially a summary of Neuman and Oaxaca [2003].

Consider the following Mincer-style model of earnings with sample selection problem, in matrix notation:

$$y_j^* = X_j\beta_j + u_j, \tag{2.1}$$
$$y_j^r = Z_j\beta_j^r + v_j, \tag{2.2}$$
$$\begin{aligned} D_j &= \mathbb{I}(y_j^* - y_j^r > 0) \\ &= \mathbb{I}(Z_j\gamma_j + e_j > 0), \end{aligned} \tag{2.3}$$
$$y_j = D_j y_j^*, \tag{2.4}$$

where y_j^*, y_j^r, and y_j are the $(1\times M_j)$ vectors of (respectively) offered, reserve, and observed log-wages with $j \in \{N, I\}$ (for natives and immigrants) and M_j the number of observations in each sample, X_j is the $m \times M_j$ matrix of observed labour market characteristics/endowments that affect the offered wages (constants included)—these characteristics/endowments are years of schooling and tenure, for example; Z_j is the $n \times M_j$ matrix of all characteristics/endowments that affect the participation in the labour force, with $m < n$ and $X_j \subset Z_j$; D_j is the dummy variable for employment, and $\mathbb{I}(\cdot)$ is the usual indicator function; $\gamma_j = \beta_j^* - \beta_j^r$, where $\beta_j^* = (\beta_j, 0)$, with zeros for all those variables in Z_j and not in X_j; v_j and u_j are the disturbances, and $e_j \equiv u_j - v_j$.

The expected value of observed wages, conditional on X, is given by:

$$\begin{aligned} \mathbb{E}(y_j|X_j) &= \mathbb{E}(y_j^*|X_j, D_j = 1) \\ &= X_j\beta_j + \mathbb{E}(u_j|X_j, e_j > -Z_j\gamma_j) \\ &= X_j\beta_j + h_j(Z_j\gamma_j), \end{aligned} \tag{2.5}$$

where the conditional error term is not typically zero, but it is assumed that $\mathbb{E}(u_j|X_j, e_j > -Z_j\gamma_j)$ can be represented by a function only of an index, $Z_j\gamma_j (\equiv g_j)$. The joint error distribution is assumed to be normal with density $(0, 0, \sigma_{v_j}, \sigma_{e_j}, \rho_j)$ (normalise $\sigma_{e_j} = 1$), $h_j(\cdot) = \lambda_j(\cdot)\theta_j$, $\lambda_j \equiv \phi(Z_j\gamma_j)/\Phi(Z_j\gamma_j)$ is the (Inverse) Mills ratio, where $\theta_j \equiv \rho_j\sigma_{v_j}$, and $\phi(\cdot)$ is the standard normal d.f. To estimate the parameters of interest β's, the strategy would be to use Heckman's two-step procedure.[5]

The decomposition of the log-wage difference for women with selectivity bias is then:

$$\bar{y}_N - \bar{y}_I = \big(\bar{X}_N - \bar{X}_I\big)\hat{\beta}_N + \bar{X}_I\big(\hat{\beta}_N - \hat{\beta}_I\big) + \big(\hat{\lambda}_N\hat{\theta}_N - \hat{\lambda}_I\hat{\theta}_I\big), \qquad (2.6)$$

where $\bar{y}_j$ is the mean predicted wage, $\bar{X}_j$ are the mean values of labour market characteristics/endowments, $\hat{\beta}_j$ and $\hat{\theta}_j$ are estimates of the (respectively) endowment coefficients and the market treatment of the selectivity part of the equation,[6] and $\hat{\lambda}_j$ is the mean of the fitted values of the individual Mills ratios $\{\hat{\lambda}_{j,i}\}$, where i is an individual index.

The last term in the equation (2.6) is the selectivity differential. It says which group of women, on average, is more likely to be employed $(\hat{\lambda}_j)$ and how the market treats this $(\hat{\theta}_j)$.[7] The selectivity differential can then be treated in a number of ways. First, the wage differential can be adjusted for selectivity—as in equation (2.7)—and the *adjusted* wage differential can be decomposed using the usual Blinder-Oaxaca method.

$$\bar{y}_N - \bar{y}_I - \big(\hat{\lambda}_N\hat{\theta}_N - \hat{\lambda}_I\hat{\theta}_I\big) = \big(\bar{X}_N - \bar{X}_I\big)\hat{\beta}_N + \bar{X}_I\big(\hat{\beta}_N - \hat{\beta}_I\big). \qquad (2.7)$$

The first part of this decomposition is the part of the wage gap that can be attributed to the differences in objective labour market characteristics (such as schooling) of the two groups of women. In particular, this part asks the question, "assuming the immigrant women's characteristics were treated by the market in the same way as the native women's, how much does the immigrant women's characteristics' difference from those of the natives contribute to the wage gap?" Of course, the average characteristics' difference can be either positive or negative: in reality, immigrant women can be more educated or have longer average tenure. We shall find this out

[5]The purpose of this project is to compare how various wage-gap decompositions relate to each other and to provide a discussion on identification of these decompositions. Thus, it suffices to choose the simplest estimation technique possible and assume the normality of errors. However, if the joint error distribution is not normal, we can turn to Buchinsky [1998] for semi-parametric wage-gap decomposition [using the SLS estimator from Ichimura, 1993, in the first step of the heckit estimator].

[6]$\hat{\theta}_j$ is the estimate of $\rho_j\sigma_{v_j}$

[7]Strictly speaking, it is the denominator of $\lambda_{j,i}$ that is the probability that "a population observation with characteristics $X_{j,i}$ is selected into sample," that is, the probability that a woman with characteristics $X_{j,i}$ is working [Heckman, 1977].

in the empirical section.

The second part of the adjusted wage gap is the part of the wage gap that is not possible to attribute to the endowments, but to the differences in coefficients of the offered-wage equation.[8] This part is typically called "discrimination", since in cases that it is not zero, it says that the market treats one unit of immigrant labour market characteristics differently to one unit of the same labour market characteristics of the natives.[9]

Next, the last term in the equation (2.6) can itself be decomposed into a "human capital/explained" and "unexplained" components in a number of different ways.

The difference in the means of expected conditional error terms from the equation (2.5) can be decomposed as:

$$\bar{\mathbb{E}}\big(u_N|X_N, e_N > -\mu_{D,N} - Z_N\hat{\gamma}_N\big) - \bar{\mathbb{E}}\big(u_I|X_I, e_I > -\mu_{D,I} - Z_I\hat{\gamma}_I\big) \\ = \big(\hat{\lambda}_I^0 - \hat{\lambda}_I\big)\hat{\theta}_N + \big(\hat{\lambda}_N - \hat{\lambda}_I^0\big)\hat{\theta}_N + \hat{\lambda}_I\big(\hat{\theta}_N - \hat{\theta}_I\big), \quad (2.8)$$

where $\hat{\lambda}_I^0$ is the average of $\hat{\lambda}_{I,i}^0 = \phi(Z_{I,i}\hat{\gamma}_N)/\Phi(Z_{I,i}\hat{\gamma}_N)$ and i is an individual index. The term $\hat{\lambda}_I^0$ captures how the labour market participation decision for the immigrant women would look like if they faced the same selection equation that the native women face.

The first term of this decomposition, $\big(\hat{\lambda}_I^0 - \hat{\lambda}_I\big)\hat{\theta}_N$, measures the effects of the migrant differences in the parameters γ_j on the wage differential. Remember, $\gamma_j = \beta_j^* - \beta_j^r$, which means that the γ_j parameters measure both how the market treats the people's observed objective characteristics *and* how people treat their own characteristics when choosing if to work, which is inherently subjective.

The second term, $\big(\hat{\lambda}_N - \hat{\lambda}_I^0\big)\hat{\theta}_N$, measures the native–migrant differences in the variables determining the employment, Z_j—this is usually added to the endowment effect in the final decomposition. The final term, $\hat{\lambda}_I\big(\hat{\theta}_N - \hat{\theta}_I\big)$, captures the effects of the differences in how the market treats (through the wages) the probability of employment.

Neuman and Oaxaca [2003] suggest four ways to decompose the wage

[8] We can call it "the rest".

[9] Note, this is only true if in fact one unit of characteristics such as one year of education is the same across both groups. This may not be the case if the education in question occured in different countries. I try to account for that by taking only those immigrants that studied in Germany. I revisit this point when discussing the data.

differential given in equation (2.6). I shall now diverge slightly from summarising their approach and discuss what to call "discrimination". Neuman and Oaxaca [2003] almost always include the differences in the γ_j parameters into the "discrimination" part. This is inherently problematic, because the γ_j parameters measure both differences in the offered-wage equation coefficients and reserved-wage equation coefficients. The implicit assumption that Neuman and Oaxaca [2003] are making is that the differences in the γ_j parameters come primarily from the offered-wage equation. This may or may not be the most appropriate assumption, and I come back to an alternative assumption in Section 2.3.1.

The upshot of proposing different ways to view discrimination is, then, that we do not have to decide on what to call "discrimination", because every person can decide which decomposition to accept as the proper one, depending on their own beliefs. However, we have to keep in mind the implicit assumptions that go into every "discrimination" definition. With this proviso, I stay close to the definitions of Neuman and Oaxaca [2003] for the rest of the paper.

The first way to decompose the wage gap is to include the differences in θ_j's in the endowment effect, and the differences in γ_j's into the unexplained effect. This gives us Selectivity 1:

$$\begin{aligned}&\bar{y}_N - \bar{y}_I = \\ &\underbrace{\big(\bar{X}_N - \bar{X}_I\big)\hat{\beta}_N + \big(\hat{\lambda}_N - \hat{\lambda}_I^0\big)\hat{\theta}_N + \hat{\lambda}_I\big(\hat{\theta}_N - \hat{\theta}_I\big)}_{endowment} \\ &\qquad + \underbrace{\bar{X}_I\big(\hat{\beta}_N - \hat{\beta}_I\big) + \big(\hat{\lambda}_I^0 - \hat{\lambda}_I\big)\hat{\theta}_N}_{discrimination}\end{aligned} \tag{2.9}$$

In selectivity 2, the differences in the parameter θ_j are also relegated to the unexplained/coefficient part, in addition to Selectivity 1:

$$\begin{aligned}&\bar{y}_N - \bar{y}_I = \\ &\underbrace{\big(\bar{X}_N - \bar{X}_I\big)\hat{\beta}_N + \big(\hat{\lambda}_N - \hat{\lambda}_I^0\big)\hat{\theta}_N}_{endowment} \\ &\qquad + \underbrace{\bar{X}_I\big(\hat{\beta}_N - \hat{\beta}_I\big) + \big(\hat{\lambda}_I^0 - \hat{\lambda}_I\big)\hat{\theta}_N + \hat{\lambda}_I\big(\hat{\theta}_N - \hat{\theta}_I\big)}_{discrimination}\end{aligned} \tag{2.10}$$

Given that the last part of the equation (2.8) reflects the wage-gap effects of the correlation between the random error terms of the equations (2.4) and (2.3), it may be best left as a pure "selectivity" effect, as in Selectivity 3:

$$\bar{y}_N - \bar{y}_I = \underbrace{\left(\bar{X}_N - \bar{X}_I\right)\hat{\beta}_N + \left(\hat{\lambda}_N - \hat{\lambda}_I^0\right)\hat{\theta}_N}_{endowment} + \underbrace{\bar{X}_I\left(\hat{\beta}_N - \hat{\beta}_I\right) + \left(\hat{\lambda}_I^0 - \hat{\lambda}_I\right)\hat{\theta}_N}_{discrimination} + \underbrace{\hat{\lambda}_I\left(\hat{\theta}_N - \hat{\theta}_I\right)}_{selectivity} \quad (2.11)$$

The most agnostic way is to treat all of the selectivity effects as selectivity, as in Selectivity 4:

$$\bar{y}_N - \bar{y}_I = \underbrace{\left(\bar{X}_N - \bar{X}_I\right)\hat{\beta}_N}_{endowment} + \underbrace{\bar{X}_I\left(\hat{\beta}_N - \hat{\beta}_I\right)}_{discrimination} + \underbrace{\left(\hat{\lambda}_N\hat{\theta}_N - \hat{\lambda}_I\hat{\theta}_I\right)}_{selectivity} \quad (2.12)$$

Selectivity 5

Here, I depart from Neuman and Oaxaca [2003], and take a closer look at the coefficients from the selection equation, γ_j. The differences in these coefficients between the two groups of women can come from two sources: the differences in the reserved-wage equation coefficients, and the differences in the offered-wage equation coefficients. The offer equation coefficients always reflect the behaviour of the labour market. The reserved-wage coefficients *may* reflect cultural preferences and the like.

Assume that it is the differences in the reserved-wage coefficients that drive the differences in γ_j's. In this case, we could say that the reserved wage equation reflects the attitudes to work of different groups, which may be treated as part of the endowment effect. Cultural attitudes to work are, after all, part of a labour market endowment of any group, and can be altered over time.

Thus, add $\left(\hat{\lambda}_N - \hat{\lambda}_I^0\right)\hat{\theta}_N + \left(\hat{\lambda}_I^0 - \hat{\lambda}_I\right)\hat{\theta}_N = \left(\hat{\lambda}_N - \hat{\lambda}_I\right)\hat{\theta}_N$ to get Selectivity 5:

$$\bar{y}_N - \bar{y}_I = \underbrace{\left(\bar{X}_N - \bar{X}_I\right)\hat{\beta}_N + \left(\hat{\lambda}_N - \hat{\lambda}_I\right)\hat{\theta}_N}_{endowment} + \underbrace{\bar{X}_I\left(\hat{\beta}_N - \hat{\beta}_I\right) + \hat{\lambda}_I\left(\hat{\theta}_N - \hat{\theta}_I\right)}_{discrimination} \quad (2.13)$$

This would correspond to asking a question of what log-wages would immigrants get, if they face the native wage equation, but their own selection equation.

On the other hand, the differences in the γ parameters may reflect primarily the differences in the wage offer coefficients. If this is true, then the term $(\hat{\lambda}_I^0 - \hat{\lambda}_I)\hat{\theta}_N$ will reflect a part of discrimination.

This point will be revisited in Section 2.3.2.

2.3.2 Quantile regression (QR)

The question to ask at this point is, what happens across the whole wage distribution: is it likely that the wage gap is the same for different quantiles of the wage distribution? I follow Albrecht et al. [2004] in constructing counterfactual wage distributions as in Machado and Mata [2005] and similar to Buchinsky [1998], while taking account of the sample selection problem à la Heckman [1979].

Following Buchinsky [1998], rewriting the model in equations (2.1)–(2.4) in the quantile form gives:

$$y_j^* = X_j\beta_{q,j} + u_{q,j} \qquad (0 < q < 1), \tag{2.14}$$

$$y_j^r = Z_j\beta_{q,j}^r + v_{q,j}, \tag{2.15}$$

$$D_j = \mathbb{I}(y_j^* - y_j^r > 0), \tag{2.16}$$

$$y_j = D_j y_j^*, \tag{2.17}$$

where $u_{q,j} = X_j(\beta_j - \beta_{q,j}) + u_j$ and $v_{q,j} = Z_j(\beta_j^r - \beta_{q,j}^r) + v_j$, $(j \in \{N, I\})$. With this model, the conditional quantile of the observed wage is then:

$$\begin{aligned}\text{Quant}_q(y_j|X_j) &= \text{Quant}_q(y_j^*|X_j, D_j = 1) + \text{Quant}_q(u_{q,j}|X_j, D_j = 1)\\ &= X_j\beta_{q,j} + \text{Quant}_q(u_{q,j}|X_j, D_j = 1),\end{aligned} \tag{2.18}$$

where, similar to section 2.3.1, $\text{Quant}_q(u_{q,j}|X_j, D_j = 1)$ can be estimated as $\hat{\lambda}_j\theta_{q,j}$, such that it is possible to rewrite equation (2.18) in disturbance form, to get a quantile regression equivalent of equation (2.5) from section 2.3.1:

$$\text{Quant}_q(y_j|X_j) = X_j\beta_{q,j} + \lambda_j\theta_{q,j} + \varepsilon_{q,j}, \tag{2.19}$$

where $\text{Quant}_q(\varepsilon_{q,j}|X_j, D_j = 1) = 0$.

The estimation strategy is the quantile regression version of Heckman's two-step procedure from section 2.3.1. First, use Probit to estimate the γ parameters and construct the predicted Mills ratio, $\hat{\lambda}$. Next, substitute $\hat{\lambda}$ for λ in equation (2.19), and estimate β_q and θ_q from linear quantile regression.

For the purposes of decomposition, it is necessary to create a counter-factual wage distribution of immigrant women, assuming that the market treats their endowments as if they were native women. The basic approach with respect to selectivity in this case is to assume that immigrant women also have the coefficients of the selection equation from the native regression. This is exactly the Selectivity 2 given in equation (2.10), and has been followed in the gender wage-gap decomposition literature [García et al., 2001].

I use the following version of Machado-Mata algorithm for creating predicted and counter-factual log-wage distributions [Albrecht et al., 2004, Machado and Mata, 2005]:

1. Estimate γ_j with Probit and compute $\hat{\lambda}_j$ the Inverse Mills ratio,
2. Sample q from a uniform distribution,
3. Substitute $\hat{\lambda}_j$ for λ_j in quantile regression (2.19) and estimate $\beta_{q,j}$ and $\theta_{q,j}$,
4. Take a random $x_{I,i}$ from the empirical distribution of $x_{I,i}$,
5. Compute $\hat{y}_{I,i} = x_{I,i}\hat{\beta}_{q,I} + \hat{\lambda}_{I,i}\hat{\theta}_{q,I}$,
6. Repeat steps 2–5 100 times.

This creates a 100-point distribution of predicted log wages of immigrants (denoted wI in Section 2.5.2). Similarly, create the distribution of log-wages of natives (denoted wN in Section 2.5.2).

To create the counter-factual distribution of log-wages of immigrants, if immigrants followed both the selectivity and the labour market offer wage equations, replace $\hat{\lambda}_{I,i}$ with $\hat{\lambda}^0_{I,i}$, and $\hat{\beta}_{q,I}$ and $\hat{\theta}_{q,I}$ with $\hat{\beta}_{q,N}$ and $\hat{\theta}_{q,N}$, in step 5 of the above algorithm. This distribution will be denoted $WINS$ (wages of immigrants if they followed the native selection and wage offer equations) in Section 2.5.2.

Thus, there obtain the following distributions (dropping the subscript q):[10]

$$\begin{aligned} wN: &\quad X_N\hat{\beta}_N + \lambda_N\hat{\theta}_N, \\ wI: &\quad X_I\hat{\beta}_I + \lambda_I\hat{\theta}_I, \\ WINS: &\quad X_I\hat{\beta}_N + \lambda_I^0\hat{\theta}_N, \end{aligned}$$

which gives rise to the following difference:

$$wN - WINS = (X_N - X_I)\hat{\beta}_N + (\lambda_N - \lambda_I^0)\hat{\theta}_N, \tag{2.20}$$

which is nothing other than the endowment part of equation (2.10), i.e., Selectivity 2. The other part of the wage gap ($wN - wI$) is then:

$$WINS - wI = X_I(\hat{\beta}_N - \hat{\beta}_I) + \lambda_I^0\hat{\theta}_N - \lambda_I\hat{\theta}_I, \tag{2.21}$$

which is the discrimination part in equation (2.10).

Selectivity 1, 3, and 4?

The previous Section showed how to obtain a quantile regression equivalent of equation (2.10), i.e., Selectivity 2. This is done through generating a counterfactual distribution of wages for immigrants, as if they followed the selectivity adjustment as well as receiving the wage offer according to the native equations (wages for immigrants with native Mills ratios: $WINS$).

But what about other Selectivities? Let us proceed step-by-step. Recall the mean regression decomposition of the selection equation:

$$\hat{\lambda}_N\hat{\theta}_N - \hat{\lambda}_I\hat{\theta}_I = \big(\hat{\lambda}_I^0 - \hat{\lambda}_I\big)\hat{\theta}_N + \big(\hat{\lambda}_N - \hat{\lambda}_I^0\big)\hat{\theta}_N + \hat{\lambda}_I\big(\hat{\theta}_N - \hat{\theta}_I\big) \tag{2.22}$$

This decomposition relies on calculation of the mean (sometimes, counterfactual) characteristics terms, $\hat{\lambda}_N$, $\hat{\lambda}_I^0$ and $\hat{\lambda}_I$, the quantile equivalents for which do not exist. Thus, Selectivity 1–4 in equations (2.9)–(2.12) cannot be distinguished from one another, since they rely on separate identification of the three terms in equation (2.22).

In the quantile regression analysis, we first calculate the gaps between the observed wage distributions (say, $wN - wI$) at various quantiles, then es-

[10]From now on, I will drop the subscript q when presenting the distributions.

timate the counter-factual distribution (say, of immigrant women when they face native wage offers and selection, $WINS$), compare this new (counter-factual) distribution to the native wage distribution at various quantiles, and see how the wage gap (at various quantiles) changed ($wN - WINS$).

The gap $wN - WINS$ represents the endowment effect, since any counter-factual distribution keeps the endowments of the immigrant women intact, and uses the native coefficients to estimate the wages. The rest is then $WINS - wI$, which in this case is called "discrimination". The individual parts of this discrimination part ($WINS - wI$) cannot be identified. It is because in quantile regressions, measuring the equivalent of the last part from equation (2.22), for example, entails the knowledge of the $\hat{\lambda}_I$ of the median person, which is likely different across distributions.

When the counter-factual distribution is generated using a set of quantile coefficients $\hat{\beta}_N$ and the Mills ratios $\hat{\lambda}_I^0$, the person with the median income (the "median person") may be John. John's characteristic λ_J^0 will therefore be the "median person's" characteristic, and this will typically have nothing to do with the median value of all observations of the Mills ratios $\{\lambda_i^0\}$. On the other hand, when the income distribution is generated using the quantile coefficients $\hat{\beta}_I$ and the Mills ratio λ_I, the median person may be Ronald, with his Mills ratio $\lambda_R^0 \neq \lambda_J^0$ as the median Mills ratio. John, of course, could be at the top or the bottom of this other distribution. The mean value of the Mills ratios $\{\lambda_i^0\}$ will be the same in both cases.

Thus, the decompositions Selectivity 1, 3 and 4 (corresponding to equations (2.9), (2.11) and (2.12), respectively) cannot be estimated, since they depend crucially on the last term of equation (2.22), $\hat{\lambda}_I(\hat{\theta}_N - \hat{\theta}_I)$, belonging to the endowment part in the first case, and to the selectivity part in the latter two, and on all the terms of equation (2.22) belonging to the selectivity part in Selectivity 4.

The only thing that can be estimated exactly is Selectivity 2. This is furthermore indistinguishable from Selectivity 3, due to the impossibility of estimating the selectivity part on its own.

Finally, we close with the following:

Identification: The individual parts of the difference $WINS - wI$ can be identified if the ranking of the persons' log wages does not change across the distributions (in our earlier example, say, John is always the median guy, Ronald is always the 75th percentile guy, and so on).

One sufficient condition for this is that the coefficients do not change across the quantiles, that is, if the true model is the simple OLS.

Selection equation coefficients

If Selectivities other than 2 are not possible, what *can* we do? With some assumptions, we can look at selection equation coefficients, γ, which reflect the difference in the coefficients of the offer and the reserved wage equations. This has been looked at in Section 2.3.1.

To the extent that the differences in the reserved-wage equation coefficients dominate the differences in the offer wage coefficients, we can write these differences into the endowment part of the wage gap. In this case, we create the counter-factual distribution $WINC$: this is the distribution of log-wages of immigrants, if they face the native wage equation, but their own selection equation (which corresponds to Selectivity 5 from equation (2.13)):

$$\begin{aligned} wN: &\quad X_N\hat{\beta}_N + \lambda_N\hat{\theta}_N, \\ wI: &\quad X_I\hat{\beta}_I + \lambda_I\hat{\theta}_I, \\ WINC: &\quad X_I\hat{\beta}_N + \lambda_I\hat{\theta}_N, \end{aligned}$$

which leads to the difference:

$$wN - WINC = (X_N - X_I)\hat{\beta}_N + (\lambda_N - \lambda_I)\hat{\theta}_N. \tag{2.23}$$

Furthermore, investigating $WINS - WINC(= (\hat{\lambda}_I^0 - \hat{\lambda}_I)\hat{\theta}_N)$ may give some indication of the differences in the attitudes to work between the two groups of women, but only if the reserved-wage equation coefficients reflect (mainly) cultural preferences.

On the other hand, the differences in the γ parameters may reflect primarily the differences in the wage offer coefficients. If this is true, then the term $(\hat{\lambda}_I^0 - \hat{\lambda}_I)\hat{\theta}_N$ will reflect a part of discrimination, in which case the distribution $WINC$ will have no useful meaning.

Adjusted wage-gap decomposition

Apart from Selectivity 2 and $WINC$, we can attempt to gain some feeling for the size of the selectivity differences $\hat{\lambda}_N\hat{\theta}_N - \hat{\lambda}_I\hat{\theta}_I$ from equation (2.22), by doing the adjusted wage-gap decomposition (recall equation (2.7)), and comparing the results to the Selectivity 2 decomposition.

It is easy to generate the distributions of wages, adjusted for selectivity, with a different version of the pervious algorithm:

1. Estimate γ_j with Probit and compute $\hat{\lambda}_j$ the Inverse Mills ratio,
2. Sample q from a uniform distribution,
3. Substitute $\hat{\lambda}_j$ for λ_j in quantile regression (2.19) and estimate $\beta_{q,j}$ and $\theta_{q,j}$,
4. Take a random $x_{I,i}$ from the empirical distribution of $x_{I,i}$,
5. Compute $\tilde{y}_{I,i} = x_{I,i}\hat{\beta}_{q,I}$ ($\equiv \hat{y}_{I,i} - \hat{\lambda}_{I,i}\hat{\theta}_{q,I}$ defined before),
6. Repeat steps 2–5 100 times,

and, similarly, for the native women. For the immigrant women using native women's coefficients, substitute $\hat{\beta}_{q,N}$ for $\hat{\beta}_{q,I}$ in step 5, to get the counterfactual distribution of "adjusted" immigrant women's wages, $WINA$:

$$\begin{aligned} wNadj: &\quad X_N\hat{\beta}_N, \\ wIadj: &\quad X_I\hat{\beta}_I, \\ WINA: &\quad X_I\hat{\beta}_N, \end{aligned}$$

which gives the difference:

$$wNadj - WINA = (X_N - X_I)\hat{\beta}_N. \tag{2.24}$$

Please, note that this is not the same as Selectivity 4 (equation (2.12)), for the reasons given in Section 2.3.2: equation (2.24) provides an *adjusted* distribution, in which a person at the 25th quantile can come from the 75th quantile from the original distribution, for all we know.

In the mean regression world, it was possible to correctly write the following identity (using equation (2.7)):

$$\bar{y}_N - \bar{y}_I - \left(\hat{\lambda}_N\hat{\theta}_N - \hat{\lambda}_I\hat{\theta}_I\right) \equiv \tilde{y}_N - \tilde{y}_I, \tag{2.25}$$

However, in the world of distributions, a quantile $Q(\cdot)$ value of the wage from the adjusted distribution is not the same as the corresponding quantile wage value from the normal distribution minus the associated with that value selection adjustment:

$$Q(\tilde{y}_j) \equiv Q(y_j - \hat{\lambda}_j \hat{\theta}_j) \neq Q(y_j) - Q(\hat{\lambda}_j \hat{\theta}_j). \tag{2.26}$$

Nevertheless, this decomposition is useful in that it might tell us something about the relative sizes of endowment and coefficient effects, after abstracting away from the selectivity. Here, we ask the following question: whatever the selectivity issues, what would the wage gap be if immigrants' endowments (other than their selecting themselves into the labour force) were treated the same way as those of the natives?

Furthermore, the size of the selectivity-adjusted gap, as compared to the non-adjusted wage gap, might also hint on the importance of the selectivity differences.

With respect to the "discrimination" definition in this case, we avoid discussing the selection equation coefficient differences by taking them out.

2.4 Data

All data comes from the German Socio-Economic Panel. One object of this paper is to study the effect of selection into the labour force, so the sample used includes only women (native and immigrant) of age 25–65, that were surveyed in 2006. The techniques utilised here are cross-section techniques, and 2006 has the most up-to-date information and one of the largest samples for the natives and immigrants alike.

Since selectivity into the labour force is a problem mostly applicable to women, only the female sub-sample is used. An immigrant is any woman that did not have German citizenship since birth (including all those without German citizenship at all).

I follow Gang and Zimmermann [2000] in selecting only those women who have finished school in Germany. I select these if a foreign woman replied to have had schooling in Germany in the SOEP questionnaire, or if a German woman had not replied "No" to the same question. This is to ensure that education differences between natives and immigrants are minimised.

A person is deemed employed if her employment status in the questionnaire is "employed full-time", "in regular part-time employment" or "in vocational training" (the latter indicates a strong desire to be in the labour force), unemployed if "marginally employed" or "not employed", with all other observations being dropped (including "working zero hours near retirement" and missing observations).

The dependent variable is a log of a generated hourly wage. In the sample, most people have contracts that stipulate hours to be worked and the salary, which can be interpreted as stipulating an hourly wage. To generate the hourly wage, I divided the reported monthly wage by hours worked. I dropped observations with missing or improbable wage answers (i.e., hourly wage below 4 Euro or above 50 Euro). The unemployed have zero hourly wage. The reported "actual hours per week" worked were divided by 10, as the given answers were almost always 10 times the probable hours (i.e., over 400 hours worked per week).

The independent variables are:

- Years of schooling[11]
- Years of tenure[12]
- Age and Age Squared: to account for diminishing returns to age[13]
- Marriage status
- Number of children that are less than six years old
- Log of monthly income from other household members (e.g., from a spouse or parents)

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[11] García et al. [2001] suggest that education can be endogenous. Furthermore, Albrecht et al. [2003] suggest using different degrees earned instead of years of education: since even with the same number of years of education, people can have different quality of education that would be better shown with the degrees earned. I leave these adjustments for future research.

[12] Heckman [1977] suggests that the years of tenure are exogenous in the wage equation but endogenous in the selection equation, and therefore need to be instrumented. On the other hand, the recent literature seems to ignore this point altogether. Some preliminary regressions with instrumenting for tenure along the lines of Heckman [1977] return nonsensical results such as insignificant coefficients across the board and negative predicted log-wages. Furthermore, the Wald test cannot reject the exogeneity of tenure for the immigrant subsample. Given all this, I follow Albrecht et al. [2003, 2004] and Buchinsky [2001] by concentrating just on the selectivity adjustment, and leave the endogeneity of tenure for future research.

[13] Age is often used as a proxy for tenure [see, e.g., Albrecht et al., 2003]. However, SOEP contains tenure information directly, so age can be used in its own right.

The variable for other household income was generated using the total (net) household monthly income minus the personal (net) monthly income, both for the last month before the questionnaire.

Tables 2.1 and 2.2 provide some summary statistics for the full sample, including the unemployed.

Table 2.1: Summary statistics: immigrant women

Variable	Mean	Std. Dev.	Min.	Max.
employed	0.425	0.495	0	1
schooling	10.885	2.371	7	18
tenure	5.770	5.613	0	32
No. of children below 6y.o.	0.399	0.581	0	4
married	0.729	0.445	0	1
hourly wage	3.414	4.199	0	16.702
monthly income, other HH	1653.172	952.03	1	5300
age	34.915	5.39	26	53
N		1227		

Table 2.2: Summary statistics: native women

Variable	Mean	Std. Dev.	Min.	Max.
employed	0.568	0.495	0	1
schooling	12.316	2.517	7	18
tenure	10.812	7.28	0	37
No. of children below 6y.o.	0.38	0.674	0	3
married	0.599	0.49	0	1
hourly wage	4.936	5.067	0	50
monthly income, other HH	1740.401	1247.838	1	8000
age	38.473	8.087	26	54
N		16825		

2.5 Empirical results

2.5.1 Mean regression

Tables 2.3–2.4 provide results from the probit regressions for the immigrant and native selection equations. The Z-variables not included in X in further regressions are: marriage dummy, number of children under six years of age, and log of other household members' monthly income. All these variables affect the decision of a woman to enter the labour force, but should not affect a wage offered to her in the labour force. All variables have expected sign and significance.

We can not directly compare the coefficients from different samples. However, we can note the marriage has a higher coefficient in the immigrant sub-sample than in the native one, a finding that we would expect from anecdotal evidence. On the other hand, the income of other household members plays a much more pronounced role in the native subsample, while having a small effect on the immigrant women's decision to participate in the labour force.

One could classify both these variables as an indication of support from other household members. Thus, we can say that the more support a woman receives from her household, the less it is necessary for her to enter the labour force, irrespective of the group she belongs to. However, the way her household supports her might be different:

A native woman may spend more time at home, pursuing education (for example), while being supported by her parents, and enter the labour force after obtaining her education (Tables 2.1 and 2.2 show that native women have 1.5 years of education more, on average, than immigrants; this difference is significant under a two-sample t-test with equal variances). Immigrant women, on the other hand, may be forced to leave education earlier, perhaps because their parents do not have enough income to support their daughters' education.

This story is consistent with the significant and positive coefficient on the age variable for the native women, and close to zero for the immigrant women. For native women, age is a good predictor of employment, as opposed to immigrant women. Furthermore, the same forces may entice immigrant women to rely more on marriage, reflected in the incidence of married women (0.729 for immigrant women to 0.599 for natives, Tables 2.1 and 2.2; the difference is significant under a t-test) and the size difference of the marriage dummy's coefficient in the regressions for the two sub-samples.

The coefficients for schooling and the number of small children probably do not differ, but tenure seems to have a stronger effect on an immigrant's decision to work than on a native's. However, it is not possible to read much into the results for these variables.

There seems to exist an indication of potential differences in the mechanism of selection into the labour force for different groups of women in

Germany, but this is not a conclusive proof thereof.

Table 2.3: Probit for immigrant women selection

Variable	**Coefficient**	**(Std. Err.)**
schooling	0.137^{**}	(0.020)
tenure	0.141^{**}	(0.011)
age	0.002	(0.080)
age squared	-0.001	(0.001)
married	-0.396^{**}	(0.094)
No. of children below 6y.o.	-0.667^{**}	(0.081)
log of other HH income	-0.044	(0.027)
Intercept	-0.615	(1.495)
N	1227	
Log-likelihood	-599.864	
$\chi^2_{(7)}$	473.86	

Significance levels : † : 10% $*$: 5% $**$: 1%

Table 2.4: Probit for native women selection

Variable	**Coefficient**	**(Std. Err.)**
schooling	0.116^{**}	(0.005)
tenure	0.107^{**}	(0.002)
age	0.041^{**}	(0.014)
age squared	-0.001^{**}	(0.000)
married	$-0.047^{\dagger}$	(0.024)
No. of children below 6y.o.	-0.590^{**}	(0.019)
log of other HH income	-0.140^{**}	(0.008)
Intercept	-0.799^{**}	(0.287)
N	16825	
Log-likelihood	-8887.674	
$\chi^2_{(7)}$	5336.974	

Significance levels : † : 10% $*$: 5% $**$: 1%

Tables 2.5 and 2.6 show the results of the second step of the Heckman's two-step estimator for immigrant and native women, respectively. The estimated coefficients in these tables are supposed to indicate how the German labour market treats one unit of endowments (schooling, tenure, etc.) of different groups of women.

Again, it is difficult to compare the coefficients directly, but the immigrant regression results (Table 2.5) are quite striking.[14] The immigrant intercept has a very large and significant value, schooling has a positive and significant value, and everything else seems unimportant. The native intercept, on the other hand, is much smaller (by an order of nine—Table 2.6), while everything else has expected signs and significance.

The intercept should indicate the very basic discrimination of the labour market, if there is any, since it is what the market would pay to a candidate of a particular sub-sample with zero other endowments. The particular intercepts from Tables 2.5 and 2.6 would indicate a positive discrimination towards immigrant women.

Table 2.5: OLS: Immigrant women, dependant variable: log hourly wage

Variable	Coefficient	(Std. Err.)
schooling	0.033**	(0.006)
tenure	0.002	(0.004)
age	-0.027	(0.017)
age squared	0.000†	(0.000)
Mills ratio (immi)	0.067	(0.168)
Intercept	2.024**	(0.350)
N	522	
R^2	0.095	
$F_{(5,516)}$	10.891	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

Of course, drawing conclusions only from the coefficients of two different regressions is problematic, and we now move onto the Blinder-Oaxaca decomposition of the (predicted) wage gap (results are given in Table 2.7). The log-wage gap is estimated to be 0.0543, and the two-sample t-test shows that this difference is significant. Again, the coefficient entry indicates positive discrimination, as it explains from negative 78 to negative 186 percent of the log-wage gap. We learn that no matter the decomposition, the endowment differences play the biggest role in explaining the gap between average native and immigrant wages.

Selectivity 2, reflecting the most encompassing view of discrimination, attributes the smallest effect to it (negative 78 percent). Selectivity 4, which

[14]Significance sign on the Mills ratio would normally be troubling, but in this case can come from a relatively small sample size.

Table 2.6: OLS: Native women, dependant variable: log hourly wage

Variable	**Coefficient**	**(Std. Err.)**
schooling	0.061**	(0.002)
tenure	0.013**	(0.001)
age	0.048**	(0.004)
age squared	-0.001**	(0.000)
Mills ratio (nat)	0.185**	(0.053)
Intercept	0.225*	(0.088)
N	9356	
R^2	0.191	
$F_{(5,9350)}$	441.203	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

treats all of the selectivity as such, attributes the largest (negative) effect to the coefficient differences.

The selectivity-adjusted decomposition (called “Sel.-adj” and related to equation (2.7)) shows no significant difference between the average wages (according to a *t*-test), and again shows the large negative coefficient effect (indicating positive discrimination).

It is worth noting that “Sel.-adj” (log-) wage gap is the same as in Selectivity 4, minus the selectivity part. The value added of the Selectivities 1–4 is exactly that the wage gap is decomposed into three different parts, but all in one equation.

Finally, Selectivity 5 shows no practical difference to Selectivities 1–4: the endowment plays the biggest role in explaining the wage gap, while the coefficient differences indicate positive discrimination.

To sum up, there is one strong result that can be inferred from this analysis: the endowment effect dominates the wage gap. Thus, to address the wage dap, it is necessary to improve the educational attainment and other endowments of the immigrants. Even among working women, natives have one year more education than immigrants. Among unemployed, the gap increases to 1.5 years (see Tables 2.1–2.2 for the full sample; summary stats for employed are not presented).

In the next section, we turn to the comparison of the wage gap at various quantiles of the wage distribution.

Table 2.7: Blinder-Oaxaca decomposition with selectivity bias for women

	Sel.-adj	Sel.1	Sel.2	Sel.3	Sel.4	Sel.5
log-wage gap	0.006	0.0543	0.0543	0.0543	0.0543	0.0543
Endowment	0.107	0.1509	0.0965	0.0965	0.1071	0.1013
% of gap	1859 %	277.66 %	177.56 %	177.56 %	197.07 %	186.36 %
Coefficient	−0.101	−0.0965	−0.0421	−0.0965	−0.1013	−0.0469
% of gap	−1759 %	−177.66 %	−77.56 %	−177.66 %	−186.47 %	−86.36 %
Selectivity	NA	0	0	0.0544	0.0486	0
% of gap	NA	0 %	0 %	100.11 %	89.40	0 % %

2.5.2 Quantile regression

We utilise information from the regressions in Tables 2.3–2.4 to construct the Mills ratios, just like with the mean wage-gap decompositions, but then we follow the algorithms provided in Section 2.3.2 to construct the actual and counter-factual predicted wage distributions, wI, wN, $wIadj$, $wNadj$, $WINS$, $WINC$ and $WINA$.

Tables 2.12 and 2.13 provide the quantile regression results for immigrants and natives, with their respective Mills ratios. Similarly to the mean regressions, the intercept for immigrant regression is larger than the intercept for native regression, at almost all quantiles. Again, the rest of the coefficients (apart from schooling) are insignificant for the immigrants at almost all quantiles, while for the native regression the coefficients have the expected signs and significance.

It is not possible to say much beyond what has been said for the mean regression, on the basis of the differences in coefficients for the two subsamples, so we turn to the different distribution-based decompositions, presented in Tables 2.8–2.9 and 2.10–2.11.

Tables 2.8–2.9 show the quantile values for all the distributions in question: the log wage distributions for natives (wN) and immigrants (wI), two counter-factual distributions: for immigrants, as if they followed the selectivity adjustment as well as receiving the wage offer according to the native equation (wages for immigrants with native Mills ratios: $WINS$), and for immigrants, as if they were paid like natives for their labour market characteristics, while keeping their own selectivity adjustment (wages for immigrants with native coefficients: $WINC$); and the selectivity-adjusted distributions $wNadj$ and $wIadj$ for natives and immigrants, respectively, and $WINA$, the counter-factual distribution of selectivity-adjusted immigrant log wages, if immigrants followed the wage-equation of the natives. I bootstrap the confidence intervals.

The values in these tables are estimated in the following way: I repeat the algorithm given in section 2.3.2 25 times to generate 25 distributions of each type. Then, for each quantile and each distribution (wN, $WINS$, etc.), I take the median value from those 25 points to be the estimate for that quantile of that distribution, and the lower and upper values create the bootstrapped confidence intervals.

Next, to see whether the wage distributions are similar, I generate a χ-squared statistic for every quantile, with the null hypothesis that the pointwise confidence intervals come from the same distribution. The p-values are presented in Tables 2.10–2.11: small p's reject the null even at quantiles where the confidence intervals overlap.

It is striking to see how the predicted log-wage gap behaves across the distribution: the immigrants actually get *higher* wages than the natives at the bottom of the distribution, *same* wages in the middle, and *lower* at the top (see Figure 2.1). From Tables 2.8–2.11: below the 35th percentile, wN is significantly lower than wI (at a one percent level), such that the wage gap is actually favouring immigrants.[15] In the middle of the distribution (quantiles 35–45), there is no significant distinction between the values, while at the top end of the distribution, $wN > wI$. The selectivity-adjusted $wNadj > wIadj$ for all quantiles.

Furthermore, if immigrant women follow the selectivity and wage equations of the native women, they get basically the same wages as if they follow their own equations (notice the identical estimates of wI and $WINS$ in Tables 2.8–2.9 and the p-values and signs in the column $wI = WINS$ in Table 2.10), and *still* experience the wage gap for exactly the same quantiles (wage gap at the bottom of the distribution favouring immigrants, no wage gap in the lower middle, and expected wage gap at the top half of the distribution—notice the p-values and signs in the column $wN = WINS$).

Remember that the distribution $WINS$ reflects the treatment of selectivity that corresponds to Selectivity 2 from equation (2.10) from Section 2.3.1, and the differences between wN and $WINS$ correspond precisely to the endowment effect from equation (2.10).[16] Thus, this decomposition indi-

[15] At the five percent level, there are more quantiles where the distributions are unequal.

[16] As mentioned at the end of section 2.3.2, $WINS$ is constructed using the endowments of immigrants and the coefficients of the natives from both the offer wage and selection equations (the latter through $\hat{\lambda}_I^0$).

Table 2.8: The log-wages at various quantiles of different distributions for immigrants and natives: two factual (wN and wI) and two counter-factual ($WINC$ and $WINS$—for immigrants as if they were paid like natives but selected themselves into work like immigrants, and for immigrants as if they were paid and followed the selectivity-into-work equation like natives, respectively). CI are the bootstrapped confidence intervals around the quantile values.

	10	ub	15	ub	20	ub	25	ub	30	ub
wN	1.65		1.72		1.80		1.86		1.91	
CI	1.57	1.79	1.63	1.87	1.70	1.91	1.78	1.96	1.81	2.01
wI	1.73		1.79		1.86		1.92		1.96	
CI	1.67	1.82	1.73	1.89	1.78	1.94	1.82	1.98	1.85	1.99
$WINS$	1.73		1.79		1.85		1.91		1.96	
CI	1.65	1.86	1.72	1.94	1.79	1.95	1.85	1.99	1.90	2.00
$WINC$	1.61		1.68		1.72		1.78		1.82	
CI	1.50	1.76	1.61	1.79	1.66	1.83	1.71	1.87	1.76	1.91
$wNadj$	1.24		1.39		1.54		1.69		1.79	
CI	1.12	1.58	1.22	1.67	1.30	1.80	1.47	1.94	1.64	1.99
$wIadj$	0.67		0.81		0.95		1.09		1.17	
CI	0.42	0.83	0.63	1.02	0.69	1.19	0.81	1.25	0.91	1.32
$WINA$	1.21		1.35		1.45		1.56		1.65	
CI	0.91	1.57	1.15	1.62	1.31	1.68	1.41	1.79	1.48	1.84
	35	ub	40	ub	45	ub	50	ub	55	ub
wN	1.97		2.02		2.06		2.09		2.13	
CI	1.89	2.08	1.94	2.14	1.98	2.17	2.01	2.22	2.08	2.24
wI	1.99		2.00		2.02		2.04		2.04	
CI	1.86	2.01	1.92	2.03	1.99	2.05	2.00	2.06	2.02	2.08
$WINS$	1.98		2.00		2.02		2.04		2.04	
CI	1.95	2.02	1.97	2.04	1.99	2.04	2.01	2.05	2.02	2.07
$WINC$	1.86		1.89		1.94		1.99		2.03	
CI	1.79	1.96	1.85	1.99	1.88	2.04	1.91	2.07	1.95	2.11
$wNadj$	1.87		1.95		2.01		2.06		2.09	
CI	1.75	2.05	1.80	2.09	1.87	2.15	1.95	2.19	2.03	2.25
$wIadj$	1.22		1.30		1.35		1.45		1.50	
CI	1.00	1.36	1.19	1.42	1.24	1.49	1.35	1.54	1.40	1.61
$WINA$	1.77		1.82		1.91		1.97		2.02	
CI	1.64	1.93	1.71	1.98	1.79	2.03	1.83	2.07	1.91	2.10

Table 2.9: Table 2.8 continued

	60	ub	65	ub	70	ub	75	ub	80	ub
wN	2.18		2.22		2.26		2.33		2.37	
CI	2.11	2.28	2.13	2.31	2.19	2.39	2.25	2.41	2.29	2.47
wI	2.06		2.09		2.14		2.19		2.24	
CI	2.03	2.14	2.04	2.17	2.05	2.23	2.09	2.26	2.14	2.28
$WINS$	2.06		2.10		2.14		2.18		2.24	
CI	2.03	2.13	2.04	2.16	2.06	2.22	2.14	2.25	2.17	2.30
$WINC$	2.08		2.13		2.17		2.24		2.28	
CI	2.00	2.17	2.04	2.22	2.09	2.26	2.19	2.30	2.22	2.36
$wNadj$	2.16		2.21		2.28		2.32		2.38	
CI	2.08	2.29	2.13	2.31	2.15	2.37	2.22	2.41	2.30	2.46
$wIadj$	1.57		1.63		1.70		1.76		1.81	
CI	1.48	1.67	1.52	1.73	1.62	1.77	1.69	1.83	1.75	1.90
$WINA$	2.08		2.12		2.19		2.24		2.28	
CI	1.98	2.18	2.03	2.25	2.11	2.28	2.16	2.31	2.20	2.35

	85	ub	90	ub
wN	2.46		2.54	
CI	2.32	2.52	2.41	2.66
wI	2.28		2.35	
CI	2.22	2.35	2.27	2.47
$WINS$	2.28		2.35	
CI	2.21	2.35	2.26	2.44
$WINC$	2.34		2.42	
CI	2.25	2.43	2.32	2.48
$wNadj$	2.45		2.52	
CI	2.37	2.54	2.41	2.60
$wIadj$	1.88		1.95	
CI	1.80	1.96	1.88	2.03
$WINA$	2.32		2.38	
CI	2.26	2.44	2.30	2.50

cates that the *whole* difference between the wages of natives and immigrants comes *only* from the endowment differences.

If we believe Selectivity 2 and this conclusion, we must also accept that at the bottom of the distribution, immigrants seem to have a better mix of labour market characteristics/endowments. This reverses for the top half of the distribution.

Table 2.10: p-values for the test of equal wages at given quantiles for given pairs of distributions. Zeros indicate the rejection of the null hypothesis that the bootstrapped quantile (point-wise) confidence intervals come from the same distribution.

	$wN = wI$	$wI = WINS$	$wI = WINC$	$wN = WINS$	$wN = WINC$
10	0 (<)	1.00	0 (>)	0 (<)	0.09
15	0 (<)	1.00	0 (>)	0.02	0.02
20	0 (<)	0.57	0 (>)	0 (<)	0 (>)
25	0 (<)	1.00	0 (>)	0 (<)	0 (>)
30	0 (<)	1.00	0 (>)	0 (<)	0 (>)
35	0.57	0.26	0 (>)	0.57	0 (>)
40	0.57	1.00	0 (>)	0.26	0 (>)
45	0.26	1.00	0 (>)	0.09	0 (>)
50	0 (>)	0.57	0.02	0 (>)	0 (>)
55	0 (>)	1.00	0.26	0 (>)	0 (>)
60	0 (>)	0.57	1.00	0 (>)	0 (>)
65	0 (>)	1.00	0.02	0 (>)	0 (>)
70	0 (>)	1.00	0 (<)	0 (>)	0 (>)
75	0 (>)	0.57	0 (<)	0 (>)	0 (>)
80	0 (>)	0.26	0 (<)	0 (>)	0 (>)
85	0 (>)	0.57	0 (<)	0 (>)	0 (>)
90	0 (>)	1.00	0.02	0 (>)	0 (>)

Recall also that in the mean-wage decomposition, Selectivity 2 provided the lowest effect of coefficient differences, and that effect indicated positive discrimination (Table 2.7). The mean-wage decomposition was a mechanical exercise, however, and in light of the QR decomposition evidence, we see that the effect of differences in coefficients seems insignificant. On the other hand, the magnitude of the endowment effect is supported in both cases.

To remind us, the analysis in this Section assumes that the differences in selection equation coefficients come primarily from the offered-wage equation. Next, I show what happens if the alternative assumption is accepted.

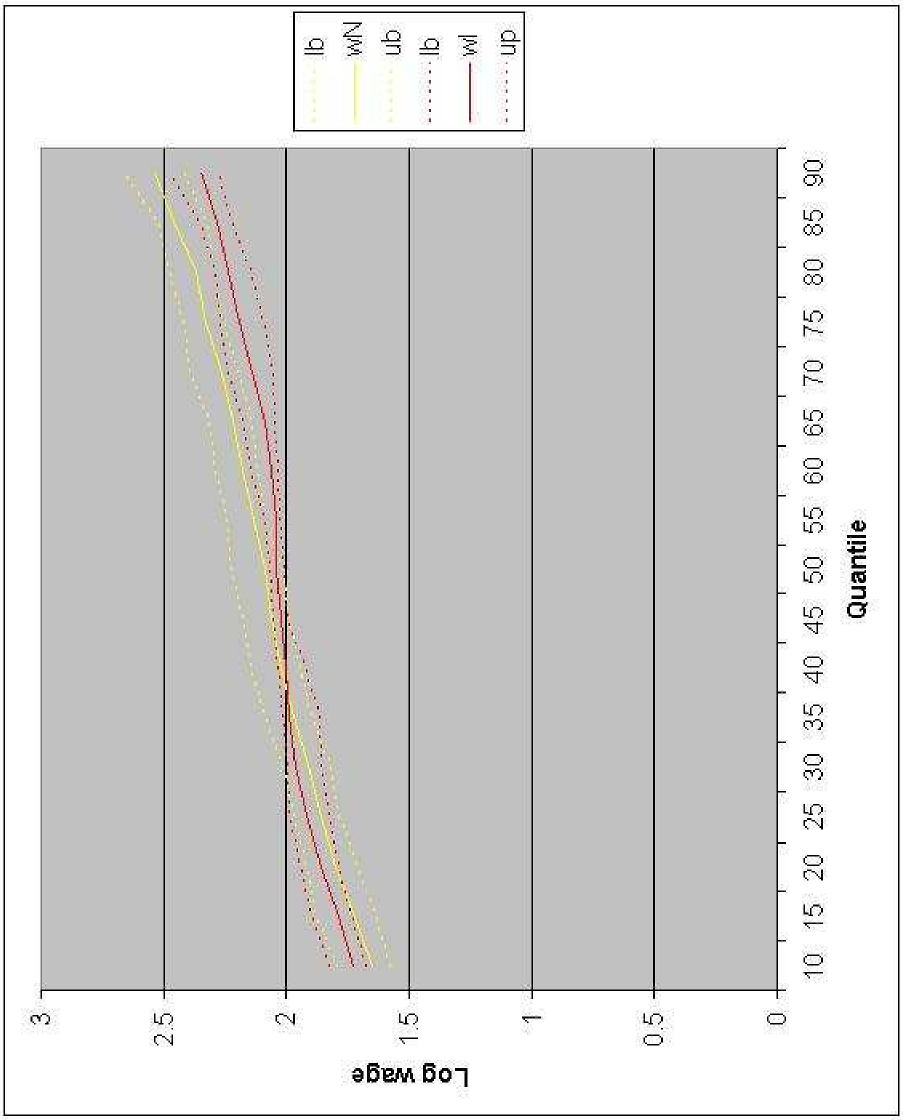

Figure 2.1: Predicted log-wage distributions wN and wI with their bootstrapped upper and lower bounds

Table 2.11: p-values for the test of equal wages at given quantiles for given pairs of distributions. Zeros indicate the rejection of the null hypothesis that the bootstrapped quantile (point-wise) confidence intervals come from the same distribution, Table 2.10 continued

	$wNadj = wIadj$	$wIadj = WINA$	$wNadj = WINA$	$WINS = WINC$
10	0 (>)	0 (<)	0.57	0 (>)
15	0 (>)	0 (<)	0.02	0 (>)
20	0 (>)	0 (<)	0 (>)	0 (>)
25	0 (>)	0 (<)	0.02	0 (>)
30	0 (>)	0 (<)	0 (>)	0 (>)
35	0 (>)	0 (<)	0 (>)	0 (>)
40	0 (>)	0 (<)	0 (>)	0 (>)
45	0 (>)	0 (<)	0 (>)	0 (>)
50	0 (>)	0 (<)	0 (>)	0 (>)
55	0 (>)	0 (<)	0 (>)	0.26
60	0 (>)	0 (<)	0 (>)	0.57
65	0 (>)	0 (<)	0 (>)	0.09
70	0 (>)	0 (<)	0 (>)	0 (<)
75	0 (>)	0 (<)	0 (>)	0 (<)
80	0 (>)	0 (<)	0 (>)	0 (<)
85	0 (>)	0 (<)	0 (>)	0 (<)
90	0 (>)	0 (<)	0 (>)	0 (<)

Selection equation coefficients: $WINC$

As discussed in Section 2.3.2, we can assume that the differences in the γ parameters reflect primarily the differences in the reserved-wage equation coefficients: i.e., γ parameters reflect the personal preferences, cultural attitudes, etc., which can be attributed to endowment.

We see that $wI > wN > WINC$ at the bottom of the distribution, and $wI < WINC < wN$ at the top (see Table 2.10 and Figure 2.2). The difference $wN - WINC$ is the endowment effect from Selectivity 5, but $WINC - wI$ means that there also exists a significant non-endowment gap. This decomposition indicates positive discrimination at the bottom of the distribution, and negative at the top: If immigrant women kept their own selectivity technology, but faced the offered wage equation of the native women, they would have been worse-off at the bottom of the distribution, and better-off at the top.

Compare this to the results from the mean regression given in Table 2.7, which show positive discrimination *on average*.

Remember also that until the 50th quantile, the wage $WINS$ was higher or not significantly lower than that of the natives. We can see that $WINC < WINS$ at the bottom of the distribution, $WINC = WINS$ for quantiles 55–65, and $WINC > WINS$ at the top (see Figure 2.3, the column $WINS = WINC$ in Table 2.11 and predicted wages in Tables 2.8–2.9).

The only difference between $WINS$ and $WINC$ is the part $(\hat{\lambda}_I^0 - \hat{\lambda}_I)\hat{\theta}_{q,N}$, which reflects precisely the difference between $\hat{\gamma}_N - \hat{\gamma}_I$. This is the difference in the attitudes to work in two populations, by our initial assumption. Thus, if the initial assumption of this Section is correct, immigrant women's attitudes to work are more positive at the top of the wage distribution, and more negative at the bottom, when compared to the native women.

Adjusted wage-gap decomposition: $WINA$

The selectivity-adjusted decomposition, on the other hand, indicates catching-up throughout the whole distribution if immigrants face the natives' wage offer equation (see Figure 2.4, and the p-values in the column $wNadj = WINA$ in Table 2.11). The large difference $WINA - wIadj$ indicates discrimination across the whole distribution (see the column $wIadj = WINA$ in Table 2.11). If we abstract away from the selectivity differences, then almost all of the wage gap comes from the coefficient part (Figure 2.4 and the absolute values of the wages in Tables 2.8–2.9).

However, this is not consistent with the equivalent approach for the mean-wage decomposition ("Sel.-adj" from Table 2.7 and equation (2.7)), which indicated no significant difference in the means of the selectivity-adjusted wages.

Furthermore, it is hard to believe that the prominence of the labour market characteristics in previous sections comes mainly through the selection equation. Remember, that the main difference between the endowment effects in Selectivities 1–5 and in the adjusted wage gap decomposition is in the treatment of the differences in the labour market characteristics' effects on the selection equation. That is, the differences in Z-variables are included in the endowment effect in Selectivities 1–5, but are taken out of the wage gap in the selectivity-adjusted decomposition.

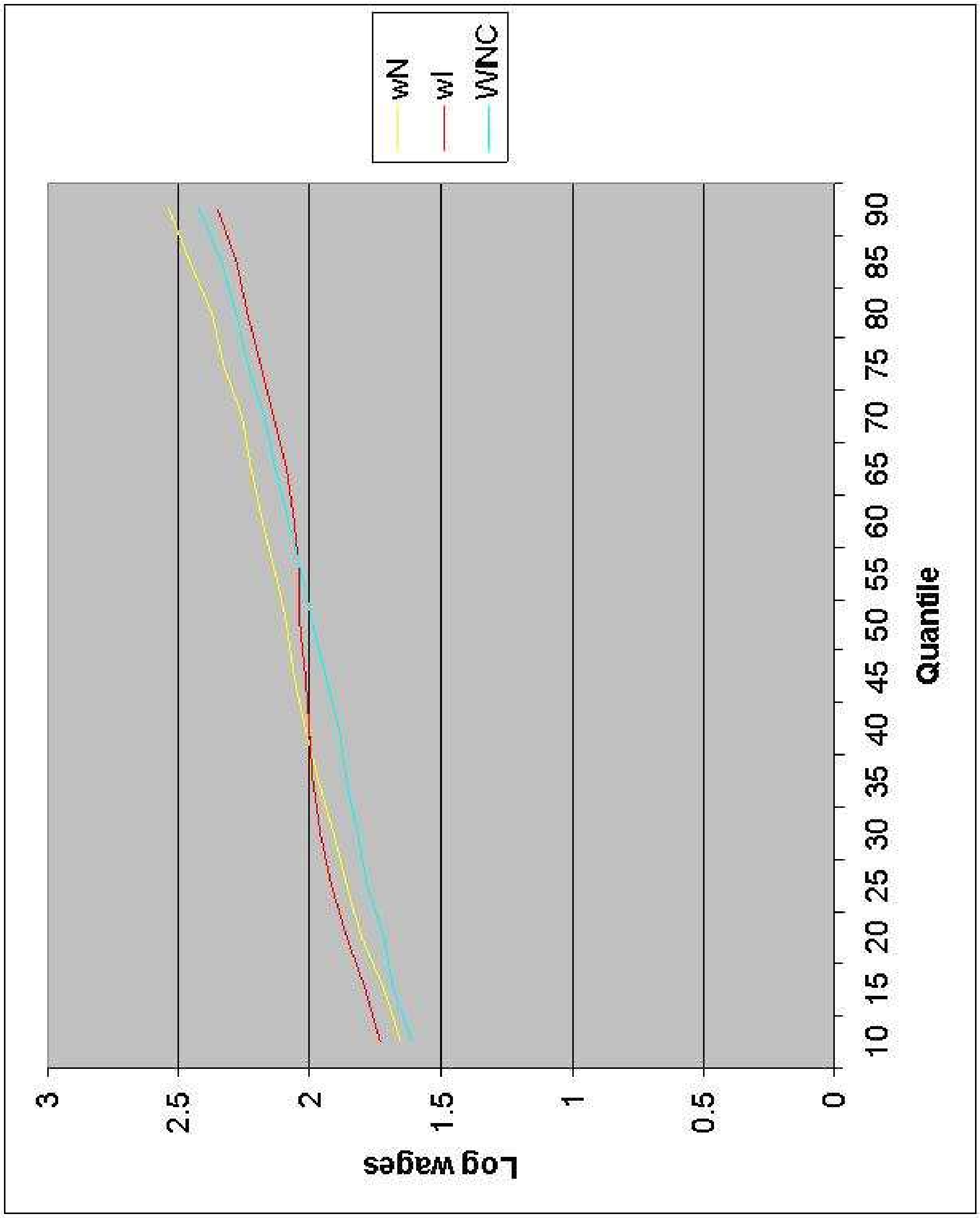

Figure 2.2: Log-wage distributions wN, wI and a counter-factual distribution $WINC$; note: $WINS$ is almost identical to wI, so not shown

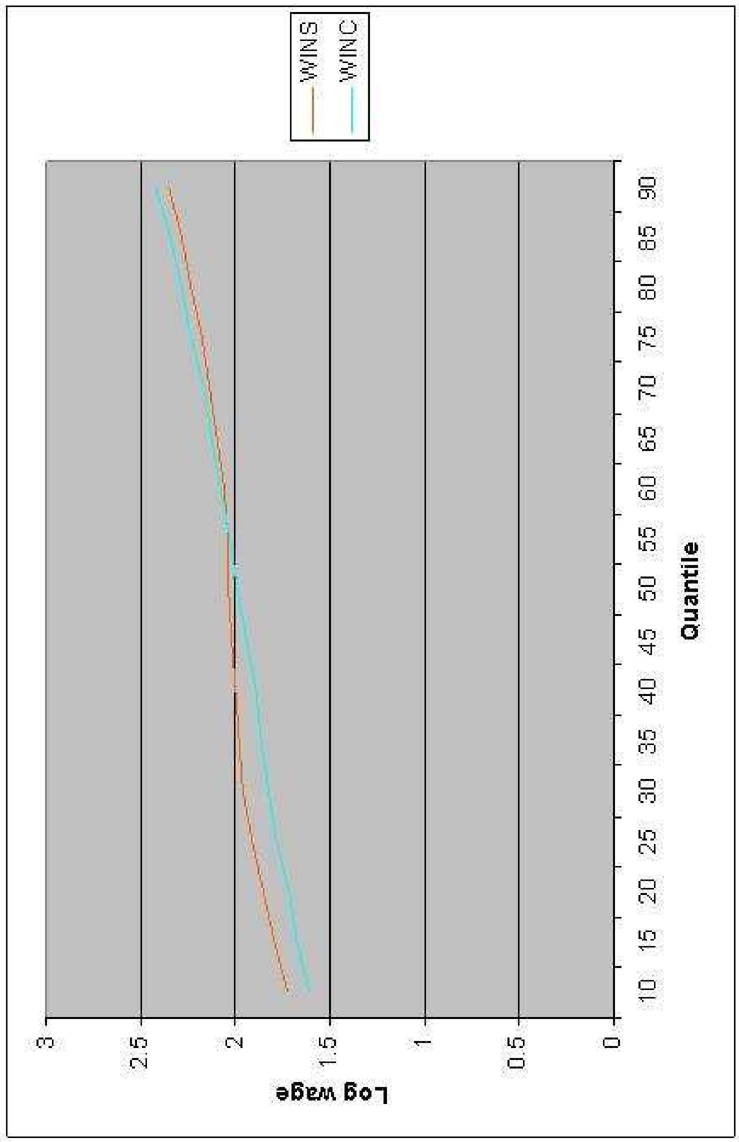

Figure 2.3: Counter-factual distributions $WINS$ and $WINC$; note: $WINS$ is almost identical to wI

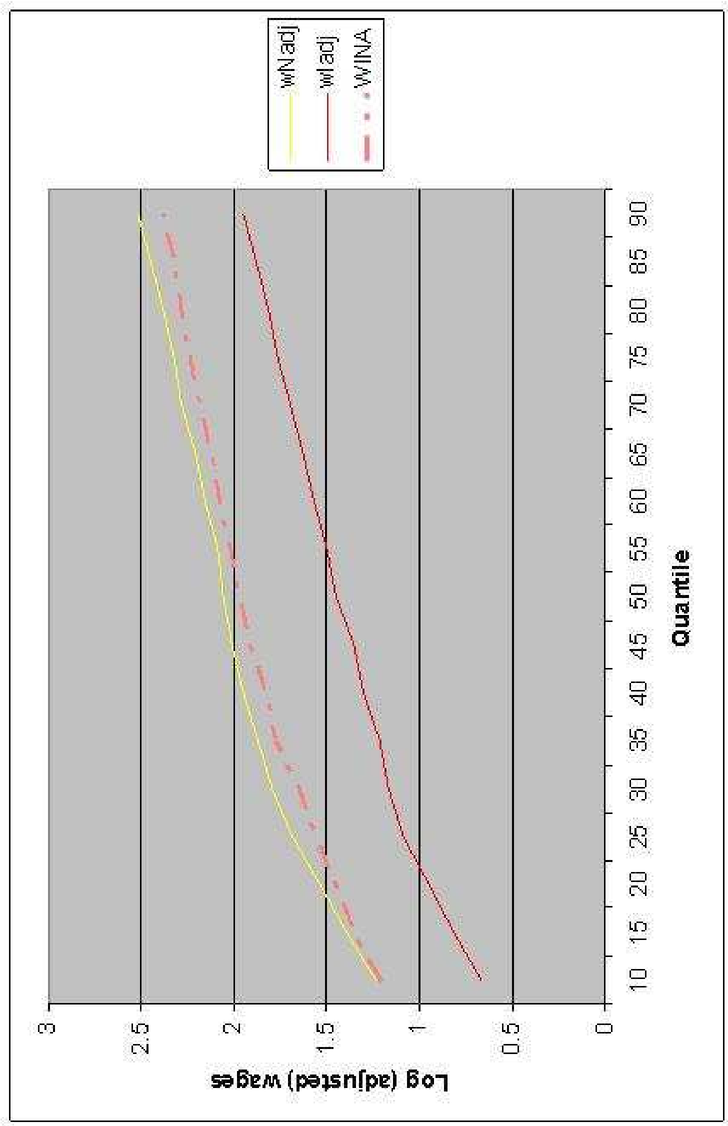

Figure 2.4: Selectivity-adjested distributions $wNadj$, $wIadj$ and the counter-factual distribution $WINA$

2.6 Conclusion

This paper attempted to shed some light, in the quantile regression context, on various ways to decompose the wage-gap according to Neuman and Oaxaca [2003]. It turns out that Selectivity 2, in which the differences in the selectivity equation coefficients and the Mills ratio coefficient are both treated as part of discrimination, has the most straight-forward quantile regression (QR) equivalent, and no other Selectivity from Neuman and Oaxaca [2003] is possible without additional (stringent) assumptions on the distribution of wages.

The QR decompositions based on Neuman and Oaxaca [2003] assume that selection equation coefficients are influenced primarily by the offer-wage equation coefficients. On the other hand, it might be possible to compare how differences in attitudes to work affect the wages, all else being equal, under an alternative assumption that selection equation coefficients are influenced primarily by the reserved-wage equation coefficients. In this vein, I also have introduced a novel way of decomposing the wage gap.

Furthermore, the paper highlights the differences between these approaches using a mean and quantile regression-based decompositions: while the mean regression paints a very consistent picture of positive discrimination and the importance of endowments in explaining the wage gap, the QR approach most consistent with the mean regression results (i.e., Selectivity 2) does not find any evidence of discrimination, but supports the predominant importance of the endowment effect in explaining the wage gap.

Under the assumption that the selection equation coefficients reflect attitudes to work, the paper shows two things: First, that immigrants possess more positive attitudes to work than their native counter-parts, at the top of the distribution, the reverse holding at the bottom, with equality at the 55th–65th quantiles; and Second, that there seems to be positive discrimination at the bottom of the distribution, and negative at the top, with none in the middle. However, the paper does not establish the validity of said assumption.

Furthermore, given the difficulties implementing various selectivity-based decompositions, the paper points out potential attractiveness of a selectivity-adjusted wage decomposition. However, in this case the results from the QR and mean regression approaches differ widely in the importance of the coefficient differences in the wage offer equations.

Finally, if anything should be taken away from this research, it is its practical message: to address the income inequality between immigrant and native women in Germany, the endowment differences should be addressed first and foremost. These are also the easiest to tackle of all factors contributing to the wage gap. According to most evidence, the endowment differences could also be the *only* contributing factor.

Before finishing off, a couple of words about future research. As a next step, the analysis should be repeated while taking account of potential endogeneity of several regressors. Heckman [1977] presents strong evidence that years of tenure is endogenous in the selection equation, but not in offered wage equation. García et al. [2001] suggest that education can be endogenous. Furthermore, Albrecht et al. [2003] suggest using different degrees earned instead of years of education: since even with the same number of years of education, people can have different quality of education that would be better shown with the degrees earned.

Finally, a word on the implicit assumptions behind the word "discrimination". I have tried to make these explicit: in particular, on the importance of the reserved-wage and the offered-wage equation coefficients, and how they affect the differences in the selection equation coefficients. Alas, these remain assumptions. Thus, there seems to be a benefit of a directed survey into the reserved wage equation of the labour market participants and unemployed, in context of this research.

Table 2.12: QR for immigrant women, dependant variable: log hourly wage

Variable	Coefficient	(Std. Err.)
Equation 1 : q15		
schooling	0.077**	(0.009)
tenure	0.002	(0.005)
age	-0.027	(0.030)
age squared	0.001	(0.000)
Mills ratio (immi)	0.240	(0.173)
Intercept	1.051*	(0.440)
Equation 2 : q25		
schooling	0.071**	(0.008)
tenure	0.006	(0.005)
age	0.016	(0.024)
age squared	0.000	(0.000)
Mills ratio (immi)	0.083	(0.214)
Intercept	0.519	(0.480)
Equation 3 : q35		
schooling	0.053**	(0.007)
tenure	0.014*	(0.007)
age	0.036	(0.036)
age squared	0.000	(0.000)
Mills ratio (immi)	0.509*	(0.236)
Intercept	0.311	(0.670)
Equation 4 : q45		
schooling	0.025†	(0.013)
tenure	0.005	(0.008)
age	-0.028	(0.056)
age squared	0.001	(0.001)
Mills ratio (immi)	0.189	(0.238)
Intercept	1.935†	(1.121)
Equation 5 : q50		
schooling	0.023†	(0.013)
tenure	0.004	(0.007)
age	-0.038	(0.052)
age squared	0.001	(0.001)
Mills ratio (immi)	0.155	(0.223)
Intercept	2.157*	(1.074)

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... table 2.12 continued

Variable	**Coefficient**	**(Std. Err.)**
Equation 6 : q55		
schooling	0.014	(0.012)
tenure	-0.002	(0.005)
age	-0.040	(0.040)
age squared	0.001	(0.001)
Mills ratio (immi)	0.028	(0.222)
Intercept	2.382**	(0.831)
Equation 7 : q65		
schooling	0.025*	(0.011)
tenure	-0.006	(0.006)
age	-0.037	(0.031)
age squared	0.001	(0.000)
Mills ratio (immi)	-0.269	(0.309)
Intercept	2.404**	(0.608)
Equation 8 : q75		
schooling	0.029**	(0.011)
tenure	0.009	(0.008)
age	-0.003	(0.030)
age squared	0.000	(0.000)
Mills ratio (immi)	0.000	(0.433)
Intercept	1.790**	(0.517)
Equation 9 : q85		
schooling	0.034**	(0.007)
tenure	0.010†	(0.005)
age	-0.006	(0.030)
age squared	0.000	(0.000)
Mills ratio (immi)	0.000	(0.214)
Intercept	1.901**	(0.508)
N	522	
Log-likelihood	.	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

Table 2.13: QR for native women, dependant variable: log hourly wage

Variable	**Coefficient**	**(Std. Err.)**
Equation 1 : q15		
schooling	0.046**	(0.004)
tenure	0.011**	(0.002)
age	0.006	(0.006)
age squared	0.000	(0.000)
Mills ratio (nat)	0.000	(0.137)
Intercept	1.014**	(0.170)
Equation 2 : q25		
schooling	0.051**	(0.003)
tenure	0.009**	(0.002)
age	0.044**	(0.006)
age squared	-0.001**	(0.000)
Mills ratio (nat)	-0.038	(0.076)
Intercept	0.332*	(0.136)
Equation 3 : q35		
schooling	0.053**	(0.002)
tenure	0.014**	(0.002)
age	0.056**	(0.005)
age squared	-0.001**	(0.000)
Mills ratio (nat)	0.111	(0.089)
Intercept	0.100	(0.095)
Equation 4 : q45		
schooling	0.053**	(0.003)
tenure	0.012**	(0.001)
age	0.065**	(0.007)
age squared	-0.001**	(0.000)
Mills ratio (nat)	-0.004	(0.080)
Intercept	0.084	(0.151)
Equation 5 : q50		
schooling	0.055**	(0.003)
tenure	0.013**	(0.002)
age	0.061**	(0.007)
age squared	-0.001**	(0.000)
Mills ratio (nat)	-0.020	(0.096)
Intercept	0.169	(0.134)

Continued on next page...

... table 2.13 continued

Variable	**Coefficient**	**(Std. Err.)**
	Equation 6 : q55	
schooling	0.060**	(0.003)
tenure	0.013**	(0.002)
age	0.062**	(0.005)
age squared	-0.001**	(0.000)
Mills ratio (nat)	0.024	(0.105)
Intercept	0.054	(0.120)
	Equation 7 : q65	
schooling	0.067**	(0.002)
tenure	0.014**	(0.002)
age	0.066**	(0.005)
age squared	-0.001**	(0.000)
Mills ratio (nat)	0.141†	(0.084)
Intercept	-0.063	(0.112)
	Equation 8 : q75	
schooling	0.073**	(0.003)
tenure	0.017**	(0.002)
age	0.060**	(0.006)
age squared	-0.001**	(0.000)
Mills ratio (nat)	0.492**	(0.082)
Intercept	-0.106	(0.149)
	Equation 9 : q85	
schooling	0.068**	(0.003)
tenure	0.016**	(0.002)
age	0.067**	(0.006)
age squared	-0.001**	(0.000)
Mills ratio (nat)	0.513**	(0.061)
Intercept	-0.105	(0.129)
N	9356	
Log-likelihood	.	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

Chapter 3

Informational effects of migration on trade

3.1 Introduction

> By virtue of links to their home countries, they [immigrants] may realize lower costs associated with foreign trade and thereby be more likely to trade than non-immigrants.
>
> *Head and Ries [1998]*

Regions within one country tend to trade much more with *each other* than with similar regions *across a border* [McCallum, 1995]. A simple gravity equation of trade, where trade depends on the size of trading partners and the distance between them, fits trade patterns very well, but cannot explain this particular fact.

Head and Ries [1998] proposed that informational costs can explain part of this "puzzle" and that immigration can facilitate the transmission of this information. A trading company needs to know the tastes and product characteristics in different countries, and migrants possess superior knowledge of foreign market conditions [Gould, 1994, Head and Ries, 1998].

There are three broad channels through which (im)migration is suggested to affect trade: (1) information transmission (i.e., when migrants carry with them knowledge of trading opportunities in their home countries), (2) contract enforcement (i.e., when members of one ethnic group prefer to deal with each other in inter-national contracting because of high inter-group trust or punishment possibilities), and (3) preference-driven demand creation (i.e., when a new migrant creates demand for goods from his home country).

There are many studies that find positive correlation between bilateral trade flows and the aggregate number of immigrants from the trading partners, for different countries [Gould, 1994, Wagner et al., 2002, Rauch and Trindade, 2002, are just some of the studies]. While it is clear how the demand creation channel works, the process of information transmission and contract enforcement can not be elucidated through these studies due to four major reasons:

1. First of all, there can be reverse causality in the immigration–trade relationship. It can be argued that goods traded carry information about countries, and this information influences the decision of migrants to move. If so, then immigration effect on trade from a simple regression of trade on same-year stock of immigrants will be biased upward. This paper is the first, to my knowledge, to use the lagged immigration variable to instrument for the current immigrant stock to get a more reliable estimate.

2. Second, immigrant heterogeneity is not taken into account—current studies use the aggregate number of immigrants to obtain estimates of the *average* immigrant effect on trade. As immigrants differ with respect to their labour market involvement in the host country, however, the *average* effect has little meaning.

   As an exception, Head and Ries [1998] do differentiate between different immigrant categories, but only the categories that migrants sort themselves into while *entering* the country, e.g., family reunification, independent, entrepreneur, refugee. This cannot measure what immigrants do in the labour market *after* they enter the country, which is of much higher importance for trade. The present paper investigates the importance of different groups of migrants.

3. Third, not all goods' trade requires information transmission in the same way, and while almost all studies distinguish between simple and complex goods [see, e.g., Gould, 1994, Rauch and Trindade, 2002], no study utilises finer data on trade. If such data is available, distinguishing between different sub-classes of complex goods (e.g., end

goods versus goods that serve as inputs into other goods' production) helps to further highlight a role an immigrant plays in facilitating trade. The present paper develops this direction further.

4. Finally, the information and contract-enforcement channels may only be two of many alternative consistent explanations for the correlation of the total stock of immigrants and bilateral trade flows of a country. One other possible explanation could be that migrants are a proxy for some third confounding factor, say, a general knowledge of the host country in the immigrant home country (and vice versa), and this confounding factor affects both migration and trade, with no causal effect between these two.

   Due to the data availability issues, the previous studies tried to deal with this problem in a number of indirect ways: Girma and Yu [2002] distinguish between Commonwealth and non-Commonwealth immigrants to the UK, to control for similar institutional factors, which are just a subset of the knowledge stock; Gould [1994] uses country fixed effects, but at the cost of increasing the 'noise to information' ratio and thus biasing the estimates [see Griliches, 1986, Wagner et al., 2002, for discussion]; Girma and Yu [2002] and Rauch and Trindade [2002] control for same language between countries, although again, language can only capture a part of the "knowledge" stock, in particular missing all the information on the countries whose citizens do not speak the same language but share a lot in common through history, such as Austria and Hungary.

   The present paper proposes a more direct measure of the "knowledge" factor.

In this paper, I want to concentrate only on the Information Transmission and Contract Enforcement channels (amalgamated into the IT-CE channel, for both have the same implications for immigration–trade link). The preference-driven demand creation is more straightforward to understand. In addition, it affects primarily imports of the goods from the migrant's home country into his host country, as opposed to IT-CE, which affects flows in both directions.

To highlight the IT-CE channel and to abstract away from the demand channel, I use only the trade flows from the immigrants' host region to their home region, called "exports" in the rest of the paper. The host regions in this case are German Bundesländer, and the home regions are various trading partner countries of these Bundesländer.

I start the analysis with a standard log-linear equation used in the literature: a log of host Bundesland–to–home country exports is regressed on a log of migrants from that home country living in that host Bundesland; other co-variates are also included [see, e.g., Head and Ries, 1998, Rauch and Trindade, 2002, etc.]. This specification assumes constant elasticity for the effect of immigrant stock on exports. Next, I introduce four innovations in the research on the immigrant–trade link, compared to the earlier literature:

First of all, I use the lagged immigration variable as an instrument for immigration. Apart from econometric reasoning (to exclude reverse causality), this is motivated by the necessary lag of an immigrant's potential effect on trade after the date of immigration: it is likely to take a year to set up a trading business.

Second, I differentiate between the sub-groups of immigrants (from the same home country) based on their labour market status in the host region, since not all immigrants have the same effect on exports. In particular, an immigrant company manager is more likely to utilise his knowledge of his home market in setting up a trading opportunity than, say, a fruit picker. This paper is the first to use such detailed data (from German micro-census) on the migrant labour-market participation—the data is presented in detail in section 3.2.4.

Third, the present paper distinguishes between different types of exports, similar to Gould [1994] and Rauch and Trindade [2002]. However, unlike past studies that concentrated on producer/consumer or homogenous/differentiated goods dichotomies, I utilise finer disaggregation level to distinguish, for instance, between non-industrial goods and raw materials, or between raw materials, semi-finished goods, and finished input goods. This leads to understanding of which groups of migrants are relevant for which trade, with a greater level of precision.

Last, I propose a proxy for the "confounding factor" that could explain both immigration and trade. This is the most tentative contribution, due to the data limitations, but it confirms the main theme of the paper that only certain immigrants matter and only for certain good types.

I hypothesise that in the case of Germany, both trade and migration can be explained by some general level of information about Germany in its trading partner countries, and I use information on German diplomatic missions abroad to investigate this question. Introducing a proxy for this information level indeed decreases the coefficient of immigrant variables by as much as 32 percent.

The evidence found in this paper supports the information and the contract enforcement hypotheses, finds no evidence for dominance of alternative hypotheses of immigrant–trade link, and sharpens the estimated coefficient values of the immigrant–trade elasticities:

- The control regression produces similar elasticity to those found in the literature: 0.147.[1] Using lags of immigrant stock as instruments for immigration leads to the reduction of estimates by 12 to 16 percent. This means that the estimates in the past studies are likely biased upwards.

- Distinguishing immigrants by what they do in the labour market produces elasticities of 0.294 for (EU) white-collar versus 0.127 for (EU) blue-collar workers, for example. This sharpens the distinction between migrant types.

- Controlling for different product types further highlights the effect of immigrants in the markets for complex, information-intensive goods.[2] Consistent with predictions, I find, for example, that (EU) white-collar workers have a strong above-average influence on the industrial end product and complex input product trade, and no effect at all for non-industrial goods.

- Controlling for the "knowledge" about Germany abroad reduces the elasticity of the blue-collar workers further, but the elasticity of the (EU) white-collar workers remains significantly larger than average.

The rest of the paper is structured as follows: Section 3.2 introduces the IT-CE story, the empirical approach to testing it, and the data. Section

[1] This is close to the estimates in the literature: between 0.129 from Head and Ries [1998] and 0.160 from Girma and Yu [2002].

[2] These results are qualitatively similar to the rest of the literature [see, e.g., Gould, 1994, Rauch and Trindade, 2002]. Unlike the rest of the literature, this paper utilises finer product categories, to distinguish between the end products and input products within the group of industrial products, for example.

3.3.1 presents the results of the general regression with aggregate immigrant stock and all exports: this repeats the approach taken in the literature, for comparison purposes, and introduces the results with lagged immigration variable. Section 3.3.2 introduces the second innovation: it repeats the analysis of section 3.3.1, controlling for the differences in immigrant participation in the labour market. Sections 3.3.3 and 3.3.4 repeat the analysis of sections 3.3.1 and 3.3.2, this time distinguishing between the types of exports and with a proxy for third factors, respectively, to further clarify the IT-CE story of the link between immigration and trade. Finally, section 3.4 concludes.

3.2 Set-up

3.2.1 The migrant story

In this paper, I eschew the preference-driven demand creation story of the immigration–trade link. This channel is very simple and yet may suffer from various complications. A large immigrant group may practice import substitution, meaning negative correlation between immigrant stock and trade; this can be size-dependent. To avoid this sort of effect, I only study exports from the host region to the home country of the immigrants.

The intuitive explanation of how immigrants may affect trade is simple: an immigrant, due to his experience in both his host and home countries, possesses superior knowledge of supply and demand in his home and host countries, and is thus able to utilise this comparative advantage vis-á-vis a local, to realise a potential trading opportunity. This view of immigrants-as-carriers of information is exemplified in the opening quotation.

Another view, that of contract enforcement, has similar structure: immigrants may prefer to deal with those within their ethnic or national group, which allows them a higher level of trust or higher punishment possibilities (through within-group pressure) for renegade behaviour. This is well presented in Rauch [2001] and Rauch and Trindade [2002], who study ethnic Chinese networks around the world and find evidence for higher trade between countries with higher proportions of ethnic Chinese minorities.

But immigrants are heterogeneous in their potential effect on trade. Take the three largest groups of working migrants that can potentially affect trade in any country: blue-collar workers, white-collar workers and self-employed.[3] If the IT-CE story is correct, we would expect blue-collar workers to have a small effect on exports: they are not likely to influence the decision of a company, and therefore not likely to utilise their potential information of foreign contacts.

We would expect the self-employed immigrants to have stronger effect than blue-collar workers, because they can set up trading businesses. However, a lot of immigrant self-employed are in non-exporting service industries. For example, nearly a third of all self-employed migrants (27.7%) is in the hotel and restaurant industry. As a group, then, it is unclear if the self-employed have stronger or weaker influence on exports than blue-collar workers.

While self-employed (with or without employees) are heads of their own companies, white-collar workers may be further removed from the decision-making of their respective companies, but still closer to the decision-making than blue-collar workers. On the other hand, white-collar workers could be employed in larger companies than self-employed entrepreneurs. Furthermore, white-collar workers are well represented in international businesses, unlike the self-employed. A priori, due to this trade-off (smaller influence in larger and international companies), it is impossible to say whether white-collar workers have a stronger potential effect on exports than self-employed, but the expectation is that the second effect dominates. We can also expect white-collar workers to have larger effect than blue-collar workers.

To further highlight the channels through which immigrants are able to affect exports, consider different types of goods. For simple commodities (e.g., wheat, steel) or simple non-industrial products (e.g., some foodstuffs), we would expect zero effect of immigrant-carried information: the price of a commodity alone sends the necessary signal. Thus, if the IT-CE story is the relevant one, we would expect no significant difference in effects of all three groups of immigrants on Bundesland exports of raw materials (e.g., iron ore) and non-industrial goods (e.g., foodstuffs). In fact, for these product types and all the immigrant groups, we would expect no significant effect whatsoever.

For complex goods, on the other hand, the price does not reflect all the

[3]Trainees and family workers are further groups in my dataset, but they can be ignored as they are not likely to affect exports. The same goes for unemployed.

necessary information. Thus, we would expect a stronger-than-average effect of white-collar immigrants on trade in complex industrial products (such as semi-finished and finished goods), and zero effect of blue-collar workers on trade in the same product groups.

This discussion sets up the stage for empirical investigation into the relative effects of different groups of migrants, on different groups of products, and through this into clarifying the different hypotheses of the link between trade and immigrants.

3.2.2 Gravity model

To test the relationship between exports and immigration, I start with an empirical gravity model of trade, which also encompasses immigrant stocks as an explanatory variable.[4] This model assumes constant elasticity of immigration on trade (η):[5]

$$\ln X^{ij} = \alpha + \eta \cdot \ln Immi^{ij} + \beta_1 \cdot \ln Dist^{ij} + \beta_2 \cdot \ln GDP^j + \beta_3 \cdot \ln GDP^i + \beta_Z \cdot Z^{ij}, \quad (3.1)$$

where X^{ij} is the export from host Bundesland i to immigrant home country j; $Immi^{ij}$ is the immigrant stock from country j in Bundesland i; $Dist^{ij}$ is the distance between the capital cities of Bundesland i and country j; GDP^j and GDP^i are the home country and host Bundesland GDP measures; Z^{ij} is a vector of additional controls used in the literature—these are described in section 3.2.4.[6]

For comparison purposes, equation (3.1) is very similar to those in the

[4] "Gravity" refers to the fact that bigger and closer countries trade more with each other. There are different approaches to derive a theoretically-driven gravity equation from a general equilibrium model of trade [see, e.g., Anderson and van Wincoop, 2003, Bergstrand, 1985]. However, utilising these models is data-consuming due to their general equilibrium nature. Given the data limitations, and in particular inability to obtain detailed data on Germans abroad, the approach taken here is a simpler gravity-style model, which is very similar to Head and Ries [1998] and Wagner et al. [2002].

[5] Some authors proposed models with diminishing (export) returns to immigration [see, e.g., Gould, 1994]. It is a priori not clear which model is best. However, for the comparison to the most of the literature and in the absence of hard arguments against it, the linear model is a good choice. Of course, the particular type of the model is an assumption. At least for the relationship between size of the trading partners and the distance between them, the model is also consistent with theory, as mentioned above.

[6] The results reported below are robust to the inclusion and exclusion of various Z-variables, such as GDP per capita.

literature [see, e.g., Wagner et al., 2002]. I modify this equation in several ways to take account of the innovations of this paper:

First, I modify equation (3.1) to utilise the disaggregated information on immigrant employment, which is taken from the German micro-census. To do this, I follow Head and Ries [1998] in decomposing the elasticity η from equation (3.1) into the base elasticity η_b and additional elasticities θ's, dependent on the employment group, such that an export elasticity for a country j is then:

$$\eta^j = \eta_b + \eta_{eub} \cdot EU + \theta_s \cdot S_s^j + \theta_w \cdot S_w^j + \theta_{eus} \cdot EU \cdot S_s^j + \theta_{euw} \cdot EU \cdot S_w^j, \quad (3.2)$$

where η_b is the export elasticity for a non-EU country, whose immigrants into Germany were entirely blue-collar workers, and η_{eub} is the additional effect of EU blue-collar migrants; S_s^j and S_w^j are respectively the shares of self-employed and white-collar immigrants among the total population of immigrants from a country j in Germany; EU is the EU dummy; θ_s, θ_w, θ_{eus} and θ_{euw} are the added effects of self-employed, white-collar, and additionally EU self-employed and white-collar immigrants, respectively.

Depending on the make-up of immigrants from country j in Germany and whether the immigrant home country is in the EU, the additional elasticities θ's are added to the base elasticity η_b to obtain the total elasticity of j-originated immigration on j-destined exports. Example 3.1 helps to clarify this:

Example 3.1 *If all immigrants from country j were white-collar immigrants, the share of white collars would be $S_w^j = 1$, and the elasticity would therefore be $\eta^j = \eta_b + \theta_w$ if country j were not an EU country, and it would be $\eta^j = \eta_b + \eta_{eub} + \theta_w + \theta_{euw}$ if country j were an EU country.*

In this case, instead of just $\ln Immi^{ij}$, the variables of interest are $\ln Immi^{ij}$, $S_s^j \times \ln Immi^{ij}$ and $S_w^j \times \ln Immi^{ij}$. If η from equation (3.1) is substituted with η^j from equation (3.2), the new model then becomes:[7]

$$\begin{aligned}\ln X^{ij} = \quad & \alpha + \eta_b \ln Immi^{ij} + \eta_{eub} EU \ln Immi^{ij} \\ & + \theta_s S_s^j \ln Immi^{ij} + \theta_w S_w^j \ln Immi^{ij} \\ & + \theta_{eus} EU \cdot S_s^j \ln Immi^{ij} + \theta_{euw} EU \cdot S_w^j \ln Immi^{ij} \\ & + \beta_1 \ln Dist^{ij} + \beta_2 \ln GDP^j + \beta_3 \ln GDP^i \\ & + \beta_Z \cdot Z^{ij}. \end{aligned} \tag{3.3}$$

Within the context of equation (3.3), the expectation is that the white-collar variables have significant positive coefficients; since these coefficients have to be added to the coefficient of the base group of migrants (blue-collar workers) to get the elasticity of exports, this would mean that the influence of white-collar workers on trade is higher than that of blue-collar workers. The blue-collar and self-employed effect is not a priori clear, given the amount of blue-collar influence in any company and the amount of self-employed in non-trading industries.

The effect of EU versus non-EU immigrants on trade is also not a priori clear: On the one hand, it is assumed that within the EU, the "normal" IT-CE mechanisms should work well, such that the immigrant networks are of limited additional value in this respect. On the other hand, German EU-destined exports have larger (than non-EU exports) share of semi-finished goods and finished goods that act as inputs into further production, indicating higher share of within-firm trade (or outsourcing)—and trade in these goods requires more intensive information transmission and more trust than trade in simpler goods, such that the scope for within-EU immigrant-related IT-CE can be higher.

To sum up the expectation on the signs of the immigrant group coefficients in different scenarios:

Hypothesis 3.1 *Assume the IT-CE hypothesis as the relevant immigrant–trade mechanism. If all exports are treated the same, and if the "confounding factors" are not controlled for, expect the following from the model in equation* (3.3)*:*

[7] For the more detailed job descriptions, the elasticity decomposition looks identical, but with the following variables: manual non-agriculture workers serve as the base; workers in agriculture, engineering, technical jobs, sales, banking, local transport, other transport, office jobs, security, journalistic jobs, health professionals, social workers, and other workers. Again, the EU-interaction terms are included.

- *θ_w and θ_{euw} should be positive and significant,*
- *η_b, θ_s and θ_{eus} cannot be signed,*
- *η_{eub} and θ_{eus} cannot be signed, but η_{eub} should be significantly smaller than θ_{euw}.*
- *If the lagged immigration variable is used, expect the size of the base elasticity to decline.*

Typically, this is the place at which the analysis is repeated for different product types. Typically, these product types are either consumer and producer goods [Gould, 1994] or homogenous and differentiated products [Rauch and Trindade, 2002]. The present paper goes beyond these dichotomies and looks at much finer product classes, given by:

List 3.1 (Product types used) *(1) Non-industrial products, (2) industrial goods (including raw materials, semi-finished and finished products), (21) raw materials, (22) semi-finished products, (23) finished products (including input and end products), (231) (finished) input products, (232) end products, (22+231) goods that serve in another product's production process (semi-finished products plus inputs).*[8]

If the IT-CE hypothesis is correct, we would expect the white-collar immigrants to have stronger effect the more complex an exported good is. If the self-employed immigrant effect on exports is above average, expect it also to become stronger with the complexity of a good. The effect of the blue-collar workers should be less than the white-collar effect.

Hypothesis 3.2 *Assume that everything is as in Hypothesis 3.1, except suppose that the exports are distinguished by the sub-groups given in List 3.1. Then, in equation* (3.3) *expect:*

- *θ_w and θ_{euw} (and θ_s and θ_{eus} if larger than average) should be larger (and positive) the more complicated the product group is: i.e., close to zero for non-industrial products and raw materials, positive and bigger for finished products, and somewhere in-between for semi-finished products,*[9]

[8] This categorisation is given by Statistisches Bundesamt (German Statistical Office).

[9] Since these coefficients come from different regressions with different dependent variables, we cannot test their respective sizes against each other, but we would expect the differences in sizes to show, nevertheless.

- *η_b, θ_s and θ_{eus} cannot be signed,*
- *η_{eub} and θ_{eus} cannot be signed, but η_{eub} should be significantly smaller than θ_{euw}, the more complex an exported product is.*

3.2.3 Confounding factors

Finally, we can address the confounding factor critique. Suppose that the effect of the blue-collar workers turns out to be positive, significant, and large compared to other immigrant groups: this cannot be explained by the IT-CE hypothesis. One reason for this could be that it picks up an effect of some unobservable factor, a stock of "knowledge" in one country about the other, which affects both migration *and* trade.[10] Suppose that the true model is:

$$\ln X^{ij} = \alpha + \gamma_1 \ln Immi^{ij} + \gamma_2 K^{ij} + \beta_1 \ln Dist^{ij} + \beta_2 \ln GDP^j + \beta_3 \ln GDP^i + \beta_Z \cdot Z^{ij}, \quad (3.4)$$

where K^{ij} is the knowledge of Bundesland i in country j, and the rest is as in Equation (3.1).

Equation (3.4) assumes that immigration carries the knowledge of country j into Bundesland i, but trade is also affected by the knowledge of i in j—this is captured in the variable K^{ij}. In this case, since migration from j to i is likely correlated with K^{ij}, the estimate of η from Equation (3.1) will pick up the joint effect $\gamma_1 + f(\gamma_2)$ from the true model in Equation (3.4), where $f(\gamma_2)$ captures the effect via migration of the knowledge stock on exports. If $\gamma_1 = 0$ in reality, this will not be identified through η.

I attempt to proxy these unobservable K^{ij} with the number of German diplomatic missions (in logs) in the home country of a given immigrant group. There inevitably will be some collinearity between the immigration variable $\ln Immi^{ij}$ and the diplomatic missions variable K^{ij}, which will lead to increased variance of the estimates of γ_1 and γ_2 (i.e., less precision). The upshot is the reduction of bias. Once there is a proxy for K^{ij}, we would

[10] Of course, there can be other confounding factors, but the "stock of knowledge" is general enough to encompass most of them. Deeper investigation is worthwhile, but this warrants a separate article. We shall treat the exercise here as just an example of potential confounding factors. The main goal is to see if the coefficients on immigration variables decline or stay unchanged.

expect the coefficient of the blue-collar group—i.e., the “irrelevant” migrant group—to diminish in size.

Furthermore, the effect of white-collar group could also disappear. This would be a strong signal that the IT-CE hypothis is wrong, and the relevant effect comes purely from this “third” factor. We sum up the hypothesis thus:

Hypothesis 3.3 *Assume that everything is as in Hypothesis 3.2, except now introduce a proxy for the third “confounding” factor, such as the abstract stock of knowledge in one country about the other. Then, expect a decrease in the value and significance of the immigrant effect on exports, compared to the results of Equations* (3.1) *and* (3.3)*.*

Before we move onto the results, one point has to be made. I do not include other potential confounding factors like common language or language distance, that have been mentioned in the trade literature. It would be a valuable addition to our understanding to combine all the potential factors in one regression, but this is beyond the scope of this paper. I do, however, control for some factors common to EU and non-EU countries through dummies.

3.2.4 The data

Each data point is an export flow from a particular German Bundesland to a particular country or a country grouping in a particular year, together with explanatory variables that fit this Bundesland–country–year profile. The choice of countries and country groupings was dictated by the information on the immigrants, obtained from anonymised German micro-censuses of 1996, 1997, and 1998: while the export data was available for each Bundesland and each country in the world, the immigrant groups in German data are sometimes highly aggregated. Table 3.1 gives the list of all countries and country groupings in the sample.

I chose the years 1996, 1997, and 1998 due to a relatively quiet period of the world history at that time, such that there will be as little noise as possible from wars and refugees in the immigrant data. Nevertheless, it turns out to be difficult to draw firm conclusions from the data on non-EU migrants exactly for the reason that they are dominated by the refugees

Table 3.1: Countries and country groups in the sample

Austria	Bosnia-Herzegovina
GB	Croatia
Greece	Serbia & Montenegro
France	CIS
Italy	Poland
Netherlands	Romania
Portugal	Slovak Rep, Czech Rep, Hungary
Spain	Turkey
other EU	other Europe
Morocco	other Africa
USA	other America
Iran	other Middle East
Vietnam	other South Asia
East Asia	

NOTE: "other EU" means: Belgium, Denmark, Finland, Ireland, Luxemburg, Sweden; "other Europe": Switzerland, other CEE, other West Europe; "Other Middle East": e.g., Lebanon, Jordan, Syria, Iraq, Israel; "Other South Asia": e.g., Afghanistan, India, Cambodia, Lao, Pakistan, Thailand, Sri Lanka; "East Asia": e.g., China, Hong-Kong, Indonesia, Japan, Korea, Macao, Philippines from ex-Yugoslavia, for example, and refugees are not expected to influence exports.

Because the lags of immigrant stocks are used, my regressions are pooled regressions for 1997 and 1998 only, with clustering option for standard errors to take account of the same countries present in both years. Any differencing technique would have resulted in no information from the distance, so this is not typically done in spatial trade modelling. The resulting coefficients are the result of cross-country heterogeneity; time dimension plays little role.

In the regressions based on equations (3.1)–(3.4), I use the following variables:

X^{ij} the export from host Bundesland i to immigrant home country j in a given year. The Bundesland-specific export is any good that has its last production stage in that Bundesland, and not an export of the Bundesland with the headquarters of the producing company. So, for example, a Sachsen-produced Mercedes car exported to Poland is an export of Sachsen, and not of Baden-Württemberg, even though the headquarters of Daimler-Benz is in Stuttgart.

$Immi^{ij}$ the immigrant stock from country j in Bundesland i in a given year[11]

$Dist^{ij}$ the distance in kilometres between the capital city of Bundesland i and the capital of country j[12]

GDP^{j} the home country GDP

GDP^{i} the host Bundesland GDP

Z^{ij} includes: home country and host Bundesland GDP per capita in logs,[13] home country price level in logs (a representative country is taken in a region where more than one country is present), the average years of education in the immigrant group in logs (from country j in Bundesland i), EU dummy.

[11]These were obtained from the micro-censuses. Since the micro-census samples only about 500,000 people out of the total population of over 81 million, the numbers from micro-censuses were then scaled up in proportion to the total population in Germany in a given year to achieve the total numbers of migrants in each occupation.

[12]This is road distance if in the same continent (obtained from www.map24.de), or a geographical shortest arc distance, if on different continents; a representative country is taken in a grouping of many countries: refer to Appendix A.1 for more details.

[13]These were constructed from the GDP data and the population data.

All the German-specific data is obtained from Statistisches Bundesamt (German Statistical Office): exports, population, German Bundesländer GDP, and the immigrant numbers from the micro-censuses.

The country GDP, population, price levels were obtained from Penn World Tables, 6.0, and from IMF in case of Angola and Libya (data missing from PWT).

Some summary statistics are presented in Appendix A.1.

3.3 Results

3.3.1 Base regression and the lag question

Table 3.2 presents results of the equation (3.1) in four different variants: regression **A** includes the log of all immigrants in the same year as the exports—this corresponds to the regression used in the literature [see, e.g., Wagner et al., 2002]. Note the implied immigration elasticity of exports: 0.147. This lies between 0.129 found in Head and Ries [1998] and 0.160 in Girma and Yu [2002], and is comparable to other elasticities in the literature [see Wagner et al., 2002]. All of the other coefficients have expected signs.

Regression **A lag** is the same but uses the lagged immigration stock—notice the drop of 12% in the immigration elasticity η, from 0.147 to 0.130 [c.f. 0.129 in Wagner et al., 2002].

Regression **B** is the same as **A** except that the immigrant stock has the following groups deleted: trainees, family workers, and unemployed or those with missing observations on their labour-market involvement. Since the dropped groups were not likely to affect trade, it is not surprising to see the coefficient of the remaining immigrants increase from 0.147 to 0.154.[14] Regression **B lag** is the same as **B** but with the lagged immigration stock—again, the coefficient drops by about 16% to 0.129.

Before going further, let us discuss the choice to include the lagged variable. On the economics side, this is motivated by the natural lag between a decision of an immigrant to set-up an export business and exports. This is especially true if the immigrants are new. However, the year of entry

[14] There is a more prosaic explanation for this increase, too. There are many immigrants with missing occupation in the data: these migrants enter the immigrant stock in regressions **A** but not in **B**. The stock of migrants thus decreases from average of 85,607 for all Bundesländer to 12,804, which must be reflected in the higher coefficient in regressions **B**.

into Germany is missing from my dataset. Thus, the lagged variable cannot distinguish between new immigrants in the previous year (relevant for the following year's exports) and those immigrants that may leave the country the following year (irrelevant for same exports).

On the econometrics side, the lagged immigration stock is nevertheless a good instrument for the current immigration stock. This rules out reverse causality, since this year's exports are not likely to influence last year's immigration,[15] even if they can potentially influence the same year's immigration (through transmitting information of their own).

Taking these two issues into account, we cannot be sure which approach is the right one. I provide both results throughout, for comparison. The qualitative results are the same for both, yet the lagged regressions give lower estimates for the immigration effect. This might indicate that some form of endogeneity exists, and the results in the literature are biased upwards.

Next, I investigate the differences in the immigrants' involvement in the labour market, and their influences on exports.

Table 3.2: Dependent variable: $\log X$; all non-dummy variables are in logs; regression **A** uses all immigrants in the same year as exports, regression **A lag** is the same but with lags; regression **B** uses only blue-collar, white-collar and self-employed immigrants in the same year as exports, regression **B lag** is the same but with lags

Variable (coef)	**A**	**A lag**	**B**	**B lag**
Immigrant stock (η)	0.147**	0.130**	0.154**	0.129**
GDP in home country	0.805**	0.807**	0.803**	0.808**
GDP in host Bundesl.	0.929**	0.930**	0.932**	0.935**
GDP per cap in home	0.443**	0.434**	0.445**	0.434**
GDP per cap in host	0.769**	0.709**	0.740**	0.693**
price level	−0.852**	−0.865**	−0.860**	−0.870**
distance	−0.767**	−0.776**	−0.764**	−0.782**
Intercept	−29.959**	−29.050**	−29.730**	−28.933**
N	687	669	682	664
R^2	0.9	0.901	0.901	0.901
F	522.29	534.549	527.78	536.862

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

[15] This is an assumption, but one that is plausible.

3.3.2 Occupations of immigrants

Table 3.3 presents the results of two versions of regression in equation (3.3): regression **C** uses same-year immigrant stock, while regression **C lag** uses lagged immigrant stock. In both regressions, immigrant stock contains only blue-collar, white-collar workers and self-employed. Blue-collar non-EU workers (denoted in the table as "blue-collar") offer the base effect, and to get the elasticity of all other groups (white-collar or self-employed non-EU migrants, or any of the three EU migrant groups), one has to add the relevant coefficients to the base blue-collar coefficient.

Table 3.3: Dependent variable: $\log X$; all non-dummy variables are in logs; self-employed and white-collar worker variables are actually shares of self-employed and white-collar workers in Germany from the trading partner countries, times the log of total immigrant stock from the same countries in individual Bundesländer, and the blue-collar worker (base) variable is log of this total immigrant stock; regression **C** uses only blue-collar, white-collar and self-employed immigrants in the same year as exports, regression **C lag** is the same but with lags

Variable	**C**	**C lag**
blue-collar (η_b)	0.203^{**}	0.178^{**}
self-employed (θ_s)	-0.187	-0.044
white-collar (θ_w)	-0.089	-0.081
EU×blue-collar (η_{eub})	$-0.076^{\dagger}$	-0.070
EU×self-employed (θ_{eus})	-0.158	-0.512^{*}
EU×white-collar (θ_{euw})	0.256^{**}	0.274^{**}
EU fixed effect	-0.241	0.057
GDP in home country	0.787^{**}	0.804^{**}
GDP in host Bundesland	0.929^{**}	0.924^{**}
GDP per cap in home country	0.613^{**}	0.549^{**}
GDP per cap in host Bundesland	0.738^{**}	0.679^{**}
price level	-0.968^{**}	-0.969^{**}
distance	-0.684^{**}	-0.747^{**}
Intercept	-30.849^{**}	-29.412^{**}
N	682	664
R^2	0.907	0.908
F	296.091	305.225

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

In regression **C**, EU blue-collar workers have a borderline significant negative coefficient, EU self-employed have negative and insignificant coefficient, and white-collar workers from the EU countries have positive and significant coefficient. Once added to the base coefficient, this indicates that the export elasticity from EU white-collar workers ($0.294 = 0.203 - 0.089 - 0.076 + 0.256$) is significantly higher than the base export elasticity (0.203), as well as the elasticity from EU blue-collar workers ($0.127 = 0.203 - 0.076$), as predicted.

However, export elasticity of EU self-employed cannot be distinguished from that of EU blue-collar workers, using a Wald test. It is, however, possible to reject the equality of the EU white-collar coefficient and the EU self-employed coefficient, using a Wald test (with a 90% confidence).

In regression **C lag**, we see the same pattern. The individual coefficients change, however: the base coefficient declines from 0.203 to 0.178, while the EU white-collar coefficient increases from 0.256 to 0.274. Adding the base coefficient, the white-collar coefficient and EU interaction terms' coefficients gives a new EU white-collar elasticity of 0.301 (a slight increase from 0.294). This is consistent with the hypothesis that blue-collar coefficient captures some potential reverse causality effect from trade to migration, while white-collar elasticity should indicate the hypothesised above-average causal effect.

The lower-than-average self-employed effect is consistent with the over-representation of immigrant self-employed in non-exporting service industries. As mentioned before, nearly a third of all self-employed migrants (27.7%) is in the hotel and restaurant industry.

Interestingly, both regressions show significant base effect, which corresponds to the non-EU blue-collar worker elasticity. The EU blue-collar elasticity is lower than that of non-EU blue-collar workers (0.127 to 0.203 in regression **C**). However, this difference is only borderline significant in regression **C** and not at all in regression **C lag**.

More importantly, the EU white-collar effect is significantly higher than that of non-EU white-collar immigrants. This difference might have the following explanations:

First, if the IT-CE hypothesis is correct, the drastic difference between EU and non-EU white-collar workers might hint towards the prevalence of different types of goods exported to the EU and non-EU countries. In extreme, if all non-EU-destined exports of Germany were raw materials, their trade would not require much information other than price—and thus, no room for non-EU white-collar immigrants. On the other hand, when all EU-destined exports are complex inputs into the production of another good abroad, this requires personal contacts and collaboration.

The German Bundesländer exports of complex inputs into other production are in fact higher for the EU than non-EU (including non-EU industrial nations): for Bavaria, for example, the share of "semi-finished" goods from all exports is 0.056 for the EU, and 0.019 for the non-EU countries (including 0.020 for developing nations and 0.0186 for other developed nations).

Second, the EU–non-EU immigrant coefficients difference may also hint on the relative non-importance of differences in institutional factors: If the institutional differences were important, we would expect the without-EU export elasticity of migrants to be larger than within the EU, since within the EU the institutions do not differ as much—thus, there would be less room for IT-CE. Furthermore, if the institutional factors were important, we would expect a positive and significant coefficient for the EU dummy. However, the EU dummy is insignificant in both **C** and **C lag** regressions, and the within-EU immigrants have stronger white-collar effect. This contrasts to the findings of a UK study with Commonwealth versus non-Commonwealth migrants, where a strong "non-Commonwealth" effect is found [Girma and Yu, 2002].

I now turn to disaggregated export data to see if anything more can be said about the "non-EU puzzle", among other things.

3.3.3 Finer trade

This section looks at the evidence of immigrant influence for various disaggregated export flows. The analysis in this section only includes the Bundesländer, which are hosts to the largest immigrant populations (e.g., BW), and/or have large export volumes (e.g., Hamburg), *and* for which the trade data was readily available: Baden-Württemberg, Hamburg, Hessen, Niedersachsen, and Rheinland-Pfalz.[16]

Table 3.4 presents the immigration elasticities of exports from equation (3.1), for the sub-groups of exports given in the List 3.1, for a regression with contemporary immigrant stocks (**D**) and a regression with lagged immigrant stocks (**D lag**), both with the reduced numbers of immigrants (i.e., without unemployed, trainees, and family workers).[17] I also re-estimate the

[16] Hamburg also has a large percentage of its population as immigrants.

[17] Note, I present only the estimates of the log of immigrant stock variable, and suppress all the other variables, to save space; the left-most column contains the name of a

elasticity from equation (3.1) for *total* exports with the reduced sample of Bundesländer, for comparison. Note the elasticity for total exports changing from 0.154 or 0.129 and significant, to, respectively, 0.047 and 0.038 and insignificant (compare with Table 3.2, regressions **B** and **B lag**).

Table 3.4: Immigrant effect on dis-aggregated export groups; note: only the estimates of the log of immigrant stock variable, all the other variables suppressed; the left-most column contains the name of a dependent variable, in each case; regression **D** uses only blue-collar, white-collar and self-employed immigrants in the same year as exports, regression **D lag** is the same but with lags; regressions **F** and **F lag** are the same, but with the added variable for German consular missions abroad.

Dep. Variable	**D**	**D lag**	**F**	**F lag**
(1+2) total exports	0.047	0.038	0.032	0.022
(1) non-industrial products	−0.038	−0.046	−0.018	−0.026
(2) industrial products	0.066	0.060	0.045	0.039
(21) raw materials	0.032	0.038	0.021	−0.028
(22) semi-finished products	0.011	−0.015	−0.009	−0.037
(23) finished products	0.071	0.067	0.051	0.045
(231) finished input products	0.113^{*}	0.119^{*}	$0.094^{\dagger}$	$0.100^{\dagger}$
(232) end products	0.070	0.065	0.049	0.043
(22+232) process goods	0.084	0.074	0.065	0.053

Significance levels : $\dagger$: 10% $*$: 5% $**$: 1%

Our intuition concerning the information-intensity of certain goods seems to be correct: industrial goods have a stronger effect from immigration, with input products and end products having the highest immigrant-induced effect, while raw materials and non-industrial goods have the smallest. Semi-finished products effect seems puzzling, but the products that may serve as inputs into another product's production (semi-finished goods and finished input products) together still have a higher immigrant effect than the average effect across all goods, for both regressions **D** and **D lag** (0.084 and 0.074 versus 0.047 and 0.038).

On the other hand, the effects on all categories but one are insignificant: but the category with the significant effect is input goods, which also has the strongest effect. This is consistent with the predictions. The strong effect on input goods indicates immigrant effect on international supply chains,

dependent variable, in each case.

which arguably requires the most information.[18]

Now, let us look at Table 3.5, which presents the results of the finer analysis of the export product categories, taking into account different types of immigrants (by occupation), again for the restricted choice of immigrant occupations. Similarly to the above, regression **E** uses same-year immigrant stock, and **E lag** uses the lagged immigrant stock.

For total exports in regression **E lag**, the base elasticity is only marginally significant, self-employed have significantly lower elasticity, and no group other than the EU white-collar migrants has a significantly different elasticity. The EU white collars, however, have a significantly higher elasticity also for the goods with higher informational content, as hypothesised. For example, the only significantly positive elasticity for semi-finished goods comes from EU white-collar immigrants, and this is consistent with the suggestion that those occupying important positions in companies utilise their networks to help their companies to participate in international production chains.

In regression **E**, the qualitative effects are similar. One notable exception: EU white-collar effect is marginally more significant for input goods, and bigger for semi-finished goods. In both regressions, as before, the non-EU self-employed elasticity is lower than average. Furthermore, the EU blue-collar workers show positive above-average effect on raw material exports, which is puzzling.

Overall, it is puzzling that for the biggest Bundesländer with the biggest immigrant populations and trade, as opposed to all Bundesländer, the total immigrant effect on total exports becomes insignificant: our intuition would suggest otherwise. This might be explained by the effect of sample size on standard errors, since the signs are the same as in regressions **C** and **C lag**. Furthermore, looking at finer categories of immigrants helps to distinguish between the decision-making group effect and the rest. In particular, the EU white-collar effect is positive and significantly higher than the average effect.

One caveat needs to be mentioned, in the case of EU white-collar workers. Even if the lagged numbers are taken, there can still be reverse causality from future exports to past immigrant numbers if the companies are forward-looking and this results in hiring managers from the potential ex-

[18]See, for example, the literature on theory of the firm, and especially on trust and on complementarities in production.

port markets. At present, my dataset cannot say anything about this.

Finally, the non-EU white-collar "puzzle" remains, but might be explained in the following way: The largest non-EU group of migrants in Germany comes from ex-Yugoslavia. Together, this group is larger than the German Turkish or Italian populations. There are other refugee groups, which I cannot account for. The presence of these groups in Germany cannot be expected to be correlated with German exports to their home countries. I have tried to account for this by selecting a relatively "quiet" period in history (1996–1998), but the basic critique while referring to the non-EU coefficients stays. Such a problem cannot be present within the EU, of course.

Table 3.5: Disaggregated trade categories and the effect of immigrant groups on exports; only the immigrant-related coefficients; regression **E** uses only blue-collar, white-collar and self-employed immigrants in the same year as exports, regression **E lag** is the same but with lags; regressions **G** and **G lag** are the same, but with the added variable for German consular missions abroad; the numbers in brackets are predicted elasticities for EU white-collar migrants for some export groups.

Variable (coef)	**E**	**E lag**	**G**	**G lag**
Dep. variable: total exports				
blue-collar (η_b)	0.117*	0.089†	0.107*	0.078†
self-employed (θ_s)	−0.277†	−0.331†	−0.292†	−0.357†
white-collar (θ_w)	−0.031	−0.018	−0.011	−0.010
EU×blue-collar (η_{eub})	−0.102	−0.057	−0.092	−0.045
EU×self-employed (θ_{eus})	−0.312	−0.360	−0.339	−0.426
EU×white-collar (θ_{euw})	0.249*	0.249*	0.236*	0.231*
	(0.233)	(0.263)	(0.240)	(0.254)
Dep. Variable: (1) non-industrial products				
blue-collar (η_b)	−0.046	−0.018	0.037	0.001
self-employed (θ_s)	−2.149**	−2.058**	−1.916**	−2.014**
white-collar (θ_w)	0.384	0.372*	0.371†	0.328†
EU×blue-collar (η_{eub})	0.011	0.056	−0.011	0.028
EU×self-employed (θ_{eus})	1.771†	1.712†	2.002*	1.969*
EU×white-collar (θ_{euw})	−0.171	−0.201	−0.219	−0.175
Dep. Variable: (2) industrial products				
blue-collar (η_b)	0.128*	0.103*	0.113*	0.088†
self-employed (θ_s)	−0.321†	−0.363†	−0.343*	−0.400†
white-collar (θ_w)	−0.031	−0.023	−0.001	0.017
EU×blue-collar (η_{eub})	−0.067	−0.026	−0.053	−0.010
EU×self-employed (θ_{eus})	−0.365	−0.414	−0.378	−0.458
EU×white-collar (θ_{euw})	0.251*	0.259*	0.233*	0.232*
	(0.281)	(0.313)	(0.292)	(0.327)
Dep. Variable: (21) raw materials				

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... table 3.5 continued

Variable (coef)	E	E lag	G	G lag
blue-collar (η_b)	−0.051	−0.010	−0.039	−0.049
self-employed (θ_s)	−0.140	−0.224	−0.160	−0.321
white-collar (θ_w)	0.011	−0.019	−0.044	0.094
EU×blue-collar (η_{eub})	0.351*	0.401**	0.444**	0.429**
EU×self-employed (θ_{eus})	−0.026	−0.110	−0.038	0.206
EU×white-collar (θ_{euw})	0.398†	0.284	0.375†	0.201
Dep. Variable: (22) semi-finished products				
blue-collar (η_b)	0.054	0.019	0.026	−0.007
self-employed (θ_s)	−0.261	−0.289	−0.303	−0.352
white-collar (θ_w)	−0.116	−0.182	−0.055	−0.111
EU×blue-collar (η_{eub})	−0.014	−0.034	0.010	−0.012
EU×self-employed (θ_{eus})	−0.249	−0.171	−0.166	−0.096
EU×white-collar (θ_{euw})	0.306*	0.330*	0.269†	0.280†
	(0.230)	(0.133)	(0.250)	(0.150)
Dep. Variable: (23) finished products				
blue-collar (η_b)	0.134*	0.108*	0.120*	0.093†
self-employed (θ_s)	−0.341*	−0.383†	−0.361*	−0.419†
white-collar (θ_w)	−0.018	−0.011	0.010	0.027
EU×blue-collar (η_{eub})	−0.064	−0.019	−0.050	−0.004
EU×self-employed (θ_{eus})	−0.377	−0.436	−0.394	−0.487
EU×white-collar (θ_{euw})	0.244*	0.254*	0.226*	0.228*
	(0.296)	(0.332)	(0.306)	(0.344)
Dep. Variable: (231) finished input products				
blue-collar (η_b)	0.151*	0.148*	0.136*	0.132*
self-employed (θ_s)	−0.114	−0.223	−0.136	−0.262
white-collar (θ_w)	−0.162	−0.065	−0.131	−0.021
EU×blue-collar (η_{eub})	−0.036	−0.020	−0.024	−0.005
EU×self-employed (θ_{eus})	−0.450†	−0.412	−0.397	−0.388
EU×white-collar (θ_{euw})	0.306*	0.224†	0.287*	0.194
	(0.259)	(0.287)	(0.268)	(0.300)
Dep. Variable: (232) end products				
blue-collar (η_b)	0.141*	0.115*	0.127*	0.100†
self-employed (θ_s)	−0.381*	−0.411†	−0.402*	−0.448†

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... table 3.5 continued

Variable (coef)	**E**	**E lag**	**G**	**G lag**
white-collar (θ_w)	0.018	0.010	0.047	0.049
EU×blue-collar (η_{eub})	−0.082	−0.039	−0.068	−0.023
EU×self-employed (θ_{eus})	−0.379	−0.458	−0.401	−0.516
EU×white-collar (θ_{euw})	0.228*	0.253*	0.210†	0.227*
	(0.305)	(0.339)	(0.316)	(0.353)
Dep. Variable: (22+231) process goods (semi- and inputs)				
blue-collar (η_b)	0.118*	0.096†	0.100†	0.077
self-employed (θ_s)	−0.132	−0.228	−0.159	−0.274
white-collar (θ_w)	−0.155	−0.100	−0.117	−0.049
EU×blue-collar (η_{eub})	−0.002	0.011	0.013	0.027
EU×self-employed (θ_{eus})	−0.394	−0.342	−0.324	0.296
EU×white-collar (θ_{euw})	0.316**	0.260*	0.293*	0.224†
	(0.277)	(0.267)	(0.289)	(0.279)
N		257		

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

3.3.4 Confounding factors

This section presents the results on the "confounding factor" hypothesis, that the strong correlation between the stock of blue-collar immigrant workers and the Bundesland/home country trade flow can be explained by third factors, such as the general level of knowledge about Germany in the home countries of the immigrants, as well as the general knowledge about the immigrants' home countries in the host Bundesländer.

This knowledge is impossible to measure in reality, so I proxy for it by the amount of German consulates that exist in the home countries of the immigrants. In the case of German diplomatic missions abroad, we need to assume that their set-up is *not* a result of the immigration from those countries into Germany. This assumption is not likely to be true when considering foreign countries' representation in individual Bundesländer:

Using the number of consulates from the immigrants' home countries in given Bundesländer is thus more problematic, since they likely reflect the needs of the immigrant communities and as such are likely to have arisen *after* the immigrants settled in those Bundesländer. In this case, they would not reflect the knowledge stocks that would obtain in absence of any immigration.[19]

Regressions **F** and **F lag** in Table 3.4 show the results of equation (3.1) with the addition of the consulate variables (in Z^{ij}) as the proxies for the generic information about Germany in its trading partners. The consulate variables in the regressions of this section are: the number of German consulates in the trade partner countries, and an interaction of this variable with the EU dummy. Regressions **G** and **G lag** in Table 3.5 come from the equation (3.3) with the consulate variables in Z^{ij}. These results must be compared to regressions **D**, **D lag**, **E** and **E lag** in the same tables.

The qualitative implications of the results are the same as before: more complex goods attract a stronger immigrant effect, and EU white-collar workers are the only group with a strong and significant above-average effect.

Quantitatively, when the consulate variable is introduced in the case

[19] It has to be noted that the number of German consulates abroad is not likely to have changed in the three-year period of study, and as such it acts as constants for the countries in question. Furthermore, as these consulates are representing Germany as a whole, their effects are not Bundesland-specific. Nevertheless, to keep the analysis comparable with the other sections, I keep the Bundesland–home country level of disaggregation and the 1997–1998 period.

of contemporaneous migration and trade, the EU white-collar elasticity increases from 0.233 to 0.240 for total exports between regressions **E** and **G**, and also increases for those individual good types, for which it is significant (the information-intensive goods). When comparing regressions **E lag** and **G lag**, the EU white-collar effect decreases for total exports (from 0.263 to 0.254), but again increases for those types of goods, for which it is significant.

Overall, both lagged and contemporaneous regressions show that the base coefficient declines by around 10% for all product types. The decline is consistent with our hypothesis of unobservable information influencing both trade and migration. The robustness of this change to using lagged migration variable might indicate that the unobservable information is stable over time, but due to the short time series, this conclusion is tentative.

The puzzling size of the EU blue-collar effect on industrial raw materials remain.

3.4 Conclusion

In this paper, I have introduced four innovations to help clarify the effect of immigrants on exports from their host countries to their home countries: I have used lagged immigration stock, distinguished the groups of immigrants according to their host-country labour market involvement, utilised very fine categories of the export goods types, and proposed a novel proxy for the potential unobserved information. Several broad conclusions for policy implications can be reached from the presented analysis.

First, the evidence for the EU migration and trade is consistent with the information-transmission and contract-enforcement hypotheses of the immigration–trade link. I have proposed that the weak non-EU white-collar trade effect is not inconsistent with these hypotheses, since many non-EU migrants are refugees,[20] who have left their home countries under duress, and as such cannot be expected to set-up a trading link with their home country.

Second, immigrants are indeed different when it comes to their potential effect on trade, and treating them as one aggregated group distorts their individual effects. Tables 3.2 and 3.3 indicate that an increase of 10 percent in the number of EU white-collar immigrant to Germany will increase exports

[20] E.g., ex-Yugoslavian immigrants in the early nineties.

by between 2.94 and 3.01 percent,[21] while the same percentage increase in the group of EU blue-collar immigrants will increase German exports by between 1.27 and 1.08 percent, and the same increase in the number of all immigrants will produce a 1.47 or 1.30 percent increase in exports.

Third finding is that more complex goods are affected more by immigrant presence, and especially by the (EU) white-collar workers. This is most visible in the exports of goods that act as inputs into the production of other goods. This shows an importance of EU white-collar workers to international supply chains (see Table 3.5).

Fourth, the self-employed immigrants as a group have similar or lower influence on exports than blue-collar workers, most likely because large proportion of self-employed immigrants work in non-exporting service industries.[22] Together with the strong (EU) white-collar effect, this indicates that migrants do not individually set up exporting businesses, but influence exports through large companies.

Fifth, the elasticities found in the literature are likely to be biased upward because of reverse causality of trade on migration. This can be easily fixed by taking lags of immigration variable as an instrument for itself, which leads to lowering of coefficients by 12 to 16 percent. The qualitative results remain the same.

Finally, the estimates in the literature might also be biased upwards due to another example of endogenity: unobservable factors, which can be correlated with both migration and trade. Taking lagged immigration variable is one way to fix this problem. Trying to proxy for the missing factor is another.

I hypothesise that this missing factor is the stock of knowledge that exists in other countries about Germany, and that it can be proxied by the number of German consular missions abroad. This does not change qualitative results, but decreases the coefficients.

Overall, it is clear that a unifying framework for discussing the influence of immigrants on trade does not suffice. Immigrants are different, and care should be taken when discussing the channels through which migration may

[21] $2.94 = 2.03 - 0.89 - 0.76 + 2.56$.

[22] The insignificant coefficients of the self-employed groups are understood as having no deviation from the base coefficient. Interpreted in this way, "no significance" is also a result, albeit against one of the original beliefs that self-employed immigrants should influence trade.

affect trade. This paper has clarified which channels are important, and how they work.

Chapter 4

The effect of Free Trade Agreements on third countries in markets with differentiated goods

4.1 Motivation

Let us think of a world with international trade restricted by tariffs. What are the implications when a subset of countries signs a free trade agreement (FTA)? In particular, what happens to the welfare of the rest of the world?

The standard answer to this question is explained through the "innocent bystander problem" [Krugman, 1991]: the countries left out of an FTA suffer in welfare. The reduction in welfare is primarily due to trade diversion: joining countries trade more with each other because of lower after-tariff prices, even though there is a potentially more efficient producer in the rest of the world. Some literature on the innocent bystander problem is reviewed in the next section.

In contrast, we show that under some conditions, an FTA between a subset of countries can also benefit the non-participating countries. To present this result, we employ a model of international trade with horizontally differentiated products. For different parameters within the same model, we also re-establish the "innocent bystander" result. Thus, we can highlight the conditions under which the traditional result holds or breaks down.

The intuition behind our results is simple. The FTA between two countries reduces trade barriers and thus increases competition between their firms. This competition leads to a global reduction in prices. Surplus then is redistributed from firms to consumers, which is a standard result. In addition, however, increased competition also leads to a more equal pricing pattern across countries, which reduces the average disutility cost borne by consumers for consuming a product mix not in line with their (non-price) preferences. This is a pure global welfare creation. For a third, non-FTA country, the reduction of its firms' profits due to increased competition reestablishes the trade diversion effect in the literature. However, if that country's consumer population is large, the country's consumer surplus addition will be larger than its firms' losses and thus it will benefit from the FTA.

A key feature of our model is the non-existence of perfect price-discrimination across countries. Each of our firms has a home country but sells its goods globally. Price-discrimination is constrained in our model by potential cross-border arbitrage of consumers. When a firm raises or lowers its prices in one country, its prices in another country will then change equally. Our findings do not necessarily require that prices of a firm are equal everywhere, but we will assume this for simplicity reasons, without loss of generality. That price movements between countries are correlated and there is no perfect price discrimination is supported by several findings [see, e.g., Knetter, 1993].

In the next section, we review the relevant literature and highlight our differences and similarities. In Section 4.3, we introduce a two-country model to familiarise the reader with the workings of the model, before we move on to the welfare analysis in a multi-country case. Section 4.4 concludes.

4.2 Literature

Our paper relates to two strands of literature. The first strand of literature involves the "innocent bystander problem" [Krugman, 1991], which, as the name suggests, discusses adverse effects for third countries left out of an FTA between other countries. To the best of our knowledge, authors in this literature concur with this assessment. In contrast, we highlight conditions under which the innocent bystander is happy to be an innocent bystander.

Of course, it has to be noted that *global* barrier-free trade is welfare-maximising in our model. However, the third country will not object to an FTA between others, because it is a welfare improvement on the case of all-around protection, even for that third non-participating country.

The examples of an "innocent bystander problem" in literature are abundant: Kose and Riezman [1997, 1999] compute a general equilibrium model with asymmetric countries and examine two cases: Case 1, when a small country is left out of the FTA made up of two large countries, and Case 2, when one large country is left out of the FTA made up of the remaining large and small countries [Kose and Riezman, 1999]. They find, among other results, that in Case 1, the small innocent bystander suffers a lot, and in proportion to its relative smallness. Also in Case 2, the third large country loses from the FTA because of a deterioration in its terms of trade.

Bond et al. [2004] show how the third country can win from the creation of an FTA between two other countries, through the strategic incentives of the FTA members to change their outside tariff policy after the creation of the FTA [cited in Andriamananjara, 2004]. When such effects are not present, the third country typically loses; in contrast, we find conditions where the third country (and the world, in total) benefits without any strategic re-adjustment of tariffs by any country.

Andriamananjara [2004] shows that the countries left out of the FTA have an incentive to retaliate with their own trading bloc or with increased protection.

Winters and Chang [2000] and Chang and Winters [2002] discuss what happens to the non-members' firms when several countries enter into an FTA and drop the tariffs against members. The non-member countries' exporters to the member countries face the competition from the member countries' firms. Thus, as the member tariffs go down, the member countries' firms become more competitive, which puts pressure onto the non-member firms to lower their prices. Like in the present paper, this is an effect on the prices of imports that results purely from competition: Winters and Chang [2000] show this empirically for the case of Spain and EC, and, respectively, Chang and Winters [2002] for the case of MERCOSUR.

Ornelas [2007] provides a partial equilibrium model with differentiated goods, with redistributional effects of an FTA: that is, the FTA redistributes the welfare from third countries to the member countries, even if the countries are small compared to the rest of the world (but large enough to influence their own import prices). In our model, too, member countries can appropriate a part of non-member welfare, but this is not the only effect.

The second strand of literature introduces Hotelling line into the international trade framework, either as a spatial economy with countries occupying different segments of the Hotelling line, or as differentiated markets in different countries, connected via trade [think of two parallel Hotelling lines as two countries, see Schmitt, 1990, 1993, 1995], and asks a question of optimal trade policy.

When a spatial economy is involved, it is found that under some conditions the optimal tariff rate is strictly positive: if the companies are able to relocate, a tariff may induce a company to locate away from the border, thus leading to lower average transportation costs inside a country, and hence lower delivered prices to the consumers [Herander, 1997, Porter, 1984]. In our framework, free trade is always optimal for the world as a whole. A FTA between a subset of countries is welfare-improving compared to fully restricted trade, but the distribution of the generated surplus between member and non-member countries depends especially on their respective size.

Finally, Benson and Hartigan [1983] propose a model set-up which is similar to ours, except with two countries. They show redistributional effects of a tariff for consumers. They also show a possibility of a protected firm lowering its prices under some assumptions on competition, such as firms anticipating that their price changes will be completely matched by a competitor and thus that their market shares will remain intact. We differ in the number and the behaviour of the firms, and in our model, tariffs unambiguously increase the price of the protected firm.

4.3 The model

To study the effect of an FTA on the welfare of the non-member countries, we propose a partial equilibrium three-country model of trade in differentiated goods, in the Hotelling style. Two countries will form an FTA, and we will focus on the welfare of the non-FTA country. No effects are lost with the restriction to only three countries.

Our model can represent a world of connected spatial "line" economies, where the ends of the line stand for address-of-sale of otherwise identical goods, and consumers live along these lines at different distances from the points-of-sale. Thus, each line represents the area between the economic centres of two of the three countries, with the border somewhere on that line.

On the other hand, the model also conforms with a "tastes" interpretation, in which the ends of the line represent (national) characteristics of the goods, and consumers are distinguished by how much they prefer one country's good over another's, at given prices. As in the spatial interpretation, there is a border between each pair of countries, which mainly serves to distinguish countries by their size. We prefer this second, "tastes" approach.

We consider a partial equilibrium analysis of one industry, similar to Ornelas [2007].[1] Our industry is small in the sense that the prices in this industry do not affect prices (and thus marginal decisions) in any other industry or market (including factor markets).

Within this industry, firms compete globally in differentiated products. For our results, it suffices that the firms' price setting in various countries is inter-dependent: i.e., when a firm lowers its price in one country, its price in another country must also decrease, and vice versa. In our model, firms will set the same price in all countries. This setup was chosen for simplicity of the model exposition and with no loss of generality.

To motivate this setting, we take as examples two large markets: the automotive and the textile market. Ginsburgh [1994] provides a good overview of barriers-to-trade that existed in the EC/EU automotive market for decades and even as late as 1997.[2] By virtue of exemption from complying with Article 85 of the Common Market Treaty, as well as purely illegal activities, the European automotive industry has set up many and varying barriers to cross-border trade in cars even within EC/EU. The mentioned illegal activities landed many car manufacturers in front of European and regional courts during the 1980's and 1990's, but this is just one indication that the automotive industry was far from competitive [Ginsburgh, 1994].

[1]The model can be closed by an introduction of a competitively produced and traded numeraire good, which serves to balance the trade and fix labour income, but this is not our focus. None of our main results would change. In particular, the results of creation of consumer surplus though a more symmetric consumption of the differentiated good in an asymmetric-country world would still hold. The partial equilibrium nature of our model lets us concentrate on the imperfect competition in our chosen industry, and the associated effects.

[2]1997 corresponds to the year of the last revision of the cited paper

While the barriers-to-trade within the European automotive industry were not tariffs, they nevertheless ensured price discrimination and would fall within our model as most applied at the border. However, even given widespread cross-border price discrimination, the price *movements over time* were still correlated. Table B.1 at the end of the paper shows cross-market price correlations for selected car models across several geographic markets during 1970–1999. Within continental Europe, the price correlations are above 90 percent. The correlations between the continental and the UK markets are never below 77 percent, and often above 90. The low UK-related correlation might be explained by differences in driver's wheel position. Nevertheless, the cross-country price correlation assumption seems validated.

The textile market is subject to tariff negotiations in and with Europe, due to perceived threat of cheap Chinese and Indian textile products. This market would be prime for price discrimination. However, textiles are often traded at several textile expositions, where the buyers come from all over the world to buy centrally, at one price. An example is the Texworld Fabrics fair in Paris, organised by Messe Frankfurt.

Governments set tariffs at the border.[3] We assume that tariffs apply equally in both directions: with countries asymmetric in size, this assumption is not binding, for trade only happens in one direction in our industry. We concentrate on the case of asymmetric countries, as it provides the most interesting insights; our model is Ricardian in nature, such that symmetric countries do not trade—the discussion of this case is relegated to the Appendix B.1. Firms pay the tariffs when exporting into a foreign country. Furthermore for the firms, we assume zero marginal cost of production. As we model market power within our industry, we assume one firm in each country.

Next, we present the details of the model and establish results in a setting with two asymmetric countries to familiarise the reader with the workings of the model, before analysing the welfare implications of tariff movements in a three-country setting in Section 4.3.2.

We attempt to explicitly state and discuss every critical assumption as we go on.

[3]Tariffs are either paid by firms or consumers on a purchase: these settings are equivalent, in our model.

4.3.1 Two asymmetric countries

In the case of two countries, our model is a version of a Hotelling [1929] model. There are two products, i and j, sold in the global market, which is represented by a line of length s normalized to unity. The ends of this line constitute the point of sale of these two products. Consumers are distributed along this line from 0 to 1 with constant density $f(x) = 1$ and thus have a total mass of one (so the CDF $F(1) = 1$). Somewhere on the line is a border B, such that the segment $[0, B)$ represents consumers of one country, and the segment $(B, 1]$ the consumers of the other country.

The location x of a consumer on the line depicts that consumer's (non-price) preferences over the products. The further away x is from the point of sale at 0 or 1, the lower the utility of consuming the respective product. This can be interpreted either geographically such that consumers incur travel costs when purchasing at 0 or 1, or as tastes where distance relates to disutility because product characteristics do not fully match the preferences. As an example for the tastes interpretation, take the car market in Germany and France: the point of sale in France would then correspond to "Frenchness" and the consumers would be distinguished by how much they care about a French car relative to a German one, all else equal.[4]

Consumers are utility maximisers and buy one or zero units of a good of at most one of the countries present. Consumers closer to the border have a stronger preference for buying a foreign product, at given prices, than their fellow citizens from the "centre" of the country. Consumers at 1/2 are indifferent between buying domestic or foreign good, at equal prices. An example of the model is depicted in Fig.4.1.

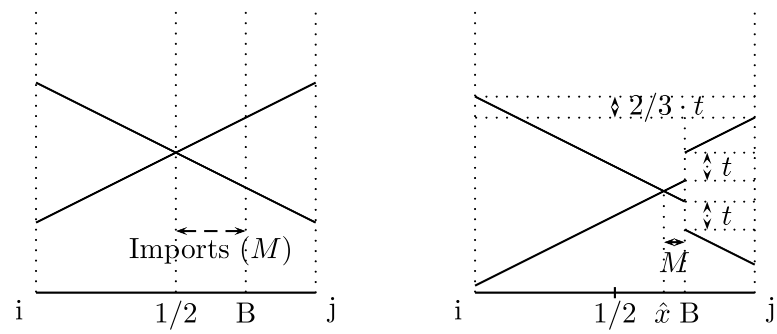
A consumer located at x with $0 \leq x \leq B$ has an additive separable utility from consuming his domestic good i or the foreign good j such that:

$$u_x(p_i) = a - p_i - r \cdot |x - 0| , \tag{4.1}$$

$$u_x(p_j) = a - p_j - t - r \cdot |1 - x| , \tag{4.2}$$

The parameter a is the maximal utility from consumption, p_i and p_j are company i's and respectively j's prices, t is the tariff that the consumer

[4] The taste dispersion can also correspond to geography. Casual observation shows that Saarland has many more French cars than Bavaria. Indeed, the official police cars in Saarland are Peugeot, while in Bavaria they are BMW or Audi.



(a) Free trade, two countries (b) Trade with tariff

Figure 4.1: Free trade and tariff with two asymmetric countries

has to pay when purchasing the foreign product and r is the transportation costs or reduction in utility because the consumed product is away from the individual preferences.[5]

The above utility function refers to a consumer x living in country i, i.e. with $0 \leq x \leq B$. The utility for a consumer x in country j, i.e., with $B \leq x \leq 1$, is symmetric in the sense that a consumption from i costs an additional t while consuming the domestic product j only costs p_j plus $r \cdot (1 - x)$.

The countries presented are asymmetric only due to their relative population sizes. If the border between countries i and j lies closer to where the good j is positioned, i is said to be *large* compared to j. Then i has more consumers and more dispersed preferences. At equal prices, the average consumer of country i prefers good i, while the reverse holds for country j. This is true irrespective of the size of the country.

The number of consumers and the dispersion of tastes go hand-in-hand in this set-up. A bigger country by our definition will have the consumers at its border farther away from its centre than the border consumers of a small country from the small country's centre. In the tastes interpretation, this means that the preferences in the large country are more dispersed, compared to the small country. There is weak evidence that large countries

[5] Assuming another well-used form of the transportation cost function—the quadratic transportation costs—will make distance even more important and should strengthen the results presented in this paper.

are in fact more diverse [see Rose, 2006]. It would be possible to disentangle the number of consumers and their dispersion with no gain of insight but at a cost of losing simplicity.

We also assume that at zero prices and a tariff $t = 0$, every consumer would have a positive utility from buying one of the products.[6] That is, we restrict our exogenous parameters to those values that lead to an effective equilibrium between both countries at $t = 0$. This in particular requires $a - \frac{3}{2}r \cdot 1 \geq 0$, or: $a \geq \frac{3}{2}r$. This is the same as saying that the market is covered.[7]

In each country, there is one profit-maximising firm. Thus there will be one firm i and one firm j, selling their products at 0 and 1 respectively. Firms have zero marginal cost and set prices to maximise profit. If the market is covered, the quantities demanded at a given price are then determined by the distance to the consumer $\hat{x}$ who is indifferent between their and their rival's products. The indifferent consumer can be found at the intersection of the consumer utility curves in Fig.4.1, which due to the tariff include discontinuities at the border. The firms' profit functions are then as follows:

$$\begin{aligned} \pi_i &= \hat{x}(p_i, p_j) \cdot p_i \\ \pi_j &= (1 - \hat{x}(p_i, p_j)) \cdot p_j. \end{aligned} \tag{4.3}$$

We now solve this simple model with two countries for the equilibria with and without tariffs. We set the border at $\frac{1}{2} < B < 1$, such that i is a large and j a small country.

Without a tariff and with equal prices, consumers in country i with $\frac{1}{2} < x \leq B$ will purchase the foreign product from country j. The consumer in country i who is indifferent between the domestic and the foreign good is at $\hat{x} = \frac{1}{2}$, such that there are imports of size $M = B - \hat{x}$ from country j into country i.[8] This is depicted in Fig.4.1(a).

Let us now introduce a tariff t—as in Fig.4.1(b):

Lemma 4.1 *Assume the market is covered ($a \geq \frac{3}{2}r$). If the countries are sufficiently asymmetric and the tariff t is sufficiently low, there exists an equilibrium with imports from the small into the large country.*

[6] The utility from consuming a hypothetical outside good is normalized to 0.

[7] For a detailed discussion of what happens if the market is *not* covered, and the resulting equilibria, please refer to Ivanov and Müller [2006].

[8] Prices will be symmetric at $p_i = p_j = r$. This is the standard Hotelling result.

Proof Assume that there are imports from j into i even under the tariff such that the indifferent consumer lies at $\hat{x} < B$. We then solve for the equilibrium prices:

$$\begin{aligned} \pi_i &= \hat{x} \cdot p_i = & (\frac{1}{2r}(p_j - p_i + t) + \frac{1}{2}) \cdot p_i \\ \pi_j &= (1-\hat{x}) \cdot p_j = & (\frac{1}{2r}(p_i - p_j - t) + \frac{1}{2}) \cdot p_j \\ &\Rightarrow & \begin{cases} p_i^* = r + \frac{1}{3}t \\ p_j^* = r - \frac{1}{3}t \\ \hat{x} = \frac{1}{2} + \frac{1}{6} \cdot \frac{t}{r} \end{cases} \end{aligned} \tag{4.4}$$

The prices p_i^* and p_j^* constitute an equilibrium under the following conditions. The indifferent consumer must lie in country i and the indifferent consumer must derive positive utility from consuming either product:

$$\hat{x} < B \Leftrightarrow t < r \cdot (6B - 3). \tag{4.5}$$

$$U_{x=\hat{x}}(p_j - t) = a - p_j - t - r(1 - \hat{x}) > 0 \Leftrightarrow t < 2a - 3r. \tag{4.6}$$

Given $B > \frac{1}{2}$ and $a > \frac{3}{2}r$, there is always a positive t that fullfills both conditions 4.5 and 4.6.

A word on the direction of trade is in order. Our firms are completely identical. This means that having to satisfy a small domestic consumer base is actually a comparative advantage in the sense that it pushes a firm to export. A bigger-market firm would be content with its own domestic consumers and would not want to export. In absence of domestic economies of scale, the small country–to–large country trade is the natural (partial) equilibrium outcome.

It would be possible to introduce domestic economies of scale, which would benefit a company in a larger country, such that it then behaves “bigger” on the global scale, exporting to smaller countries. This would correspond to different types of markets and mask the main drivers behind our results, but should not remove them. In either case, considering economies of scale should be an interesting extension to our model, but for the time being, we abstract from this consideration.

In what follows, we will focus on equilibria that always exhibit trade under a specified tariff, which also implies trade without a tariff. That is, we look at a world with asymmetric countries, $a > \frac{3}{2}r$ and low enough tariffs. The motivation is simple. If we compared a no-trade equilibrium under a tariff with a trade equilibrium under a FTA, the FTA effects would be stronger. Instead, we want to compare "apples" to "apples".

Next, we discuss the welfare implications of the tariff. Welfare of each country is measured by the sum of consumer surplus CS, producer profits π and, where applicable, a tariff revenue. In the situation of countries i and j as discussed in lemma 4.1, this implies

$$\begin{aligned} W_i &= CS_i(p_i^*, p_j^*) + \pi_i(p_i^*, p_j^*) + t \cdot \left(B - \hat{x}(p_i^*, p_j^*)\right) \\ W_j &= CS_j(p_i^*, p_j^*) + \pi_j(p_i^*, p_j^*). \end{aligned} \tag{4.7}$$

Note that the tariff proceeds enter the welfare of countries but are redistributed to neither consumers nor firms. We can immediately derive the following:

Lemma 4.2 *Assume the market is covered ($a \geq \frac{3}{2}r$). With a tariff and asymmetric countries, equilibrium prices will be unequal. Equal prices and, thus, highest welfare can be achieved* only *under free trade: starting with a tariff equilibrium, welfare strictly increases the closer the countries get to the free trade situation.*

Lemma 4.2 is a standard result in a Hotellin-style models. On the other hand, it is central to our model. Therefore, instead of a proof, we provide a detailed discussion of the Lemma:

Let us look at the case of two asymmetric countries: the intuition is the same with more than two countries.

First, lemma 4.1 shows that with a tariff and asymmetric countries, equilibrium prices will be unequal. Let us now motivate why overall welfare is maximized with equal pricing and no tariff.

To understand the welfare effects of a tariff, it suffices to compare two cases as depicted in Fig.4.2: Equal prices without a tariff and the introduction of a tariff t, holding prices fixed. The second case does not constitute an equilibrium, as argued in lemma 4.1. Instead, prices will be unequal in equilibrium. We ignore this aspect in Fig.4.2 for the purpose of simplicity but will get back to it later on.

In Fig.4.2, the consumer surplus given producer prices $p_i = p_j$ is the total area under the consumer utility curves, $U(p_i)$ and $U(p_j)$. The producer surplus is given by the dotted rectangle at the top between a, $U(p_i)$ and $U(p_j)$, and including the area (A). The parts of these areas to the left of the border B belong to country i, and to the right of B, to country j.

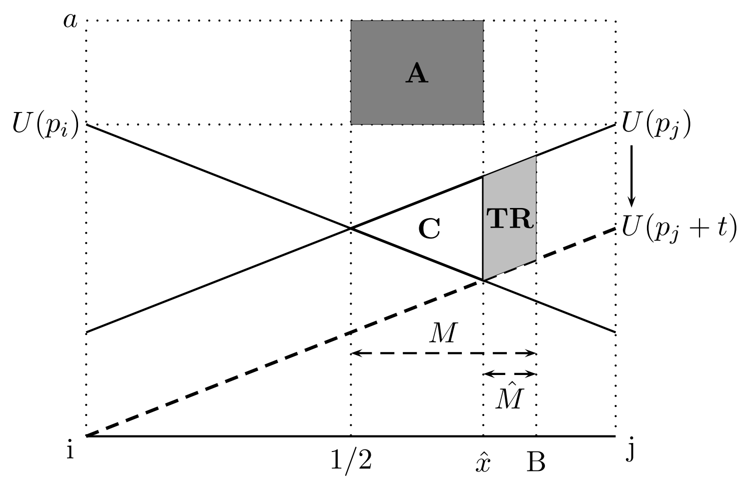


Figure 4.2: Welfare change from a price increase by firm j

Now, imagine for a moment that a tariff t is introduced and prices $p_i = p_j$ stay constant. Then, the effective price that consumers in country i pay for products imported from j increases to $p_j + t$. Thus, imports into i decrease from M to $\hat{M}$ (the indifferent consumer moves from $\frac{1}{2}$ to $\hat{x}$).

The welfare changes in the following way: Country i now has a tariff revenue (TR) (light grey parallelogram) on the remaining imports from j. This tariff revenue is paid by those consumers in i that remain purchasing product j. Thus, (TR) is a pure redistribution of welfare from consumers to the government in country i. In addition, firm i appropriates surplus from firm j because of decreased imports, depicted by the grey rectangle (A). All the other surpluses belong to the same actors also after introducing t, except for the white triangle (C).

This triangle (C) is a pure dead-weight loss, as consumers lying between 1/2 and $\hat{x}$ now purchase their less preferred good (from firm i) over their more preferred one (from firm j). In fact, such a dead-weight loss will always occur once the indifferent consumer $\hat{x}$ lies away from $\frac{1}{2}$. The dead-weight loss (C) could *only* be avoided when the effective price of firm j in country i was equal to the price of firm i, i.e., $p_j + t = p_i$. As lemma 4.1 shows, this does not constitute an equilibrium because $p_j^* + t = r + \frac{2}{3}t \neq r + \frac{1}{3}t = p_i^*$, $\forall t > 0$. Thus, under a tariff, the indifferent consumer will lie to the right of $\frac{1}{2}$ as $\hat{x} = \frac{1}{2} + \frac{1}{6} \cdot \frac{t}{r} > \frac{1}{2}$. The welfare maximizing equilibrium can result *only* from free trade, when prices are equal: with tariff $t > 0$, an asymmetric equilibrium necessarily obtains.

Note that in Fig.4.2, we compared equal prices without a tariff and the introduction of a tariff t, holding prices fixed. From lemma 4.1 instead we know that under the tariff, firms will adjust their prices compared to the pre-tariff situation. Thus the effect of the tariff is compensated by pricing to some degree, but not completely. As lemma 4.1 shows, imports will still decrease relative to the non-tariff situation and the basic intuition of Fig.4.2 holds.

Under a free trade agreement between these two countries, prices are $p_i = p_j = r$ and therefore, the overall world welfare is maximised and equal to

$$W^a = a - \frac{1}{4}r.$$

On the other hand, with a tariff t, the (asymmetric price) equilibrium of lemma 4.1 results in the overall welfare of

$$W^t = a - \frac{1}{4}r - \frac{1}{36}\frac{t^2}{r} < W^a,$$

where W^t is strictly decreasing in t.

The effect of a tariff on the welfare of the importing country is determined by the dead-weight loss in its consumer surplus versus the increased domestic firm's profit due to the appropriation of surplus from the foreign firm. Depending on the size of these changes, country i can gain or lose overall. For the exporting country, we know that welfare will be lower under the tariff as the price of its products as well as the size of exports decrease.

4.3.2 Three asymmetric countries

Let us expand the analysis to three countries i, j, as well as k, and assume that consumers of these countries are arranged along the sides of a triangle as depicted in Fig.4.3. The corners of the triangle represent the points of sale[9] of (domestic) products, just as in the case of two countries. Each side of the triangle is assumed to have length and consumer mass of one. There is one large country i and two identical small countries j and k. The borders are then $\frac{1}{2} < B_{ij} = B_{ik} < 1$ and $B_{jk} = \frac{1}{2}$.[10]

To understand the welfare analysis for individual countries in the subsequent sections, it is important to keep in mind that any move to a more equal pricing pattern, moving the indifferent consumer closer to $\frac{1}{2}$, increases welfare.

We start with the restricted trade situation between all pairs of countries, where symmetric tariffs $t_{ij} = t_{ik} = t_{jk} = t$ apply at every border.

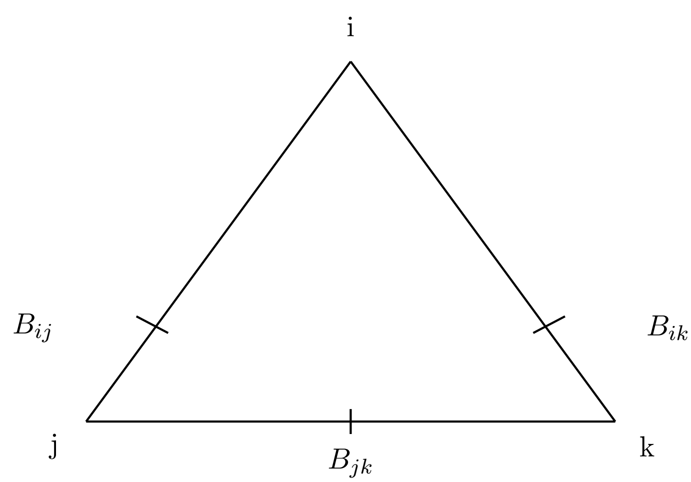


Figure 4.3: One large and two small countries

[9] Or (national) characteristics

[10] We now define without loss of generality that in the market between countries i and j, i is the origin and the position of j is at 1. In the market between countries j and k, j is the origin and the position of k is at 1.

Theorem 4.1 *Let there be two small and one large country with symmetric tariffs; let the market be covered ($a \geq \frac{3}{2}r$). Then, as long as tariffs* t *are low enough, there are two possible equilibria with imports M into the large country from the two small countries. With a low valuation* a *of the good by consumers, $a \in \left(\frac{3}{2}r, \frac{7}{2}r\right)$, a "high" price equilibrium is obtained where firms in the small countries behave like a two-product monopolist. For a high valuation $a > \frac{15+4\sqrt{2}}{10}r$, there is a "low" price equilibrium.*

Proof Because j and k are symmetric and the border between them is set to $B_{jk} = \frac{1}{2}$, the price level in both countries will be the same and there will thus be no trade across the border B_{jk}.

One possible equilibrium includes the price $p_j^c = p_k^c = a - \frac{1}{2}r$ (see Fig.4.4(a)). Under these prices, all consumers in countries j and k consume and the consumer at the border B_{jk} receives zero utility (i.e., he is just indifferent between buying any of the two closest goods or not buying at all). This price would also obtain if there were no tariff but the firms j and k colluded—we call this "high" price equilibrium. We get the following outcome:

$$
\begin{aligned}
p_j^h &= p_k^h = a - \tfrac{1}{2}r \\
p_i^h &= \tfrac{1}{2}a + \tfrac{1}{4}r + \tfrac{1}{2}t \\
\Rightarrow M^h &= 2 \cdot \left(B - \tfrac{1}{8} - \tfrac{1}{4}\tfrac{t}{r} - \tfrac{1}{4}\tfrac{a}{r}\right) \\
\Rightarrow W_i^h &= 2 \cdot \left(\tfrac{1}{8} + \tfrac{1}{4}\tfrac{t}{r} + \tfrac{1}{4}\tfrac{a}{r}\right)\left(\tfrac{7}{8}a - \tfrac{1}{16}r - \tfrac{1}{8}t\right) \\
&\quad +2 \cdot \left(B - \tfrac{1}{8} - \tfrac{1}{4}\tfrac{t}{r} - \tfrac{1}{4}\tfrac{a}{r}\right)\left(\tfrac{1}{2}Br + \tfrac{1}{8}a - \tfrac{7}{16}r + \tfrac{1}{8}t\right), \qquad (4.8)
\end{aligned}
$$

where W_i^h is the welfare of country i, and M^h are the imports into i from country j and k. Note that because j and k are symmetric, we express M^h only as dependent on $B = B_{ij} = B_{ik}$.

This equilibrium needs to be stable against deviating strategies by a single player. This requires specific conditions on a, r, and t. The details can be found in the Appendix B.2.1, but for our discussion it suffices to note that, in particular, t needs to be sufficiently small and a can not be too high. It can be shown that

$$\forall\,(a, B)\ :\ a \in \left(\frac{3}{2}r, \frac{7}{2}r\right) \quad \& \quad B \in \left(\frac{1}{2}, 1\right), \qquad (4.9)$$

there exists a sufficiently low t such that the collusive equilibrium is obtained.

Another possible equilibrium is when companies j and k charge lower-than-collusive prices due to competition with i in the foreign market. This equilibrium is labeled "low" and exhibits the following properties:

$$\begin{aligned}
& p_j^l && = p_k^l = \tfrac{5}{3}r - \tfrac{1}{3}t \\
& p_i^l && = \tfrac{4}{3}r + \tfrac{1}{3}t \\
\Rightarrow \quad & M^l && = 2 \cdot \left(B - \tfrac{2}{3} - \tfrac{1}{6}\tfrac{t}{r}\right) \\
\Rightarrow \quad & W_i^l && = 2 \cdot \left(\tfrac{2}{3} + \tfrac{1}{6}\tfrac{t}{r}\right)\left(a - \tfrac{1}{3}r - \tfrac{1}{12}t\right) \\
& && +2 \cdot \left(B - \tfrac{2}{3} - \tfrac{1}{6}\tfrac{t}{r}\right)\left(a - \tfrac{7}{3}r + \tfrac{5}{12}t + \tfrac{1}{2}Br\right). \qquad (4.10)
\end{aligned}$$

Again, for the existence of this equilibrium, conditions on a, r, and t must hold, and the firms' individual rationality conditions have to rule out profitable deviations. This requires, in particular:

$$a > \frac{15 + 4\sqrt{2}}{10} r \quad \& \quad B \in \left(\frac{2}{3}, 1\right), \qquad (4.11)$$

i.e., that the countries are sufficiently asymmetric in size and consumer valuation of the good is high enough. The detailed conditions can be found in the Appendix B.2.2.

The attractiveness of one equilibrium over the other depends on the surplus that can be extracted from domestic consumers, determined by a, and the export potential into i, which depends on the border $B = B_{ij} = B_{ik}$. If a is large, the FTA countries' firms may forgo export revenue and extract as much surplus as possible from their domestic consumers. Otherwise, the export revenue is more attractive than the domestic revenue. When comparing the two equilibria, it has to be kept in mind that we only analyze situations with trade. For a particularly high a, surplus extraction from domestic customers will be more attractive than exporting. We do not consider this case because we want to compare equilibria with trade.[11] The detailed conditions for the attractiveness of one equilibrium over the other are relegated to the end of Appendix B.2.2.

It is possible to show that the two equilibria in Theorem 4.1 are the only two pure-strategy equilibria possible under given conditions, using the

[11] Otherwise we would be comparing "apples" with "oranges". Our results comparing to the situation with the FTA would be stronger, but inadequate.

arguments of the proof of Theorem B.1 in Appendix B.1.

Next, we abolish the tariff t_{jk} between countries j and k through the formation of an FTA, while the tariffs $t_{ij} = t_{ik} = t$ are upheld. We show its implications for the world welfare through the following theorem:

Theorem 4.2 *Let there be two small and one large country with symmetric tariffs; let the market be covered ($a \geq \frac{3}{2}r$). When the small countries j and k set up an FTA, the overall world welfare increases. If the tariff t is low enough and the third, non-participating, country is big enough, that country's welfare also increases.*

Proof First, we obtain the post-FTA equilibrium prices and imports (depicted in Fig.4.4(b)):[12]

$$\begin{aligned}
& p_j^a && = p_k^a = r - \tfrac{1}{5}t \\
& p_i^a && = r + \tfrac{2}{5}t \\
\Rightarrow \quad & M^a && = 2 \cdot \left(B - \tfrac{1}{2} - \tfrac{1}{5}\tfrac{t}{r}\right) \\
\Rightarrow \quad & W_i^a && = 2 \cdot \left(\tfrac{1}{2} + \tfrac{1}{5}\tfrac{t}{r}\right)\left(a - \tfrac{1}{4}r - \tfrac{1}{10}t\right) \\
& && +2 \cdot \left(B - \tfrac{1}{2} - \tfrac{1}{5}\tfrac{t}{r}\right)\left(a - \tfrac{7}{4}r + \tfrac{3}{10}t + \tfrac{1}{2}Br\right). \qquad (4.12)
\end{aligned}$$

Prices set by firms j and k are clearly lower than before the FTA, due to stronger competition with each other.[13] Note that, due to the abolition of the tariff between them, firms j and k compete more fiercely with each other, but there will still be no trade between these countries due to their symmetry. Because the firms cannot price discriminate internationally, competition is carried over into country i where firm i lowers its price in its own market. The FTA also leads to more imports from the small countries j and k into i. Given the market is covered ($a > \frac{3}{2}r$), we have $M^h < 2 \cdot \left(B - \frac{1}{2} - \frac{1}{4}\frac{t}{r}\right) < M^a$. And for a small t, also $M^l < M^a$.[14]

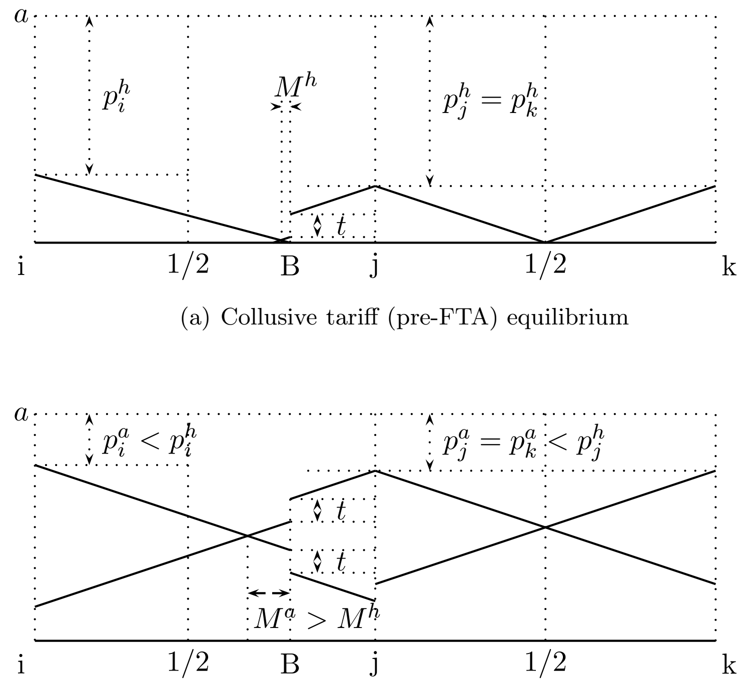
Under conditions (4.9) and (4.11) that ensure collusive and competitive equilibria, respectively, also the FTA equilibrium exists. This is due to the fact that under the FTA, there are more imports and the indifferent consumer in i lies further away from the border than before. The details

[12] Identical effects apply respectively to the comparison between the FTA equilibrium and a pre-FTA competitive equilibrium and are depicted in Fig.B.2 in the Appendix B.2.3.

[13] Note also that prices are below the competitive prices $p_j = p_k = r$ with two countries.

[14] A small t is any $t < 5r$. As discussed in Appendix.B.2.2, the competitive equilibrium also requires $t < 2r$ such that the the former condition is always fulfilled.

of the calculations of the FTA equilibrium are presented in the Appendix B.2.3.



(a) Collusive tariff (pre-FTA) equilibrium

(b) Post-i/j-FTA equilibrium

Figure 4.4: Pre-FTA and post-FTA equilibria with one large and two small countries

With the post-FTA equilibrium in mind, we now proceed to the welfare discussion. We have shown that the indifferent j/k consumer stays at $\frac{1}{2}$ and the i/j and i/k consumers move closer to the middle of their respective markets: thus, as was discussed at the end of Section 4.3.1, we immediately know that the total world welfare post-FTA is higher than before the FTA. We now show under which conditions the non-FTA country i gains, compared to the collusive pre-FTA equilibrium:

$$\begin{aligned} & W_i^a > W_i^h \\ & \qquad \Leftrightarrow \quad -\tfrac{(10a-15r+2t)(30a+(75-160B)r+14t)}{800r} > 0, \end{aligned}$$

which, together with $t > 0$, implies:

$$0 < t < \frac{5}{14}(32Br - 6a - 15r) \text{ and thus } B > \frac{1}{2} + \frac{3}{16}\frac{a}{r}. \tag{4.13}$$

A similar condition when comparing with the competitive pre-FTA equilibrium is then:

$$W_i^a > W_i^l$$
$$\Rightarrow \quad \frac{(5r-t)(5(-7+8B)r-t)}{150r} > 0,$$

which with $t > 0$ implies:

$$0 < t < 40Br - 35r \text{ and thus } B > \frac{7}{8}. \tag{4.14}$$

The welfare effect of the FTA on country i is determined by three factors: First, higher imports into i increase consumer welfare because the equilibrium moves closer to the situation with free trade. The same effect has also been discussed in the case of two countries in Section 4.3.1. Second, higher imports increase the tariff revenue of country i. And third, higher imports and lower prices reduce the profits of firm i. The sum of these countervailing effects determines the net welfare effect on country i.

The sum of the effects is positive for a large enough border B because a large border ensures that a high number of consumers in country i benefit from the downward movement in prices. On the other hand, the loss of firm i does not depend on the border but on the indifferent consumer before and after the FTA.

We have just shown how an FTA can benefit a third country, but it still remains to check the incentive for countries j and k to conclude an FTA agreement in the first place. Because all welfare effects of the FTA within countries j and k are purely redistributional, we concentrate on the potential welfare gain generated through increased exports from j and k into i. It thus suffices to compare firm j's (alternatively, k's) overall revenues from exports before and after the FTA:

$$M_j^a \cdot p_j^a > M_j^h \cdot p_j^h,$$

which implies (with $t > 0$):

$$t > \max\left\{0, \frac{5}{8}(8Br - 2a - 3r)\right\}, \quad \text{with}$$
$$0 < \frac{5}{8}(8Br - 2a - 3r) \quad \Leftrightarrow \quad B > \frac{3}{8} + \frac{1}{4}\frac{a}{r}, \tag{4.15}$$

for the collusive pre-FTA equilibrium, and separately for the competitive pre-FTA equilibrium:

$$M_j^a \cdot p_j^a > M_j^l \cdot p_j^l$$
$$\Leftrightarrow \quad \tfrac{5}{7}(12Br - 11r) < t < \quad 5r. \tag{4.16}$$

There is a range of parameters (a, B, t) with $t > 0$ that simultaneously satisfy conditions (4.13) and (4.15) (or (4.14) and (4.16), with the competitive pre-FTA equilibrium). In the case of (4.13) and (4.15) this holds for any $B > \frac{13}{24} + \frac{5}{36}\frac{a}{r}$ (and in the case of (4.14) and (4.16) for $B > \frac{7}{8}$). For these parameters, not only do countries j and k gain from forming an FTA agreement with each other, but also the "innocent bystander" i gains in welfare, because its consumers benefit from the global competition of j's and k's firms.

4.4 Conclusion

We have presented a partial equilibrium model of international trade, in which an exogenous reduction in the barriers-to-trade may have welfare implications for third, as well as for directly affected countries. When applied to the establishment of an FTA, by treating the barriers-to-trade as tariffs, we who the following: On the one hand, under some parameters, the non-participating country loses in welfare, a situation widely known as the "innocent bystander problem". On the other hand, there are situations under which *all* countries in our model world, including the non-member, may gain in welfare after setting up an FTA between a subset of countries.

The intuition behind our result is simple. Through the FTA, firms in the member countries compete more fiercely with each other and lower their prices. Competition is carried over into the third country. This moves the equilibrium outcome closer to the free trade situation. Since the free trade situation is welfare-maximising, this increases the world welfare.

For the non-participating country, in a certain parameter range, the loss in profit of its firms is outweighed by the gain in its consumer surplus plus the tariff revenue from imports, such that even the non-participating country can gain from an FTA between other countries.

There are potentially many historical settings in which the model can be applied. Setting up of Benelux Customs Union in 1948 may have lead to stronger competitive behaviour of the Benelux companies abroad. New EU members typically have had an FTA agreement with the EU prior to joining, but may have been forced to accept a reduction of barriers to *other* new members, which in turn may have lead to stronger competition of their companies in the old EU, even though nothing has changed on those borders.

Taking the model in the other direction, the break-up of former Yugoslavia and the USSR may have lead to their companies behaving in a less competitive fashion elsewhere in the world. The break-up of these countries can be seen as going from an FTA to a protective world, with an introduction of tariffs and other trade barriers between former trade partners, which within a model would lead to a less aggressive behaviour (i.e., higher prices) by the firms of the ex-member countries.

To sum up, we have attempted to highlight some factors, under which an FTA between a subset of countries may be welfare-improving for all countries, and thus may be viewed as a stepping-stone to the completely free-trade world.

Chapter 5

"Ineffective" competition: a puzzle?

5.1 Introduction

Increased competition between firms in a differentiated market can be defined as an increase in the number of firms present or, alternatively, as a decreased horizontal differentiation between a constant number of firms in a fixed market. Standard thinking about these two kinds of competition in an oligopolistic market would suggest that an increase in competition may lead to weakly lower prices in this market.

In contrast, oligopoly models with additional features like repeated interactions, collusion, threats, or taste for variety, eventually produce a countervailing effect. But even these models in general display the conventional competition effect as described above. So will, for example, more competition in equilibrium also lead to a decreased propensity of collusion and thus lower prices.

In this contribution, we use a standard one stage model of horizontal differentiation as introduced by Hotelling [1929] and Salop [1979] to show that even in a simple setting, increased competition[1] may in fact lead to higher prices without explicit communication amongst the players. Although the discovery of this effect dates back to, in particular, Salop [1979] and Economides [1989], it was not until recent research that this effect has been appre-

[1]Here, the two kinds of increased competition coincide in terms of optimizing behaviour of the firms.

ciated as reasonable strategic behaviour of the players. We independently add our empirical evidence to the con-current works of Perloff et al. [2006] and Chen and Riordan (2006b, 2006a).

In the next section, we briefly review the relevant literature and contrast it with our work. We analyze the comparative statics of the model in depth in section 5.3. Subsequently in section 5.4, we find evidence for a positive relationship between prices and the density of firms in a market of petrol stations in German cities.

5.2 Literature

The fact that it is possible to have increasing equilibrium prices with respect to decreasing differentiation in a Hotelling-type model has been pointed out before. However, it was not until recently that economists started to investigate this effect in detail.

Salop [1979] and Economides [1989] are two works that first report the non-monotone price behaviour that we investigate here. However, these authors seem to have believed the effect to be strange and difficult to see in reality.[2] Their models differ from the other standard Hotelling works[3] in one critical point: Salop and Economides both introduce an outside option for consumers to choose, such that consumers are not forced to participate in the market. In our model—which is a direct descendant of Salop [1979]—if all consumers were made to buy at least from one firm, the pricing behaviour would be monotone positive with respect to the distance between the firms, just as the standard intuition would suggest.

There exists other work that also derives seemingly counter-intuitive results about the behaviour of the firms in horizontally differentiated marketplaces, but these papers have different settings. For example, Stahl [1982] and Schulz and Stahl [1996] study externalities from many firms in one marketplace, which may lead single-product firms in one marketplace to charge higher prices than a multi-product monopolist. They do not look at competing marketplaces, which makes their results different to our paper.

In the last couple of years, many economists started to pay attention to

[2] Beckmann [1972] also reports the same behaviour, but does not discuss it.

[3] Most notably, d'Aspremont et al. [1979], Anderson [1986, 1988], Osborne and Pitchik [1987]

the possibility of "price-increasing" competition.[4] The most notable work in this field is Perloff et al. [2006] and Chen and Riordan (2006b, 2006a).

Chen and Riordan (2006b, 2006a) theoretically expose the conditions under which it is possible to expect equilibrium price to go up in the number of players in a differentiated market, amongst other things, and discuss why this is evidenced in some real-life examples. The former model in this list has Hotelling model as a special case, such that our results would coincide. The latter is a more general study of conditions under which we can expect prices to increase in the number of firms; this model approaches Hotelling model in the limit of certain parameters. One of the effects that we highlight is evident in Chen and Riordan [2006a], but we also discuss the "kink equilibria" where the duopolists independently set prices at the level of a two-product monopoly, and this is outside the parameter range discussed in that paper. Furthermore, we provide direct empirical evidence for our theoretical example.

Perloff et al. [2006] is perhaps closest to our work in the sense that it demonstrates the price-increasing effect of competition within a slightly modified Salop [1979] model, and provides empirical evidence to show this effect. The empirical evidence comes from observing prices of the incumbents and entrants before and after entry of new firms into the US anti-ulcer drug market between 1977 and 1993. While the authors are able to directly address the comparison of duopoly and one-product monopoly situations in the same market, they use a very long time series which may be susceptible to the latter entrants influencing their positioning in the characteristics space.

Our research is both different and complementary to the above. While Perloff et al. [2006] use information from the time series data of prices in a differentiated market, we use the cross-sectional information from the spatial market, which we believe is close to the spirit of Hotelling [1929] and similar models. Furthermore, we put emphasis on (and test for) the "kink" equilibria of the duopoly game, while the above works concentrate primarily on the price comparison across the monopoly-duopoly scenarios.

[4] This is in fact the name of Chen and Riordan [2006a].

5.3 The Model

The model we present is very similar to the model of Perloff et al. [2006]. We present here the basics, and leave some details to the Appendix C.1.

We have two goals:

(a) to investigate the pricing of a duopoly in a differentiated goods market as a function of the degree of differentiation, where the degree of differentiation is given by a transportation cost à la Hotelling, and

(b) to investigate the pricing of a duopoly in a differentiated goods market for a fixed degree of differentiation vis-á-vis two reference cases (one- and two-product monopoly setting) settings.

5.3.1 Set-up

Our market is a line from 0 to s with firms positioned exogenously on the opposite sides and consumers uniformly distributed with density $1/s$ and a total mass of one. This reflects short-run situation in the market where the positioning of the firms is fixed and the firms are only able to change prices. Each point x is that consumer's preferred good, giving him a utility $a > 0$.

Consumers are utility maximizers and buy one or zero units of a good from at most one of the companies present. This decision is summarised in the conditions (5.2) and (5.3) below. They may prefer to buy some homogeneous outside good, which costs 0 and delivers 0 utility to every consumer, irrespective of location.

We assume an additive separable utility form for each person located at x between 0 and s:

$$u_x(p_i, z_i) = a - p_i - t \cdot z_i, \tag{5.1}$$

where $z_0 = x$ or $z_1 = s - x$ is the distance to firm 0 and firm 1, respectively, t is the transportation cost and p_i is firm i's price.

Given firms' prices $p_i, p_{-i} \in [0, a]$, the consumer located at x buys product i if and only if: (a) he prefers good i to good $-i$,

$$u_x(p_i, z_i) \geq u_x(p_{-i}, z_{-i}) \tag{5.2}$$

and (b) he prefers good i to the outside option,

$$u_x(p_i, z_i) \geq 0. \tag{5.3}$$

As the consumers do not act strategically, we can map their decisions directly into the (piece-wise linear) demand function for the firms. The piece-wise demand equation for firm i is then given by the distance from that firm to the closest indifferent consumer weighted with the density of consumers $1/s$ on that part of the market.[5]

$$D_i(p_i, p_{-i}|a, s, t) = \max\Bigg\{ \underbrace{0}_{[0]}, \min\Bigg\{ \underbrace{\frac{a - p_i}{st}}_{[1]}, \underbrace{\frac{1}{2} + \frac{1}{2st}(p_{-i} - p_i)}_{[2]}, \underbrace{1}_{[3]} \Bigg\}\Bigg\} \tag{5.4}$$

From the demand equation (5.4) we get the profit function by multiplying by the price p_i:

$$\Pi_i(p_i, p_{-i}|a, s, t) = p_i \cdot D_i(p_i, p_{-i}|a, s, t). \tag{5.5}$$

The profit function covers the full space of $p_{-i} \in [0, a]$ and the parameters a,s,$t \in \mathbb{R}_+$ and is written out in Appendix C.1.2.

Function $\Pi_i(p_i, p_{-i}|a, s, t)$ from equation (5.5) is quasi-concave and continuous in p_i. The positive part is strictly concave. Therefore, the function has a unique maximum above zero. In fact, given any quadruplet (p_{-i}, a, s, t), the maximiser lies either in the interior of one of the non-zero piece-wise components [1] or [2] of the profit function, or in one of the corners of part [2]. One example for the demand and profit function is depicted in figure 5.1.

5.3.2 Best responses

Maximising the profit from equation (5.5) with respect to p_i, we get firm i's continuous best response function $p_i(p_{-i}|a, s, t)$. For discussion, we name the areas of the best response function. The pieces span the space for all

[5] An example for the demand for firm i's product depending on its price p_i is shown in figure C.1 in Appendix C.1.2.

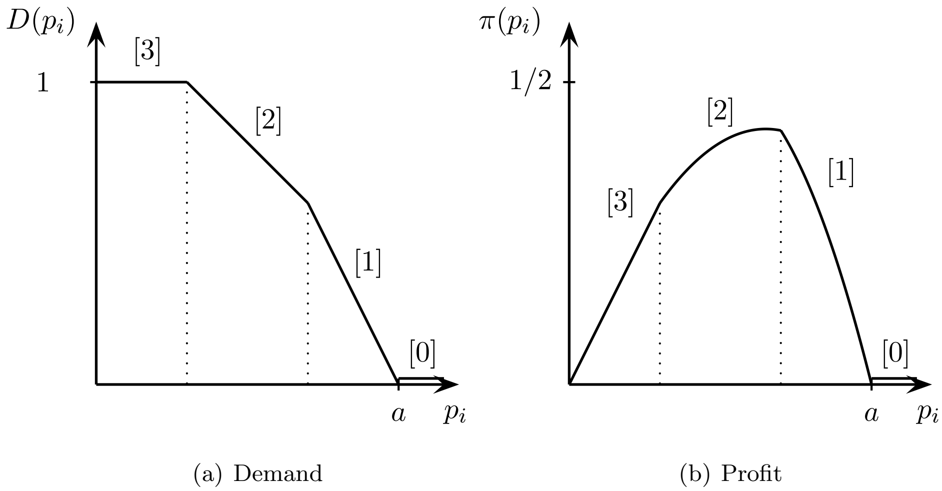


Figure 5.1: Demand and profit regions at fixed parameters $p_{-i} = 0.8$, $a = 1$, $t = 0.5$ and $s = 1$

parameters as shown in figure 5.2.

The parameters for the market size s between the firms and for the relative transportation cost t always enter in the same way as a product for the total transportation cost across the whole market st, such that we don't need to treat them separately from now on. We discuss the firms' rationale behind this best response function by letting st increase and thereby taking us through the different regions of the best response function.

GM Global monopoly ($p_i(p_{-i}|a, s, t) = a - st$): occurs when the competing firm has totally priced itself out of the market ($p_{-i} \geq a$) and the total transportation cost is so low, that the firm finds it optimal to set a price to just serve the whole market.

CM Capturing the whole market ($p_i(p_{-i}|a, s, t) = p_{-i} - st$): here, the competitor prices itself out of competition ($p_{-i} < a$ but still too high such that firm i is able to capture the whole market: $p_{-i} \geq 3st$). Together with global monopoly situation, firm i's maximum profit is at the kink between parts [3] and [2] of the graph in panel (b) of Figure 5.1.

EC Effective competition ($p_i(p_{-i}|a, s, t) = \frac{st+p_{-i}}{2}$): the best response refers to an inner maximum over the part [2] of demand and of profit equation. Here, the market is covered, and any change in prices leads to

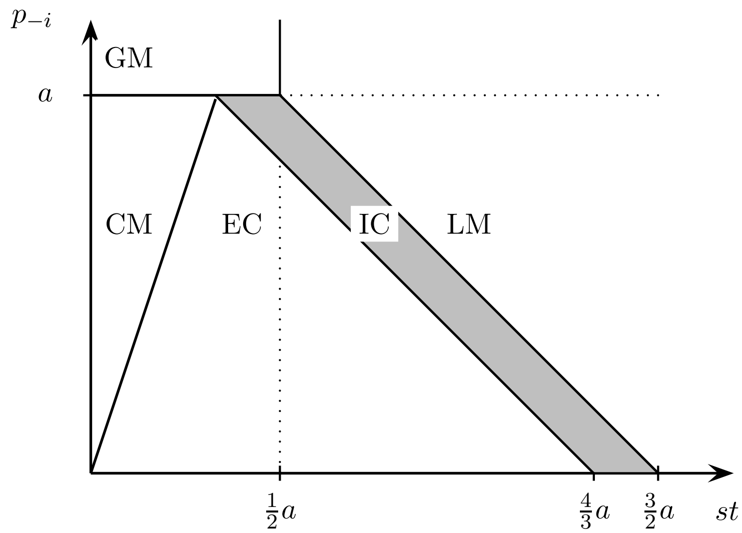


Figure 5.2: Areas of the best response function p_i in p_{-i}–st space

stealing consumers from—or driving your consumers to—the competitor.

IC Ineffective competition ($p_i(p_{-i}|a,s,t) = 2a - st - p_{-i}$): refers to the kink between [1] and [2] in the demand function and in the profit function: if the firm lowers its price, it steals the customers from the competitor; if it increases its price, some customers switch to the outside option—*not* to the competitor. This means the difference in the price elasticities around the kink in the demand leads to the firm pricing at the kink, such that the indifferent consumer is just indifferent between buying from either firm or not buying at all. Note that the prices in this region are strategic substitutes: $\partial p_i(\cdot)/\partial p_{-i} < 0$.

LM Local monopoly ($p_i(p_{-i}|a,s,t) = \frac{a}{2}$): refers to inner maximum over part [1] of the demand and profit function. The total transportation cost here is high enough, such that the firm can ignore the presence of the competitor and set prices in a local monopoly, playing against the outside option. Consumers in the middle remain unserved.

5.3.3 Equilibrium

Solving the system of best response functions, we find that there is a unique pure strategy symmetric Nash equilibrium, with an equilibrium price p_i^* for any parameter tuple (a, s, t). We characterise our equilibrium in terms of st's relation to a as we are interested in the comparative statics with respect to the level of the exogenous parameters st.

$$p^* = \begin{cases} st & \text{if } st \leq \frac{2}{3}a \\ a - \frac{st}{2} & \text{if } \frac{2}{3}a < st \leq a \\ \frac{a}{2} & \text{if } st > a \end{cases} \tag{5.6}$$

Theorem 5.1 *Over some range of product differentiation, the equilibrium duopoly price is* rising *if the market becomes* less *differentiated.*

Proof Follows directly from equation (5.6), if "product differentiation" is taken to mean some combination of the distance between the firms (s) and the transportation cost (t). ♦

The equilibrium prices in equation (5.6) lie in three different regions of the best response function (EC, IC, and LM)—corresponding to three different rationales for the behaviour of the firms—depending on the transportation cost and the distance between the firms, st. The equilibrium price of the duopoly case is pictured with a solid line in figure 5.3. As reference cases, we use the pricing of the one-product monopolist (dotted line) and of a two-product monopolist (dashed line).[6] For small st, the firms engage in effective competition and their behaviour corresponds to standard understanding of lower prices at lower levels of transportation cost or distance. The limit (as $st \to 0$) of this case is marginal cost pricing in a Bertrand competition with a homogenous good. For very high st values, the firms maximize profits by acting as local monopolists and setting the monopoly price $a/2$.

In the middle region ($st \in [a/2, a]$), we see the price first overshoot the one-product monopoly price and then return to the one-product monopoly price with higher st.

[6]Please refer to Appendix C.2 for the computation of the reference cases.

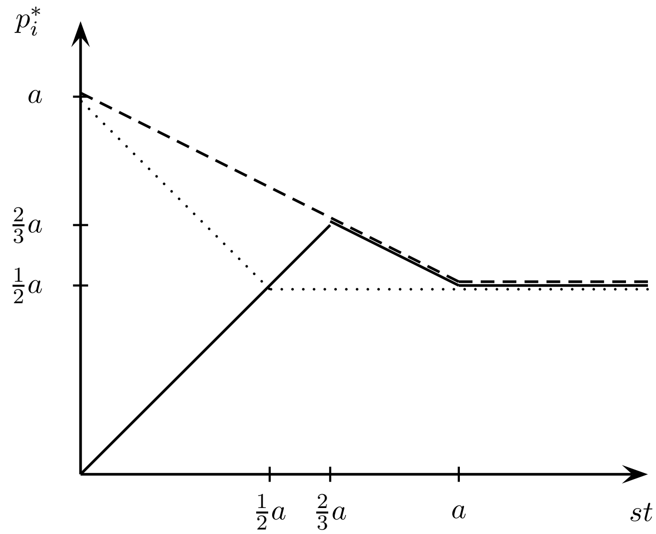


Figure 5.3: Equilibrium prices in the duopoly, and the 1-product and 2-product monopoly reference cases

For $st \in [\frac{2}{3}a, a]$, the equilibrium lies in the region of "ineffective" competition and the duopoly firms act as a two-product monopolist without explicit communication or coordination through repeated games. They are led solely by profit maximization through setting prices. Notably, at all of these st, the firms price such that the indifferent consumer is exactly indifferent between the two goods and the outside option. The firms decide not to engage in competition, instead they evade competition by jointly exploiting the consumers as long as all consumers participate.

The last paragraphs are summed up thus:

Theorem 5.2 *Depending on the degree of product differentiation, an equilibrium duopoly price may be* strictly above *a one-product monopolist price, and may* exactly equal *a two-product monopoly price.*

In Section 5.4, we devise a test to validate Theorem 5.1.[7]

5.3.4 Discussion

We argue, that this equilibrium behaviour reflects a reasonable strategy in practice. The rigidity of the partitioning of the market and the adjustment

[7] We are not able to directly test Theorem 5.2. On the other hand, Perloff et al. [2006] provide a very good treatment of an equivalent of Theorem 5.2.

over prices is directly driven by the different price elasticities of demand for the firms. In this equilibrium, they face a discretely higher elasticity of demand for price increases than for price decreases because they lose more customers to the outside option when increasing the price, than they gain consumers from the competitor when lowering the price.

Similarly, we can assess the effects of ineffective competition in the comparison of the duopoly setting to the two-product monopoly setting. In the region of $st \in [\frac{2}{3}a, a]$, the firms in the duopoly set prices like a two-product monopolist, although they could engage in competition. Here, the market is in fact less than twice the size of the market a one-product monopolist would deliberately decide to serve at its profit-maximising price for the same set of parameters. However, the mere increase in the number of firms at the positions as described in the model on this specific st-range does not decrease the equilibrium prices. As compared to the one-product monopolist, we shall even see a price increase. This effect needs to be considered, when judging on firm concentration in such markets. The effect will be prevalent in markets that at the same time are horizontally differentiated, show limited market expansion as reaction to lower prices in the market, and have an outside option for the consumers.[8]

5.4 Empirical model

In this section, we examine Theorem 5.1 (that equilibrium prices *fall* as the degree of differentiation in a market *increases*, over some range) with the data on the pricing behaviour of petrol stations along the station density in different city districts in Germany.[9] We believe that this petrol market corresponds closely to the spatial competition as presented in our model, despite some problems discussed briefly below. We take the station density, denoted as ζ, as a proxy for the inverse of the distance between the firms ($1/s$) and we assume that the per distance transportation cost t is equal in all cities. Thus, we look at an equilibrium price in our model as a function of the station density ζ, together with the two kinks at ζ' and ζ'' as depicted

[8]See Chen and Riordan [2006a] for an independent theoretical discussion of a similar topic.

[9]A district is an administrative unit at the level of a county ("Landkreis" or "Kreisfreie Stadt" in German), between a community and a state. City districts therefore contain a large city and its closest surroundings.

in figure 5.4. We adapt Theorem 5.1 to have the Empirical Hypothesis 5.1.

Hypothesis 5.1 *The equilibrium prices in the petrol market in German city districts* increase *in station density over some range of observable station densities.*

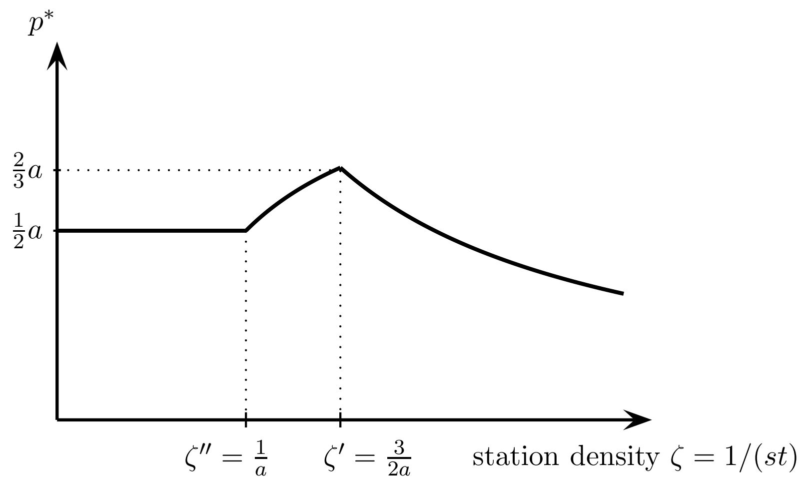


Figure 5.4: Equilibrium price prediction for station density

It is clear that effective competition (to the right of ζ') is abundant, and this has in fact been shown in Karle [2005], for this particular data set. We do not believe that local monopolies exist in the market for petrol in German city districts, which is why we do not expect to find the part of the curve that is to the left of ζ'' in figure 5.4.

What we add to the discussion is the identification of the middle section of "ineffective competition": we first reject the hypothesis that the prices are a downward-sloping function of station density across *all* station densities, then we find a suitable value for a kink point ζ', and estimate a two-part connected linear curve around this kink.

To bridge the gap between the model of section 5.3 and our empirical work, we need to assume that consumers and stations are in fact distributed uniformly within the district, that consumers do frequent the closest station, *ceteris paribus*, and that districts have zero interaction with each other. Of course, these are strict assumptions. For one, consumers' locations are typically not given by their physical address, but rather by their every-day route to and from work (which furthermore may be in a different district). On the other hand, we believe that any distortion from these problems should enter in the same way irrespective of the observed station density. Therefore, these distortions should at worst hinder our analysis and at best have no effect, but they should not help us identify the upward-sloping part of the curve around the kink ζ' in figure 5.4.

5.4.1 Data

We use daily German petrol station price data collected for 78 days starting April 13, 2005, from a service website for retail petrol price comparisons.[10]

Some of the original sample entries had missing observations for our variables of interest. For example, Sunday and Saturday prices were largely not reported by the stations, so we only include weekday prices in the sample. While there were some observations from the rural districts, only the city districts ensure that the sample observations are representative of all the petrol stations in a district. At the end, we are left with a consistent subsample of the original data that contains daily price observations for 807 petrol stations in 93 major German city districts for 63 days.

The stations are divided into brand types: Premier-brand or A-type (e.g., Shell, BP), second-tier or B-type, and independent or C-type, according to their differentiation in the eyes of consumers.

We treat the districts as markets in the sense of section 5.3. Our dependent variable is the average retail price of one litre of petrol in a district, for each day and brand type, which gives us $14,984$ observations. We need to control for the changes in variables that may influence consumer preferences (the brand type, income) and marginal cost (local wholesale price per litre), as these are held constant in the model of section 5.3. In fact, the local wholesale price changed dramatically during the sample period, while income is different across the districts. We thus consider as independent variables: station density in a district, income per capita in a district, the brand type and the local wholesale price.

The income is measured as local GDP per capita in a city; the local GDP is taken from "Volkswirtschaftliche Gesamtrechnungen der Länder 2003".

[10]For a detailed data description, see Karle [2005].

The wholesale price is the daily price reported for the petrol spot market in Rotterdam, by Energie-Informationsdienst; we take a 5-day moving average of this price to capture the adjustment lag of the retail price to the wholesale price changes. The local wholesale price is then the moving average of the Rotterdam price adjusted for time-persistent local differences, which are reported weekly by Europe Oil-telegram. The station density, ζ, is measured as the average number of stations per square kilometre in a district.

5.4.2 Testing for negative relationship between prices and station density

Suppose we know the value ζ' in figure 5.4. In order to test for negative price–station density relationship, we first partition the 14,984 observations into two parts according to the kink station density, $\bar{\zeta} = \zeta'$: with $n_1(\bar{\zeta})$ observations to the left of $\bar{\zeta}$, and $n_2(\bar{\zeta}) = 14,984 - n_1(\bar{\zeta})$ to the right. We then use OLS to estimate a two-part connected linear curve with a kink at $\bar{\zeta}$, which gives us two slope parameters for the curves on the right and left partitions. Last, we test the equality of these two parameters using a Chow test, which is stated formally below.

Of course, we cannot compute ζ'. Instead, we repeat our estimation and test pragmatically for different assumed values of $\bar{\zeta}$. We start with $\bar{\zeta} = 0.25$ and move down in increments of 0.005 until $\bar{\zeta} = 0.09$.

To estimate the two curves with the constraint that they meet at $\bar{\zeta}$, we transform the station density to be around 0 with:

$$\text{adjusted station density} = \text{station density} - \bar{\zeta}, \tag{5.7}$$

which permits us an estimation of one intercept for both parts of the curve in a single OLS regression. Now we can fit the two-part connected linear model, which allows for different parameters in different partitions:

$$\begin{bmatrix} p_1 \\ p_2 \end{bmatrix} = \begin{bmatrix} i & X_1 & 0 & Z_1 & 0 \\ i & 0 & X_2 & 0 & Z_2 \end{bmatrix} \cdot \begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta_1 \\ \delta_2 \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}, \tag{5.8}$$

where p_1 and p_2 are the $n_1 \times 1$ and $n_2 \times 1$ vectors of the dependent variable observations (the average retail petrol prices in a district, for each day and brand type) in the left and right partitions, respectively; i is a vector of 1's; X_1 and X_2 are respectively $n_1 \times 1$ and $n_2 \times 1$ (left and right partition) matrices of station density observations; Z_j is an $n_j \times 4$ matrix of control variables for two partitions (with $j = 1, 2$ and the controls being: moving average of the Rotterdam wholesale price adjusted for local differences, income, and two dummies for brand types A and B); α is the price at the connection of the two lines (corresponds to the intercept since X_1 contains only negative values after the transformation); β and γ are the slope coefficients for the left and right partitions (X_1 and X_2, respectively); δ_j is the 4×1 vector of coefficients for Z_j, $j = 1, 2$; and $\epsilon_{1,2}$'s are the disturbances (assumed i.i.d.).[11]

We allow for different effects of the Z control variables in different partitions, by partitioning all the Z control variables according to the same kink station density $\bar{\zeta}$. Our hypothesised relationship between the station density and price is different for different partitions, but the model of section 5.3 is silent about the effects of independent variables other than station density. There is no reason to assume that the effect of, for example, marginal cost on price is the same in the ranges of effective and "ineffective" competition, since in the latter part the pricing is driven by the kink feature of the demand curve.

Given the empirical model in equation (5.8), our testable hypothesis is

$$\mathbf{H_0} : \beta = \gamma. \tag{5.9}$$

The data analysis shows that at any $\bar{\zeta}$, the right partition has a negative relationship between the price and station density. If the data can identify the part of the curve that is between ζ'' and ζ' in Figure 5.4, then our test will reject the equality of slopes for the right and left partitions around $\bar{\zeta} = \zeta'$. Furthermore, the slope of the left partition should be positive.

We assume that the disturbances have a zero mean and are uncorrelated with any of the regressors.

To cope with potential heteroscedasticity, we calculate the standard errors using the White covariance matrix, such that our estimation and tests are heteroscedasticity-robust.

[11] Our estimation and tests are robust to the exclusion of the Z controls. We do not report the results here, but they can be obtained directly from the authors.

5.4.3 Results

For all tested kink points $\bar{\zeta} \leq 0.14$, we can reject the null hypothesis of equal slope coefficients in both partitions with at least 98% confidence. Furthermore, the slope in the left partition is positive and significant at a 1% level for all kink points $0.105 < \bar{\zeta} \leq 0.135$, and positive and significant at a 10% level for all kinks $\bar{\zeta} \leq 0.105$ and at a 5% level for $\bar{\zeta} = 0.14$. The model fits equally well for all the tested kink points (R^2 is slightly above 56%).

For large values of $\bar{\zeta}$, we cannot reject the null. Both slope coefficients are negative and significant and cannot be said to differ. The F-statistics and the associated p-values of the above tests for all $\bar{\zeta}$ are given in Table C.1 in the appendix C.3.

Thus, we have shown that the relationship between station density and prices is not monotonic. In particular, the relationship is positive for low station density, and becomes negative after a certain kink point. We conclude that this turning station density is around $\bar{\zeta} = 0.135$ (the highest tested potential kink point to deliver positive and significant slope of the left partition and still leave many observations to the left).

Finally, we fit the curve in equation (5.8) for $\bar{\zeta} = 0.135$. The results of the regression are given in table 5.1. To illustrate the relationship, we picture the fitted price curve against station density in figure 5.5.

To summarise,

Result 5.1 *The equilibrium pricing in the German petrol market is consistent with Empirical Hypothesis 5.1 and Theorem 5.1: across the markets with low station density, the equilibrium price is* increasing *with station density.*

5.5 Conclusion

In this contribution we showed that increased competition may lead to higher prices in a simple model of horizontal differentiation. We analysed especially the comparative statics of the price-increasing behaviour and we argued that it represents a rationalisable strategy of firms. This is supported empirically in the retail petrol market in Germany.

We can rule out alternative explanations for this price-increasing behaviour, such as collusion, since we have seen both price-increasing and

Table 5.1: Estimation results of equation (5.8) with $\bar{\zeta} = 0.135$

Variable	Coefficient	(Std. Err.)
station density$\leq \bar{\zeta}$	0.1018**	(0.012)
station density$> \bar{\zeta}$	−0.0079**	(0.002)
marginal $cost_1$	0.9651**	(0.008)
marginal $cost_2$	0.9526**	(0.007)
$income_1$	$2{\cdot}10^{-4**}$	(0.000)
$income_2$	$2{\cdot}10^{-4**}$	(0.000)
A_1	0.0197**	(0.001)
A_2	0.0157**	(0.000)
B_1	0.0131**	(0.001)
B_2	0.0059**	(0.000)
Intercept	0.8861**	(0.002)
N	14984	
R^2	0.566	
$F_{(10,14973)}$	2218.716	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

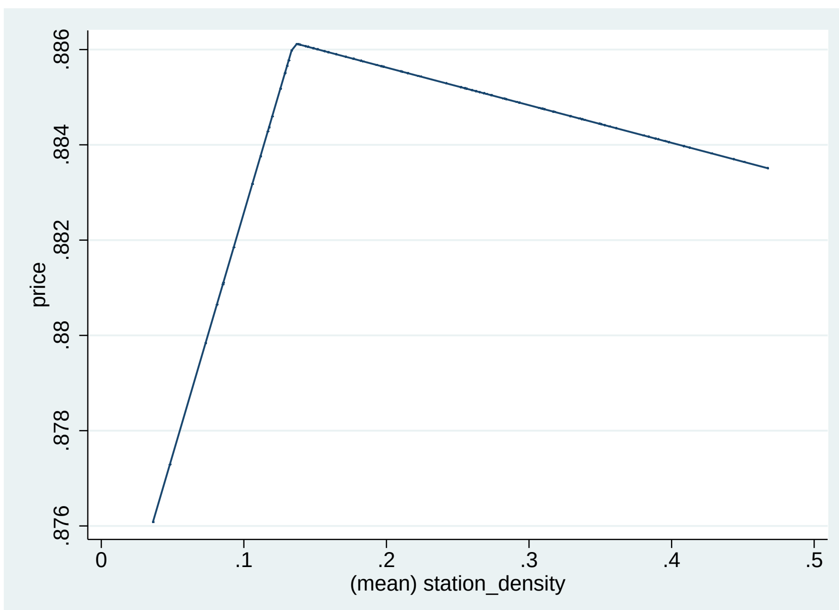


Figure 5.5: Predicted prices

price-decreasing behaviour of the firms with respect to station density. The firms in this market are typically large enough to be present in many markets; if they colluded, we would expect collusion to exist over the whole range of station densities, but this is clearly not the case.

The set of markets in which this effect surfaces is, as usual, limited but exists, as we have shown in the empirical section. The market needs to be horizontally differentiated, it needs to have an outside option for all potential buyers, and its expansion due to lower prices needs to be limited. A strictly kinked demand curve, as in our simple example, is in fact not a necessary prerequisite, as one can show for a family of locally smoothed-out demand curves. Clearly also, this model is only powerful with restricted entry and exit to the market, as we have for example in the short term examination that is done in the empirical part of the paper.

The model is general enough in its description of consumers and producers that it can also be applied to increased integration of international producer-supplier markets, which occurs when improved communication technologies and opening of the local markets reduce the perceived transportation costs[12] between previously distant agents. Take the product to be an intermediate input, the two producers to be the suppliers of this input, and the consumers as the manufacturers of a final good. As long as this producer-supplier market fulfils the conditions described in the previous paragraph, one of the model's predictions is that for a certain exogenous fall in the perceived transportation costs (i.e., more world integration) the manufacturers experience higher costs of intermediate inputs in the short run.

From a competition policy point of view, for the relevant markets with features as above, competition authorities need to consider this behaviour when judging on market concentration as classical concentration measures might be misleading, if they purely measure market share ratios of the participating firms.

Furthermore, the firms' strategy of 'evading competition' and accommodating to a shared market even without explicit communication, needs to be appreciated as a reasonable and profit maximizing strategy of players in markets that seemed to follow the standard intuition about competition.

[12]These can include real transportation costs plus information costs, etc.

Appendix A

Appendix to Chapter 3

A.1 Data

Definition A.1 (Representative country) *In a region where more than one country is present and the two countries with the biggest trade with Germany are similar in this measure, the country with the second largest trade with Germany is called "representative country" on the grounds that it is closer to the median country. If the country with the biggest trade with Germany is too dominant, it is taken to be the representative country: e.g., Russia in CIS.*

The qualitative results go in the same direction if the country with the biggest trade with Germany is used.

Tables A.1 and A.2 present the summary statistics for the variables in the regressions with all Bundesländer and for Bundesländer with finer trade data, respectively.

Table A.1: Summary statistics

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
nu. immi (micro-census)	36	(90.581)	0	1104	809
nu. immi total	5987	(14873.609)	0	179426	809
nu. immi restricted	5449	(13588.605)	0	165072	809
share self-employed (S_s^j)	0.134	(0.172)	0.008	1	809
share white collar (S_w^j)	0.352	(0.171)	0	0.669	809
share blue collar (S_b^j)	0.513	(0.22)	0	0.822	809
$S_s^j \cdot \ln Immi$	0.856	(0.77)	0.049	6.876	722
$S_w^j \cdot \ln Immi$	2.692	(1.302)	0	6.45	722
$S_b^j \cdot \ln Immi$	3.958	(1.915)	0	9.708	722
$EU \cdot S_s^j \cdot \ln Immi$	0.334	(0.552)	0	2.157	722
$EU \cdot S_w^j \cdot \ln Immi$	1.131	(1.805)	0	6.45	722
$EU \cdot S_b^j \cdot \ln Immi$	1.016	(1.783)	0	7.101	722
In millions of Euro:					
export	1,970	(3,758)	0.311	28,811	782
GDP home country	1,786,329	(3,362,173)	6,562	15,299,542	782
GDP host Bundesland	254,066	(239,458)	41,098	862,711	841
distance (km)	2,594.134	(2,637.748)	0	9,861	841
EU	0.3	(0.458)	0	1	841
price level	58.96	(30.255)	15.926	121.585	782

Table A.2: Summary statistics for limited Bundesländer and finer trade

Variable	Mean	(Std. Dev.)	Min.	Max.	N
nu. immi (micro-census)	51	(94.368)	0	750	270
nu. immi total	8430	(15524.2)	0	122138	270
nu. immi restricted	7732	(14206.655)	0	113288	270
share self-employed (S_s^j)	0.088	(0.063)	0	0.283	270
share white collar (S_w^j)	0.368	(0.162)	0.132	0.680	270
share blue collar (S_b^j)	0.545	(0.209)	0.175	0.838	270
$S_s^j \cdot \ln Immi$	0.729	(0.513)	0	2.381	267
$S_w^j \cdot \ln Immi$	3.003	(1.296)	0.924	6.098	267
$S_b^j \cdot \ln Immi$	4.520	(1.969)	1.173	9.475	267
$EU \cdot S_s^j \cdot \ln Immi$	0.326	(0.546)	0	2.098	267
$EU \cdot S_w^j \cdot \ln Immi$	1.281	(1.968)	0	6.098	267
$EU \cdot S_b^j \cdot \ln Immi$	1.224	(2.08)	0	7.588	267
In millions of Euro:					
export	2,588	(3,689)	8	25,411	270
GDP home country	1,768,272	(3,383,641)	6,562	15,299,542	270
GDP host Bundesland	301,679	(144,777)	133,607	548,536	270
distance (km)	2784.096	(2611.349)	0	9674	270
EU	0.333	(0.472)	0	1	270
price level	59.163	(29.882)	15.926	121.585	270

Appendix B

Appendix to Chapter 4

B.1 Equilibrium under two symmetric countries

Assume that there are two countries i and j and the border between them lies exactly at $B = \frac{1}{2}$. With a tariff $t = 0$, the result of this setup is familiar: each company will set prices equal to $p_i = p_j = rs = r$. The consumer indifferent between purchasing from country i or from country j lies directly at $B = \frac{1}{2}$, thus no trade occurs. Producer surplus in each country is $PS_i = PS_j = \frac{1}{2}r$. Consumer surplus in each country is $CS_i = CS_j = \frac{1}{2}a - \frac{5}{8}r$. Overall welfare in both countries is then $W = r + a - \frac{5}{4}r = a - \frac{1}{4}r$.

Now a tariff $t \geq 0$ is introduced. The following proposition then can be derived.

Proposition B.1 *With a tariff t, there can be at most one symmetric equilibrium in pure strategies, with prices $p_i = p_j = a - \frac{r}{2}$.*

Proof Assume that an asymmetric price equilibrium exists, such that country j exports into country i (see Fig.B.1(b)). Then the indifferent consumer in country i is given by:

$$\begin{aligned} a - p_i - r\hat{x} &= a - p_j - t - r(1 - \hat{x}) \\ \Rightarrow \qquad \hat{x} &= \frac{1}{2} + \frac{1}{2r}(p_j - p_i + t), \end{aligned} \tag{B.1}$$

This leads to equilibrium prices being:

$$\begin{aligned} p_i &= r + \frac{t}{3} \\ p_j &= r - \frac{t}{3}, \end{aligned} \tag{B.2}$$

which leads to the indifferent consumer outside country i with $\hat{x} = \frac{1}{2} + \frac{1}{6} \cdot \frac{t}{r} > 1/2$, a contradiction.

Alternatively, consider a candidate for an asymmetric equilibrium depicted in solid lines in Fig.B.1(c). Prices are such that firms share the market in half. Consider firm j's incentives. It has at least one profitable deviation from the solid price schedule (as shown by the dashed price schedule in Fig.B.1(c)). Therefore, the solid price schedule cannot be an equilibrium. The dashed price schedule cannot be an equilibrium, either, because firm i would now want to deviate.

Thus, consider symmetric price schedules in solid lines in Fig.B.1(d). Clearly, firm i has at least one profitable deviation (a dashed price schedule), so this cannot be an equilibrium.

Consider price schedules depicted in solid lines in Fig.B.1(e): $p_i^h = a - \frac{r}{2}, \quad i = 1, 2$. This equilibrium corresponds to the collusive or monopoly pricing outcome as it would also be obtained if the same firm offered its product in both countries.[1]

This is an equilibrium if a deviation is not profitable. Increasing prices would lead to a local monopoly outcome where some consumers in a country would not be served, which has been ruled out to be profitable already with free trade due to the assumption $a \geq \frac{3}{2}r^2$. When firm j decreases its price, the dashed line in Fig.B.1(e) represents the highest attainable profit. Firm j's price and profit in this case is:

$$p'_j = \frac{1}{2}\left(a + \frac{r}{2} - t\right), \tag{B.3}$$

$$\pi'_j\left(p_i = a - \frac{r}{2}, p_j = p'_j\right) = \frac{1}{8r}\left(a + \frac{r}{2} - t\right)^2, \tag{B.4}$$

For the price p'_j to be a successful deviation strategy for j, it needs to

[1] We thus label the equilibrium tc for collusive given a tariff.

[2] See Ivanov and Müller [2006] for detailed discussion on this assumption and the possibility of kink equilibria if it is relaxed.

be by at least t smaller than $p_i = a - \frac{r}{2}$ because otherwise no consumer in i will switch to consuming j. We can thus write:

$$\frac{1}{2}\left(a + \frac{r}{2} - t\right) \leq a - \frac{r}{2} - t, \tag{B.5}$$

$$t \geq a - \frac{3}{2}r, \tag{B.6}$$

To confirm whether a deviation strategy is profitable for j, we thus have to compare j's deviation profit with the collusive profit. The collusive price schedule (solid line) under tariff t yields:

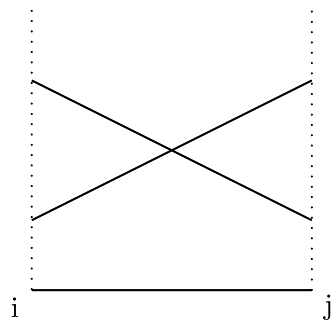
$$\pi_j^h = \frac{1}{2}\left(a - \frac{r}{2}\right). \tag{B.7}$$

As the deviation profit π_j' is strictly decreasing in t, we can analyze the deviation strategy for the lowest possible $t = a - \frac{3}{2}r$ given that this $a > \frac{3}{2}r$. The deviation profit π_j' then becomes $\pi_j'(t = a - \frac{3}{2}r) = \frac{1}{2}r$. Requiring deviation not to be profitable thus yields:

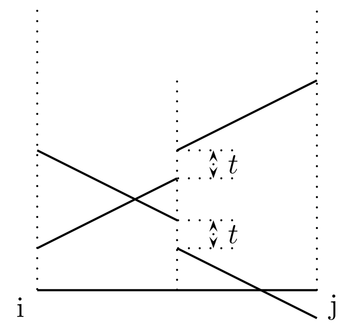
$$\begin{aligned} \pi_j^h &> \pi_j' \Rightarrow \\ a &> \tfrac{3}{2}r. \end{aligned} \tag{B.8}$$

Thus, for all $a > \frac{3}{2}r$ deviating from the collusive price schedule $p_i^h = p_j^h = a - \frac{r}{2}$ is not profitable.

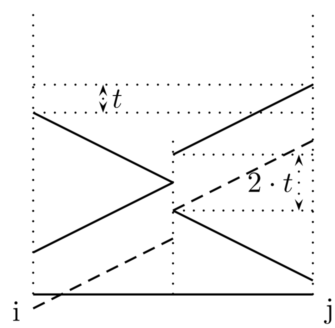
Introducing a tariff $t \geq a - \frac{3}{2}r$ then results in no trade as in the situation without a tariff. Consumer surplus in each country is $CS_i^h = CS_j^h = \frac{1}{8}r$. Overall welfare in both countries then is $W^h = \frac{1}{4}r + a - \frac{1}{2}r = a - \frac{1}{4}r$. Because all consumers are served and the average transportation cost does not differ, overall welfare does not change relative to the situation without a tariff. Yet the price in each country will increase to the collusive outcome and thus surplus is redistributed from consumers to firms.



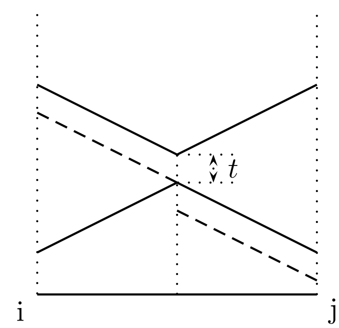
(a) Free trade, two countries



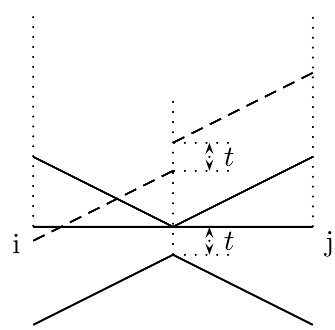
(b) Asymmetric prices



(c) Asymmetric prices, no trade



(d) Tariff, two countries



(e) Tariff equilibrium

Figure B.1: Free trade and tariff with two countries

B.2 One large and two small countries - calculation of price equilibria

B.2.1 Collusive price equilibrium before FTA

The collusive equilibrium with symmetric tariffs yields the following:

$$\begin{aligned}
& p_j^h && = p_k^h = && a - \frac{1}{2}r \\
& p_i^h && = && \frac{1}{2}a + \frac{1}{4}r + \frac{1}{2}t \\
\Rightarrow\quad & \hat{x}_{jk}^h && = && \frac{1}{2} \\
\Rightarrow\quad & \hat{x}_{ij}^h && = \hat{x}_{ik}^h = && \frac{1}{8} + \frac{1}{4}\frac{t}{r} + \frac{1}{4}\frac{a}{r} \\
\Rightarrow\quad & \pi_j^h && = \pi_k^h = && \left(\frac{11}{8} - \frac{1}{4}\frac{t}{r} - \frac{1}{4}\frac{a}{r}\right) \cdot \left(a - \frac{1}{2}r\right) \\
\Rightarrow\quad & \pi_i^h && = && \frac{1}{r} \cdot \left(\frac{1}{2}a + \frac{1}{4}r + \frac{1}{2}t\right)^2 .
\end{aligned} \tag{B.9}$$

Note that given $a > \frac{3}{2}r$ it holds that $\hat{x}_{ij}^h > \frac{1}{2} + \frac{1}{4}\frac{t}{r} > \frac{1}{2}$.

There are three conditions that need to be met such that the collusive equilibrium with trade between one large and two small countries exists.

A. B.1 *(Trade condition) Equilibrium prices allow trade, i.e. especially i imports from j and k respectively, i.e.*

$$\begin{aligned}
& \frac{1}{2} && \leq \hat{x}_{ij}^h < B < 1 \\
\Rightarrow\quad & t < 4Br - \tfrac{1}{2}r - a. &&
\end{aligned} \tag{B.10}$$

A. B.2 *(Consumer's individual rationality) All consumers consume one of the available products, especially the indifferent consumers in country i, i.e.*

$$\begin{aligned}
U(x = \hat{x}_{ij}^h, p_j - t) & = a - p_j - t - r\hat{x}_{ij}^h > 0 \\
\Rightarrow\quad & t < \tfrac{1}{3}a - \tfrac{1}{2}r.
\end{aligned} \tag{B.11}$$

A. B.3 *Firms have no incentive to deviate from the equilibrium and there is no incentive to deviate to another price, i.e. especially a price lower than*

p_j^h:

$$\begin{aligned}\pi_j(p_j^h, p_k^h, p_i^h) &> \pi_j(p_j', p_k^h, p_i^h) \\ \Rightarrow \tfrac{1}{9}a + \tfrac{29}{18}r - \sqrt{\tfrac{5201}{44}r^2 + 704ar - 224a^2} &< t \\ &< \tfrac{1}{9}a + \tfrac{29}{18}r + \sqrt{\tfrac{5201}{44}r^2 + 704ar - 224a^2}. \end{aligned} \tag{B.12}$$

Because of A.B.1 we known that a can not be too high, fact $a \leq \frac{7}{2}r$ as otherwise no positive t can fulfill the condition for any value of B. Inserting a low $a = 2r$ into the admissible range for t as given by A.B.3 yields $-23.3 < t < 26.9r$. Thus in this case A.B.2 is binding and requires a $t < \frac{1}{6}r$. Instead also A.B.1 can be binding given $B < \frac{13}{24}r$. We conclude that a low a and a sufficiently high B will always allow for a range of parameters t such that the collusive equilibrium exists.

B.2.2 Competitive price equilibrium before FTA

Finding the prices $p_j^l = p_k^l < a - \frac{1}{2}r$ that are below the collusive prices and that can support an equilibrium requires solving the following firms' profit functions:

$$\begin{aligned}\pi_j &= \pi_k = \frac{1}{2r}(p_i - p_j - t + 2r) \cdot p_j \\ \pi_i &= \frac{1}{2r}(p_j + p_k - 2p_i + 2t + 2r) \cdot p_i \end{aligned} \tag{B.13}$$

This yields:

$$\begin{aligned} p_j^l &= p_k^l = \frac{5}{3}r - \frac{1}{3}t \\ p_i^l &= \frac{4}{3}r + \frac{1}{3}t \\ \Rightarrow \hat{x}_{jk}^l &= \frac{1}{2} \\ \Rightarrow \hat{x}_{ij}^l &= \hat{x}_{ik}^l = \frac{2}{3} + \frac{1}{6}\frac{t}{r}. \end{aligned} \tag{B.14}$$

The profits then are:

$$\begin{aligned} \pi_j^l &= \pi_k^l = \frac{1}{2r}\left(\frac{5}{3}r - \frac{1}{3}t\right)^2 \\ \pi_i^l &= \frac{1}{r}\cdot\left(\frac{4}{3}r + \frac{1}{3}t\right)^2. \end{aligned} \tag{B.15}$$

As in the situation of the collusive equilibrium, several conditions need to me met such that the competitive price equilibrium is stable.

A. B.4 *The competitive price needs to be below the collusive price, i.e.*

$$\begin{aligned} p_j^l &< p_j^h \\ \Rightarrow \quad t &> \tfrac{13}{2}r - 3a. \end{aligned} \tag{B.16}$$

A. B.5 *(Trade condition) Equilibrium prices allow trade, i.e. especially i imports from j and k respecively, i.e.*

$$\begin{aligned} \frac{1}{2} &< \hat{x}_{ij}^l < B < 1 \\ \Rightarrow \quad t &< 6r\left(B - \tfrac{2}{3}\right). \end{aligned} \tag{B.17}$$

A. B.6 *(Consumer's individual rationality) All consumers consume one of the available products, especially the indifferent consumers in country i, i.e.*

$$\begin{aligned} U(x = \hat{x}_{ij}^l, p_j - t) &= a - p_j - t - r\hat{x}_{ij}^l > 0 \\ \Rightarrow \quad & t < 2a - 4r. \end{aligned} \tag{B.18}$$

A. B.7 *Firms have no incentive to deviate from the equilibrium. We first consider a deviation upwards by t by the firm in country j. This would yield the potentially highest profit for an upwards deviation which is:*

$$\pi_j(p_j^l + t, p_k^l, p_i^l) = \tfrac{1}{18}\left(25r - 10t - 8\tfrac{t^2}{r}\right) < \pi_j(p_j^l, p_k^l, p_i^l). \tag{B.19}$$

Deviating upwards by t yields a profit below the competitive equilibrium profit and thus a deviation is never profitable. We therefore also check a deviation downwards and find:

$$\begin{aligned} p_j^*(p_k^l, p_i^l) &= \tfrac{5}{4}r - \tfrac{1}{2}t \\ \Rightarrow \quad \pi_j(p_j^*, p_k^l, p_i^l) &= \tfrac{25}{16}r - \tfrac{10}{8}t + \tfrac{1}{4}\tfrac{t^2}{r}. \end{aligned} \tag{B.20}$$

To uphold the equilibrium, the resulting profit needs to be lower than the profit in the competitive equilibrium and thus:

$$t > \left(2 - \tfrac{6\sqrt{2}}{5}\right) r. \tag{B.21}$$

We conclude that the competitive equilibrium exists only for values of t that are larger than the values stated in condition.B.4 and condition.B.7 as well as smaller than the values given by condition.B.5 and condition.B.6. A common range of values for all the conditions exists for $B > \frac{2}{3}$ and $a > \frac{15+4\sqrt{2}}{10}r$, i.e. when the countries are sufficiently asymmetric in size and consumer valuation of the good high enough.

For $a \in \left(\frac{15+4\sqrt{2}}{10}r, \frac{7}{2}r\right)$ and $B \in \left(\frac{2}{3}, 1\right)$, both the collusive and the competitive equilibrium exist. The collusive equilibrium then yields higher profits given any $a < \frac{23}{6}r - \frac{2}{3}t$.[3]

B.2.3 Price equilibrium after FTA

Abolishing the tariff t_{jk} induces competition between countries j and k and will thus generally reduce prices. Reducing prices p_j and p_k is expected to lead to more imports from the small countries j and k into i. Thus we solve:

$$\begin{aligned} \pi_j &= \pi_k = \frac{1}{2r}(p_k + p_i - 2p_j - t + 2r) \cdot p_j \\ \pi_i &= \frac{1}{2r}(p_j + p_k - 2p_i + 2t + 2r) \cdot p_i \end{aligned}$$

Equilibrium prices then are:

$$\begin{aligned} p_j^a &= p_k^a = r - \frac{1}{5}t \\ p_i^a &= r + \frac{2}{5}t \\ \Rightarrow \quad \hat{x}_{jk}^a &= \frac{1}{2} \\ \Rightarrow \quad \hat{x}_{ij}^a &= \hat{x}_{ik} = \frac{1}{2} + \frac{1}{5}\frac{t}{r} \end{aligned} \tag{B.22}$$

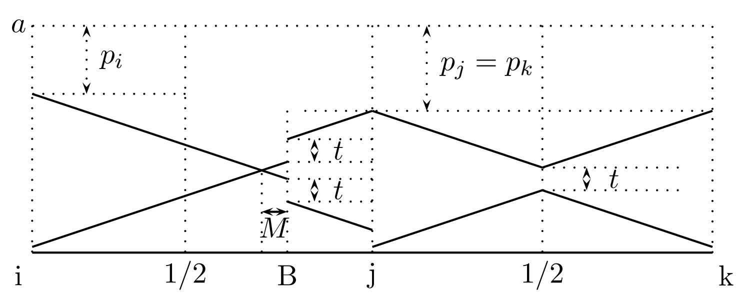
[3] And consequently for any $t < 5r$.

and the profits are:

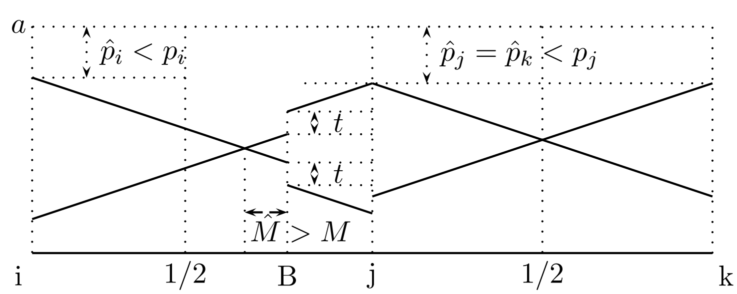
$$\begin{aligned} \pi_j^a &= \pi_k^a = \frac{1}{r}\left(r - \frac{1}{5}t\right)^2 \\ \pi_i^a &= \frac{1}{r}\left(r + \frac{2}{5}t\right)^2 \end{aligned} \tag{B.23}$$

By comparing with Appendices B.2.1 and B.2.2, one can readily observe that $\hat{x}_{ij}^a < \hat{x}_{ij}^h$ and for $t < 5r$ also $\hat{x}_{ij}^a < \hat{x}_{ij}^l$. Thus, there are more imports from the small countries j and k into i. Thus, when conditions A.B.1, A.B.2, A.B.5 and A.B.6 are fullfilled, also the FTA equilibrium exists.

The comparison between the FTA equilibrium and the pre-FT competitive equilibrium yields similar results as the comparison to the pre-FTA collusive equilibrium: Prices decrease and imports M into country i increase. Fig.B.2 depicts the two equilibria.



(a) Competitive tariff (pre-FTA) equilibrium



(b) Post-i/j-FTA equilibrium

Figure B.2: Pre-FTA and post-FTA equilibria with two small and one large country

Table B.1: Cross-market price correlations for selected car models and geographical markets. The models have been selected to have been in the European car market for the longest possible period of time (in the boundaries of 1970-1999), and to represent different European car producers.

	Belgium	France	Germany	Italy	UK
1. VW Golf					
Belgium	1				
France	0.98	1			
Germany	0.99	0.98	1		
Italy	0.97	0.97	0.98	1	
UK	0.94	0.96	0.96	0.98	1
2. Opel Astra					
Belgium	1				
France	0.95	1			
Germany	0.98	0.95	1		
Italy	0.89	0.93	0.91	1	
UK	0.8	0.78	0.77	0.85	1
3. Renault Clio					
Belgium	1				
France	0.99	1			
Germany	0.98	0.98	1		
Italy	0.92	0.94	0.96	1	
UK	0.91	0.93	0.94	0.96	1
4. Opel Corsa					
Belgium	1				
France	0.95	1			
Germany	0.98	0.95	1		
Italy	0.89	0.93	0.91	1	
UK	0.8	0.78	0.77	0.85	1
5. VW Polo					
Belgium	1				
France	0.96	1			
Germany	0.99	0.95	1		

Continued on next page...

... table B.1 continued

	Belgium	France	Germany	Italy	UK
Italy	0.93	0.93	0.93	1	
UK	0.91	0.9	0.92	0.97	1
6. Ford Fiesta					
Belgium	1				
France	0.96	1			
Germany	0.98	0.97	1		
Italy	0.92	0.97	0.95	1	
UK	0.83	0.9	0.85	0.91	1
7. BMW 3er					
Belgium	1				
France	0.98	1			
Germany	0.99	0.99	1		
Italy	0.96	0.96	0.97	1	
UK	0.94	0.96	0.95	0.97	1
8. VW Passat					
Belgium	1				
France	0.99	1			
Germany	0.99	0.98	1		
Italy	0.95	0.95	0.94	1	
UK	0.94	0.9	0.92	0.92	1
9. Peugeot 306					
Belgium	1				
France	0.97	1			
Germany	0.96	0.94	1		
Italy	0.94	0.93	0.94	1	
UK	0.89	0.85	0.89	0.91	1
10. Fiat Bravo					
Belgium	1				
France	0.93	1			
Germany	0.97	0.96	1		
Italy	0.9	0.95	0.91	1	
UK	0.8	0.88	0.81	0.94	1

Appendix C

Appendix to Chapter 5

C.1 Derivation of equilibria

The model we use can be thought as an adaptation of Salop [1979]. The market is given by a Salop circle of circumference $2 \cdot s$. Each point on the circle represents a differentiated good that is most preferred by a consumer occupying that point. Consumers are uniformly distributed along the circle, with density $1/s$, which results in a constant consumer mass of 2. There are two identical firms, positioned exactly opposite each other at 0 and s. Like Salop [1979], we are interested in the analysis of the short term behaviour in the pricing game and thus we also assume that the firms' positions are fixed exogenously. We normalise marginal costs of production to zero. When a consumer x consumes a good offered at $y \neq x$, he incurs a disutility or transportation cost, $t \cdot |x - y|$, according to the shortest arc-length distance between x and y. Consumption of either good delivers to the consumer a pure utility of $a > 0$ in monetary terms, which is then adjusted for the price paid and the transportation cost.

For simplicity, we cut the market in half.

C.1.1 *Hinterland*

Earlier work was concerned with the non-existence of pure strategy equilibria in similar Hotelling settings. We choose our set-up in a simple way, such that typical problems pertaining to pure strategies[1] do not occur, in order

[1] E.g., jumps in demand due to undercutting the rival's price, leading to non-existence of pure strategy equilibria.

to allow for clear presentation of our case. This relates to the amount of firms and their symmetric position, given which, it is impossible to obtain the *hinterland* of your competitor. Take firm i, which prices such that the consumer at location of its rival, $-i$, just prefers $-i$ to i. Lowering its price by a small amount, firm i does not gain all of the consumers *on the other side* of $-i$, because it has already been serving those consumers from the other side of the circle. The *hinterland* does not exist.

C.1.2 Profit and demand regions

Firms set prices $p_i \in [0, a]$—a compact, convex set. The lower bound is the marginal cost, normalised to zero for simplicity of exposition. Setting any price equal to or above a would lead to demand of zero for firm i. Therefore, we establish the upper bound a on the price set. Relaxing this assumption does not change the results.

$$\Pi_i(p_i, p_{-i}|a, s, t) =$$

$$\begin{cases} [0] \quad 0 & \big((p_i \geq p_{-i} + st) \wedge (p_{-i} \leq a - st)\big) \\ & \vee (p_i \geq a) \\ [1] \quad \frac{a-p_i}{st} \cdot p_i & (2a - p_{-i} - st \leq p_i \leq a) \\ & \wedge (p_{-i} \geq a - st) \\ [2] \quad \left[\frac{1}{2} + \frac{1}{2st}(p_{-i} - p_i)\right] \cdot p_i & (p_{-i} - st \leq p_i \leq 2a - p_{-i} - st) \\ & \wedge (p_{-i} \leq a) \\ [3] \quad p_i & \big((p_i \leq p_{-i} - st) \wedge (p_{-i} \leq a)\big) \\ & \vee \big((p_i \leq a - st) \wedge (p_{-i} \geq a)\big) \end{cases} \tag{C.1}$$

The piece-wise linear parts of the demand can be associated with regions of demand patterns, as described below.[2]

[0] Demand is zero if a firm prices higher than the price of its competitor at the firm's location $\big((p_i \geq p_{-i} + st) \wedge (p_{-i} \leq a - st)\big)$ or too high for all consumers at $(p_i = a)$

[2] An example for the demand for firm i's product depending on its price p_i is shown in figure C.1.

[1] The first interesting part of demand corresponds to firm i being a local monopolist. A small decrease in price leads to engaging previously idle consumers in trade; a small increase leads to him losing customers to the outside option.

[1]-[2] The kink between parts [1] and [2]. If the firm lowers its price, it steals the customers from the competitor; if it increases its price, some customers switch to the outside option—*not* to the competitor.

[2] This part corresponds to competitors being in "effective" competition: the market is covered, and any change in prices leads to stealing consumers from—or driving your consumers to—the competitor. This occurs for prices $p_i \in (p_{-i} - st, 2a - p_{-i} - st)$.

[3] This part corresponds to firm i capturing the whole market, which occurs at prices $p_i < p_{-i} - st$, or $p_i < a - st$ if firm $-i$ prices itself out of the market.

Of course, depending on the competitor's price p_{-i} and the parameters a, s, and t, some of these regions may not exist at all:

- If there is no competitor (or $p_{-i} > a$), then part [2] collapses.

- If $p_{-i} < a - st$ (low enough) and $st > a$, there is no part [1]: even for very high p_i firm i would "effectively" compete with firm $-i$.

- If $p_{-i} < st$ or $st > a$, there is no (profitable) part [3]: even for very small $p_i > 0$ firm i cannot capture the whole market from firm $-i$, either because firm $-i$ prices too low or the transport across the whole market is too expensive.

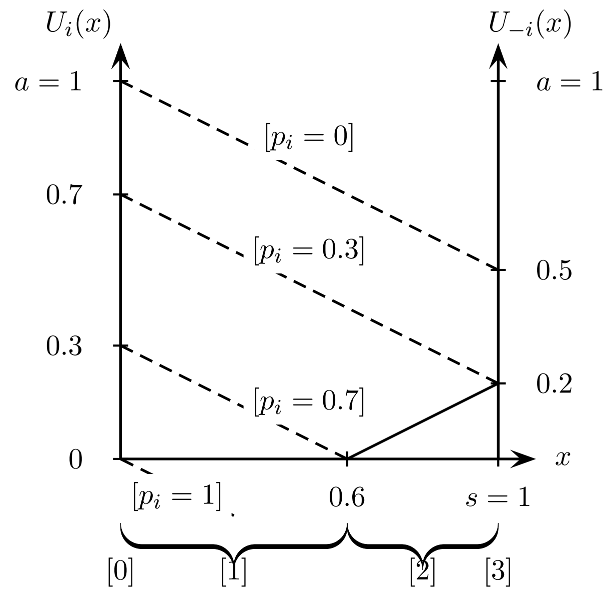


Figure C.1: Example consumer utility levels for different prices p_i with fixed parameters $p_{-i} = 0.8$, $a = 1$, $t = 0.5$ and $s = 1$

C.1.3 Best response

$$p_i(p_{-i}|a,s,t) = \begin{cases} a - st & (p_{-i} \geq a) \wedge (st \leq \frac{a}{2}) & \text{GM} \\ p_{-i} - st & (p_{-i} \leq a) \wedge (p_{-i} \geq 3st) & \text{CM} \\ \frac{st + p_{-i}}{2} & (p_{-i} \leq 3st) \wedge (p_{-i} \leq \frac{4}{3}a - st) & \text{EC} \\ 2a - st - p_{-i} & (p_{-i} \leq \frac{3}{2}a - st) \wedge (p_{-i} \leq a) \wedge (p_{-i} \geq \frac{4}{3}a - st) & \text{IC} \\ \frac{a}{2} & (st \geq \frac{a}{2}) \wedge (p_{-i} \geq \frac{3}{2}a - st) & \text{LM} \end{cases} \tag{C.2}$$

C.2 Reference cases

We compare the equilibrium price of our duopoly game to two reference cases: A one-product monopoly and a two-product monopoly.

C.2.1 One-product monopoly

One way to look at one-product monopoly is to fix the price of firm $-i$ in the duopoly profit equation (5.5) so as to price it out of the market: $p_{-i} = \hat{p}_{-i} > a$. Then, the regions [0] and [2] will disappear from the demand function (for prices $0 < p_i < a$), and we are left with

$$\Pi_i^M(p_i|a,s,t) = \begin{matrix} [1] \\ [3] \end{matrix} \begin{cases} \frac{a-p_i}{st} \cdot p_i & p_i > a - st \\ p_i & p_i \leq a - st \end{cases} \tag{C.3}$$

Solving the maximisation problem for the monopoly, we get the equilibrium prices as

$$p^{M*} = \begin{cases} a - st & \text{if } st \leq \frac{a}{2} \\ \frac{a}{2} & \text{if } \frac{a}{2} < st \end{cases} \tag{C.4}$$

C.2.2 Two-product monopoly

The two-product monopoly can be computed in the same framework, as one firm setting prices p_i and p_{-i} simultaneously. The firm will use symmetric prices as, without fixed cost for the second product, it is always better to supply the upper half of the market line with the product located at the upper end than to supply it from the lower end of the market and vice versa. This leaves more utility with the consumers, which can be extracted through higher prices. Thus we get the symmetric prices $p_i = p_{-i}$ and the profit is given by

$$\Pi_i^{2M}(p_i|a,s,t) = \begin{matrix} [1] \\ [3] \end{matrix} \begin{cases} \frac{a-p_i}{st} \cdot 2 \cdot p_i & p_i > a - \frac{st}{2} \\ p_i & p_i \leq a - \frac{st}{2} \end{cases} \tag{C.5}$$

Solving for the equilibrium prices yields

$$p^{*2M} = \begin{cases} a - \frac{st}{2} & \text{if } st < a \\ \frac{a}{2} & \text{if } a \leq st \end{cases} \tag{C.6}$$

C.3 Chow Test results

Table C.1: The F-statistic and the associated p-values for the Chow test for the parameter stability at different $\bar{\zeta}$'s

increment	F	p	R^2
.25	2.218132	.136419	.5654151
.245	2.094088	.1478908	.5654117
.24	2.280698	.131014	.564586
.235	2.1578	.1418687	.5645825
.23	2.038049	.1534272	.564579
.225	1.921477	.1657146	.5645757
.22	2.729819	.0985114	.5672181
.215	2.879594	.0897294	.5672224
.21	2.79763	.0944247	.5656854
.205	1.596892	.2063639	.5622169
.2	1.499953	.2206978	.5622142
.195	.1695287	.6805369	.56202
.19	.0887485	.7657784	.5620067
.185	.0685921	.7934014	.5620061
.18	1.978202	.1596008	.5626864
.175	2.476331	.1155927	.5624058
.17	2.615331	.1058565	.562429
.165	2.786674	.0950722	.5624336
.16	3.745212	.0529778	.5608998
.155	2.042018	.1530274	.5609509
.15	5.64495	.0175182	.5626013
.145	2.282735	.1308421	.5620812
.14	9.525839	.0020297	.5621582
.135	79.31693	5.89e-19	.5661687
.13	82.42374	1.23e-19	.5652712
.125	53.00962	3.48e-13	.5628271
.12	52.13296	5.44e-13	.5628073
.115	40.56149	1.96e-10	.5638012
.11	12.34939	.0004424	.5638718
.105	6.764859	.0093062	.563678
.1	6.484803	.01089	.5636718
.095	6.206994	.0127354	.5636657
.09	15.73746	.0000731	.5644021

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Curriculum Vitae

1981	Born in Nikolaev, Ukraine
1998	Graduation from Secondary School, Avondale College, Auckland, New Zealand
1999–2002	Bachelor of Commerce (Honours), University of Auckland, New Zealand
2003–2008	Graduate Studies in Economics, Center for Doctroal Studies in Economics (CDSE), University of Mannheim, Germany
2004–2005	Research and Teaching Assistant at the Chair for Applied Microeconomics, University of Mannheim, Germany
2004–2005	Researcher, SFB/TR 15 Project C6, Mannheim
2005–2008	Co-founding Editor, JEPS Junior Economists Peer-review Series