How do the Prices of Different Goods Respond to Exchange Rate Shocks? A Model of Quality Pricing-to-Market*

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December 2007
PRELIMINARY AND INCOMPLETE

Abstract

We develop a model of quality pricing and international trade. Our model is based on Musa and Rosen (1978). Firms sell goods of heterogeneous quality to consumers that differ in their willingness to pay for quality. In equilibrium, the market power of a given firm depends on the prices and qualities of its closest competitors more than on prices of further away firms. Mark-ups therefore depend mostly on market conditions in the vicinity of a firm's quality. We test the static and dynamic predictions of this simple model in the European car market. In this specific market, low quality cars are more likely to be exported than high quality cars. Competition abroad is stronger for low quality cars, leading to low export prices in the low quality segment. We also find that exchange rate pass-through is larger for low quality cars, as a large fraction of the competitors of low quality exporters are other low quality exporters that face the same exchange rate shocks.

*We thank Ariel Burstein and Paul Krugman and seminar participants at the Austrian National Bank, the Bank of Spain, Humboldt University, University of Munich, Paris School of Economics and the Princeton IES Summer Workshop.

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1 Introduction

In this paper, we analyze how exporters price to market in an industry differentiated by good quality. We show how equilibrium markups depend on the spacing of competition and the cost structure of the economy. We then test some of our predictions in a panel of European car prices.

We develop a model of monopolistic competition in quality. Our preferences are based on the seminal work of Mussa and Rosen (1978), where goods of heterogenous quality are sold to consumers with heterogeneous valuation for quality. In our setup, the industry is populated by a large set of firms each producing a good of unique quality. Since each firm has a monopoly over a certain quality, it has local market power over a narrow set of consumers. The degree of this market power depends on the prices and qualities of adjacent competitors.

We show that the optimal price depends on the marginal costs of production, the prices of the two competitors producing the next highest and next lowest quality, and the quality differentials between these three firms. In equilibrium, the price of a given firm depends on the cost structure and quality spacings in the entire economy, with a larger weight given to the market environment in the vicinity of the firm's quality.

Equilibrium markups depend on the heterogeneity in the cost of production and on the average spacing of good quality. The more convex the cost schedule mapping a good's quality into its marginal cost of production is, the larger is the cost differential between two firms with given qualities and the higher are equilibrium markups. Second, the larger the average quality differentials between firms are, the larger are equilibrium markups.

We nest our model in an economy featuring costly market access and transportation costs. Trade, by reducing the average quality spacing has a profound downward effect on prices. Even if the trade volume is low, the "toughening" of spatial competition brought forward by the entry of foreign firms can have a sizeable effect on markups and prices.

We next develop predictions that relate within-industry differences in import penetration to differences in markups and differences in cost pass through. For example, if the fixed cost of exporting are realtively low for low quality goods these are exported more often. First consider price levels and markups. With open markets, trade increases competition in the low quality segment more than does in the high quality segment of the industry, hence also depressing absolute prices more in the low quality sector.

Next, we derive three predictions for the pass-through of exchange rate shocks when low quality firms are more likely to export than high quality firms. First, exchange rate pass-through is larger for low quality exporters than for high quality exporters. Few high quality firms export so most of their competitors are local. When facing an exchange rate shock, in order to stay competitive, high quality exporters cannot move their prices much. Low quality firms on the other hand compete against many other exporters who face the same exchange rate shock. They can pass-through a larger fraction of the exchange rate shock without losing much market share.

Second, in response to an exchange rate shock, the export price relative to the home price of the same good moves more for low quality firms that for high quality firms. On the domestic market, high quality firms face little competition from foreign exporters, whereas low quality firms face a stronger competition from foreigners. So when the exchange rate moves, high quality firms have more freedom to move their domestic prices than low quality firms. In response to an exchange rate shock, the difference in the response of the price of export relative to the home price between high and low quality firms is even larger than the differential response of export prices.

Third, the difference in exchange rate pass-through between high and low quality firms is smaller in the long run than in the short run. In the long run, in response to a negative exchange rate shock, some high quality firms stop exporting. Surviving high quality exporters can increase their nominal price more than in the short run. So in the long run, the difference in exchange rate pass-through between high and low quality firms is dampened.

We then test our model's predictions in a panel of cars sold in five European markets from 1970 to 1999. Our data is from Goldberg and Verboven (2001 and 2005) and also includes car characteristics, so that we can construct several indices of quality. Since we have data for only five markets, but for 30 years, we focus on the time series predictions of the model rather than on the cross-country predictions.

We focus on the model's predictions that exchange rate pass through differs between high and low quality exporters.[1] To our knowledge, these predictions are novel to the literature on pricing-to-market and on exchange rate pass-through, and hence demonstrating that they are both statistically significant and economically large provides the sharpest distinction of our theory against competing models of price setting in the international economy.

[1] Exchange rate movements are endogenous to productivity, wages, and many other macroeconomic variables. A further advantage of focusing on the differential pass-through rate of different car groups is that while the exchange rate may be endogenous, the differential pass-through should not be biased if the endogeneity is equally strong for low and high quality cars, which we believe is a reasonable assumption.

We document three regularities of the exchange rate pass-through rates for cars of different quality. First, we document that short term pass-through rates of exchange rate changes into nominal prices are higher for low quality cars than for high quality cars and that low quality cars also tend to be traded more often in our sample. Our empirical estimates suggest that this differential effect is large: the short term pass-through rate is below 10 percent for the highest decile of car quality, while it is around 20 percent for the lowest decile of car quality.

Second, we evaluate the response to exchange rate shocks of the relative prices of the same car in the importer market and the exporter market. We find that the relative pass-through rate is significantly larger for low quality than for high quality cars. The magnitude of this difference is larger than the difference we document for nominal prices.

Third, we show that pass-through rates for different car qualities tend to be more similar in the long run than in the short run. This is true when using either nominal prices or relative prices.

Summarizing, we find strong evidence that there are different pass-through rates for cars of different quality, and the timing of pass-through follows the predictions of our model. Our findings are economically large and statistically significant. They can explain large variations of pass-through rates even within a narrowly defined industry.

Literature review: TO BE DONE.

The remaining of the paper is organized as follows. In section 2, we present a theoretical model of quality pricing and derive predictions for exchange rate pass-through and pricing-to-market. In section 3, we test those predictions on a panel of car prices. Section 4 concludes.

2 Model

In this section, we build a model of monopolistic competition, quality pricing and international trade.

There are two countries, home and foreign (foreign variables are denoted with an asterisk). There is a mass 1 of consumers in each country. There are two goods, a homogenous, freely traded good $\mathcal{A}$, and a quality differentiated good $\mathcal{Q}$. Labor is the only factor of production.

Preferences: Consumers consume a continuum of good $\mathcal{A}$, and either zero or one unit of one of the $\mathcal{Q}$ goods available. Consumers differ in their valuation for quality (v). For simplicity, we assume that valuations are uniformly distributed over $[0,1]$. A consumer with valuation for quality v who consumes 1 unit of good $\mathcal{Q}$ with quality q and a units of good $\mathcal{A}$, derives a utility, $U_v(q,a) = v \times q + a$. Without loss of generality, we normalize the price of the $\mathcal{A}$ good to 1, and use good $\mathcal{A}$ as the numéraire. We can rewrite the utility of a consumer with valuation for quality v who buys a good of quality q at a price $p(q)$ in the following reduced form,

$$U_v(q) = v \times q - p(q) \tag{1}$$

An important property of these preferences is that valuation and quality are complementary. Higher valuation consumers are willing to pay more for quality. This property will allow monopolistic firms to target different segments of the market.

Technology: In each country, there are infinitely many firms, each producing a good of different quality. Firm n has a blueprint to produce a good of quality up to quality level q_n.[2] Firms are ordered in decreasing order of quality ($q_1 > q_2 > \ldots > q_n > \ldots$) where q_1 is the highest quality. Quality falls at a constant rate $\gamma < 1$,

$$q_{n+1} = \gamma q_n \tag{2}$$

Firms face a constant return to scale technology, with a convex cost of quality. If we normalize the wage to 1 (in units of the numéraire good $\mathcal{A}$), the cost of producing one unit of $\mathcal{Q}$ good of quality q is,

$$c(q) = q^\theta \tag{3}$$

with $\theta > 1$. We assume Bertrand competition. Each firm sets the price for its own quality, taking as given the prices set by other firms and the demand from consumers.

2.1 Firm Optimality and Recursive Pricing

We begin by characterizing the general pricing solution without imposing restrictions on the distribution of qualities, valuations, or the precise form of the marginal cost of producing a good of quality q. For notational simplicity, we use the convention $p_n = p(q_n)$ and $c_n = c(q_n)$.

For the moment, we assume that the marginal cost to produce a good of a quality q (this cost is equal to $c(q)$) is such that in equilibrium, all firms sell a positive amount. The reader is

[2] Note that firm n could choose to produce a lower quality than q_n. In equilibrium, ist is optimal for a firm to never do this. However, firms may choose to slightly "downgrade" theri output when they export abroad.

reminded that $c(q)$ is independent of the quantity produced, i.e. the production function exhibits constant returns to scale.

Optimal pricing: A consumer with valuation v is indifferent between two goods q_n and q_{n+1} if and only if their prices p_n and p_{n+1} are such that $v = \frac{p_n - p_{n+1}}{q_n - q_{n+1}}$. For any $n > 1$, given the prices p_{n-1} and p_{n+1} set by the firms above and below, a firm n that sets a price p_n will reach all consumers within the range $[\underline{v}_n,\ \overline{v}_n]$, with[3]

$$\underline{v}_n = \frac{p_n - p_{n+1}}{q_n - q_{n+1}} \quad \text{and} \quad \overline{v}_n = \begin{cases} \frac{p_{n-1} - p_n}{q_{n-1} - q_n} \text{if } n > 1 \\ v_{\max} \text{ if } n = 1 \end{cases} \tag{4}$$

Since each consumer that buys from the firm demands 1 unit, demand equals simple the number of consumers between $\underline{v}_n$ and $\overline{v}_n$, equal to $\int_{\underline{v}_n}^{\overline{v}_n} f(v)\,dv$. Optimal pricing thus solves[4]

$$(p_n - c_n)\left(-\frac{\partial \overline{v}_n}{\partial p_n} + \frac{\partial \underline{v}_n}{\partial p_n}\right) \approx (\overline{v}_n - \underline{v}_n)$$

where we have approximated $f(\underline{v}_n) \approx f(v\,|v\epsilon\,[\underline{v}_n,\ \overline{v}_n]) \approx f(\overline{v}_n)$. This approximation, which holds with equality in our closed form solution below, is in order since we assume that the number of firms is large. Therefore, over the narrow monopoly range each firm has, the density of consumers is approximately constant. This solves for prices of one firm given the prices of its competitors.

$$p_n = \begin{cases} \frac{1}{2}c_1 + \frac{1}{2}(q_1 - q_2)\,v_{\max} + \frac{1}{2}p_2 & \text{if } n = 1 \\ \frac{1}{2}c_n + \frac{1}{2}\frac{q_n - q_{n+1}}{q_{n-1} - q_{n+1}}p_{n-1} + \frac{1}{2}\frac{q_{n-1} - q_n}{q_{n-1} - q_{n+1}}p_{n+1} & \text{if } n > 1 \end{cases} \tag{5}$$

The above conditions assume that the optimal price exceed marginal costs c_n. A sufficient condition for this to be true is that the marginal cost of production is increasing and convex in quality.

[3] In this section, we continue to assume that there is an infite set of firms in the neighbourhood of $q = 0$. Not making this assumption would lead to a slighlty different lower cutoff $\underline{v}_N = v_{\min}$ for the firm N with the lowest cutoff in (4).

[4] In deriving the equilibrium, we only consider the case where a firm with quality q_n only competes with its direct competitors (quality q_{n-1} and q_{n+1}). We prove in the appendix that in equilibrium, no firm wants to deviate, undercut its direct competitors entirely, and compete with firms beyond q_{n-1} or q_{n+1}.

Lemma 1 *(5) is indeed the optimal price for all firms* $n \ \varepsilon \ [1, \ \infty]$ *if*

$$\begin{aligned} \frac{\partial c(q)}{\partial q}\,|_{q=0} &= 0 \\ \frac{\partial^2 c(q)}{(\partial q)^2}\,|_{q\varepsilon\ [0,\ q_1]} &> 0 \\ \frac{\partial c(q)}{\partial q}\,|_{q=q_1} &\leq v_{\max} \end{aligned}$$

hold.

Proof. *No firm will ever encounter a competitor that is active in the market at a price below marginal costs:* $p_{n-1} \geq c_{n-1}$ *and* $p_{n+1} \geq c_{n+1}$. *Hence*

$$p_n - c_n \geq \frac{1}{2}\frac{q_n - q_{n+1}}{q_{n-1} - q_{n+1}}(c_{n-1} - c_{n+1}) - \frac{1}{2}(c_n - c_{n+1})$$

and firm n *has a nonnegative margin if* $\frac{c_{n-1}-c_{n+1}}{c_n - c_{n+1}} > \frac{q_{n-1}-q_{n+1}}{q_n - q_{n+1}}$, *which requires* $c(q)$ *to be convex. Next, for the lowest quality firm with* $q \to 0$ *to sell a good we require that* $\frac{\partial c(q)}{\partial q}\,|_{q=0} = 0$. *Last, quality increases must not be too expensive such that the highest consumer* $v_{\max}$ *would prefer to buy a good of quality lower than* q_1. ■

The fact that costs have to be more than linearly increasing in quality is straightforward given our preference structure. All consumer prefers higher quality goods, yet they do so at different rates equal to v. Faced with a pricing schedule $p(q)$, each consumer chooses a quality that satisfies $v = \frac{\partial c(q)}{\partial q}$. That is, unless the marginal increases in quality successively become more and more expensive, all consumers will make the same choice of quality. Only if increases in quality sucessively are more and more expensive, all firms sell in equilibrium and different consumers choose different qualities.

2.2 Autarky equilibrium

We next characterize the closed economy equilibrium with our assumptions for the distribution of qualities where $\frac{q_n - q_{n+1}}{q_{n-1} - q_{n+1}} = \frac{\gamma - 1}{\gamma^2 - 1} = \frac{1}{\gamma}\frac{q_{n-1} - q_n}{q_{n-1} - q_{n+1}}$ and $\overline{v}_1 = 1$. Profit maximization gives the following sequence of prices (5),

$$2p_n = \begin{cases} c_1 + (\gamma - 1)\,q_1 + p_2 & \text{if } n = 1 \\ c_n + \frac{\gamma - 1}{\gamma^2 - 1}p_{n-1} + \gamma\frac{\gamma - 1}{\gamma^2 - 1}p_{n+1} & \text{if } n > 1 \end{cases} \qquad (6)$$

In addition, since quality goes down to zero for n large, and since consumers always have the option of consuming the numéraire good $\mathcal{A}$ only, we need to impose the transversality condition, $\lim_{n\to\infty} p_n = 0$.[5]

Proposition 1 *The equilibrium price sequence for $n > 1$ is given by,*

$$p_n = A\lambda^{n-2} + \alpha c_n \tag{7}$$

with $0 < \lambda < 1$. Under some mild conditions, $\alpha > 1$ and $A > 0$.[6]

Proof. See appendix A. ∎

Firms charge a mark-up over their marginal cost. They are able to do so because quality and valuation are complementary. High valuation consumers are willing to buy high quality goods at a premium because they care more about quality than others. Even though from the point of view of one single consumer, all $\mathcal{Q}$ goods are perfectly substitutable, the heterogeneity in valuation among consumers allows firms to exert some local monopoly power.

Most of our results will be based on this key insight of local monopoly power. Firms compete more with their direct competitors than with faraway firms. If one firm were to change its price, it would have a first order impact on the pricing decision of the firms right above and the firm right below. Further away firms will be affected too, but only through the cascading effect of neighboring firms affecting neighboring firms and so forth. To simplify, the impact of one firm changing its price dies exponentially with the distance in quality.

A direct consequence of this local monopoly power is that the further apart firms are (the smaller γ), the more local monopoly power a firm has, and therefore the larger the mark-up it can charge ($\frac{\partial \alpha}{\partial \gamma} < 0$). When such an economy opens up to international trade, foreign firms locate between domestic firms and drive mark-ups down. Note also that in the limit of a continuum of firms, we converge to a perfectly competitive equilibrium with price equal to marginal cost.

In the next section, we embed this model of quality pricing in an open economy framework. Domestic and foreign firms compete in the same market.

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[5] We also need to impose that the highest valuation consumer ($v = 1$) prefers good q_1 over the numéraire good $\mathcal{A}$, which is true if θ is not too large.

[6] $\lambda = 1 + \gamma - \sqrt{1 + \gamma + \gamma^2}$, $\alpha = \frac{(\gamma+1)}{2(\gamma+1) - \left(\gamma^{\theta} + \gamma^{1-\theta}\right)}$, $A = \frac{(1-\gamma)\gamma q_1 - (\gamma q_1)^{\theta}\left(\gamma^{1-\theta}(2\alpha - 1) + \alpha(\gamma+2)\right)}{2\left(1+\gamma+\sqrt{1+\gamma+\gamma^2}\right) - \gamma}$. Note that $\alpha > 1$ requires that γ is not too small and/or θ not too large. For γ small and/or θ large, $\alpha < 0$.

2.3 Trade equilibrium

With our empirical application in mind, we assume that firms face a fixed export cost such that only low quality firms export. This assumption is ad hoc. Whether high or low quality firms export depends on the exact shape of the fixed export cost, for which we have no prior.[7]

We model nominal exchange rates as cross country differences in productivity in the $\mathcal{A}$ sector. One worker produces one unit of $\mathcal{A}$ good abroad, and ω units at home. In terms of the numéraire $\mathcal{A}$ good, the foreign wage is equal to 1, and the domestic wage is equal to ω.[8] The marginal labor requirement to produce the $\mathcal{Q}$ goods is the same at home and abroad. We will consider cases where the home firms are at a cost disadvantage, $\omega > 1$. From the point of view of an individual domestic firm, an increase in ω is equivalent to an appreciation of the home currency, that is our measure summarizes trade costs, the exchange rate and nominal wages.

$$\omega \equiv \tau E \frac{w}{w^*}$$

Foreign variables are denoted with an asterisk. All domestic firms above $\bar{n}$ export.[9] They position themselves half way in between foreign firms, so that qualities are ordered in the following way,

$$q_1^* > q_2^* > \ldots > q_{\bar{n}}^* > q_{\bar{n}} > q_{\bar{n}+1}^* > q_{\bar{n}+1} \ldots$$

The distance between a domestic exporter and a foreign firms is given by,[10]

$$q_n = \delta q_n^*, \text{ with } \delta = \sqrt{\gamma} \tag{8}$$

High quality domestic firms only face domestic competitors, whereas low quality home and foreign firms compete on the domestic market. As in the autarky case, we can derive the optimal pricing

[7] Our rationale for assuming that only low quality firms export is that there is a larger demand for low quality goods, so that even with the same fixed export cost, entry is easier for low quality firms. However, for simplicity, we assume that valuations are uniformly distributed, and assume instead that fixed costs increase sufficiently fast with quality so that high quality firms are prevented from exporting.

[8] We only consider equilibria where the $\mathcal{A}$ sector is large enough so that both country produces some of it so that relative wages are exogenous.

[9] We solve for $\bar{n}$ endogenously as a function of the fixed export cost in section 2.5.

[10] We can prove that if a foreign firm were allowed to optimally chose its location, it would locate between q_n and q_{n+1}. The assumption that it locates exactly half way in between is a simplification.

strategy of domestic and foreign firms,[11]

$$
\begin{aligned}
2p_n &= \omega c_n + \frac{\delta}{1+\delta} p_n^* + \frac{1}{1+\delta} p_{n+1}^* \text{ if } n \geq \bar{n} \\
2p_n^* &= \begin{cases} c_1 + (1-\gamma)\, q_1 + p_2 & \text{if } n = 1 \\ c_n + \frac{\gamma}{1+\gamma} p_{n-1}^* + \frac{1}{1+\gamma} p_{n+1}^* & \text{if } 1 < n < \bar{n} \\ c_{\bar{n}} + \frac{\delta}{1+\delta} p_{\bar{n}-1}^* + \frac{1}{1+\delta} p_{\bar{n}} & \text{if } n = \bar{n} \\ c_n + \frac{\delta}{1+\delta} p_{n-1} + \frac{1}{1+\delta} p_n & \text{if } n > \bar{n} \end{cases}
\end{aligned} \tag{9}
$$

As in the autarky case, we must impose the transversality conditions $\lim_{n\to\infty} p_n = \lim_{n\to\infty} p_n^* = 0$.

Proposition 2 *The equilibrium price sequence for $n > 1$ for domestically produced and imported goods is given by,*

$$
\begin{cases} p_n^* = A \times \lambda^{n-2} + \alpha \times c_n & \text{if } n < \bar{n} \\ p_n^* = A_T^* \times \lambda_T^{n-2} + \alpha_T^* \times c_n & \text{if } n > \bar{n} \\ p_n = A_T \times \lambda_T^{n-2} + \alpha_T \times c_n & \text{if } n > \bar{n} \end{cases} \tag{10}
$$

with $0 < \lambda_T < \lambda < 1$.[12]

Proof. See appendix B. ■

When trade opens up, several features of the price schedule change. In the foreign country, high quality firms ($n < \bar{n}$) do not face any new competitors, so they have the same local monopoly power as in autarky. Low quality local firms ($n > \bar{n}$) on the other hand now compete against imported goods. Low quality exporters face both the more intense competition of foreign firms, and the extra hurdle of a cost disadvantage ($\omega > 1$). The more intense competition among low quality firms implies that firms cannot charge as high a mark-up as they would in autarky, or alternatively that prices increase with quality at a lower pace ($\lambda_T < \lambda$).

In the next section, we turn to the predictions of this model regarding exchange rate pass-through and pricing-to-market.

2.4 Exchange rate pass through and pricing-to-market

We begin by comparing the price of the same good under autarky and trade. Since trade affects the low quality segment of the market more, prices decrease more in this sector.

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[11] For simplicity, we assume that a foreign firm with quality q_n can only discount its quality below that of the domestic firm q_n, but it still faces the same marginal cost $c(q_n)$.

[12] With $\lambda_T = 2(1+\delta)\left(1+\delta-\sqrt{1+\delta+\delta^2}\right)-\delta$, $\alpha_T^* = \frac{(1+\delta)\left(2(1+\delta)+\omega\left(1+\delta^{1-2\theta}\right)\right)}{2\left(2(1+\delta)^2-\delta\right)-\left(\gamma^\theta+\gamma^{1-\theta}\right)}$, $\alpha_T = \frac{(1+\delta)\left(2\omega(1+\delta)+\delta+\delta^{2\theta}\right)}{2\left(2(1+\delta)^2-\delta\right)-\left(\gamma^\theta+\gamma^{1-\theta}\right)}$, $A_T^* = A\left(\frac{\lambda}{\lambda_T}\right)^{\bar{n}-2} + (\alpha-\alpha_T^*)\frac{c_{\bar{n}}}{\lambda_T^{\bar{n}-2}}$, and $A_T = A\left(\frac{\lambda}{\lambda_T}\right)^{\bar{n}-2} + (\alpha-\alpha_T)\frac{c_{\bar{n}}}{\lambda_T^{\bar{n}-2}}$.

Lemma 2 *Compare the autarky pricing schedule (7) to the pricing schedule for domestic goods under trade (10). It is true that*

$$\frac{\vartheta\left(\frac{p(q_n)^*}{p(q_n)}\right)}{\vartheta q_n} < 0$$

Proof. *See appendix C.* ■

Following an appreciation of the home currency ($\Delta\omega > 0$), in the short run, the set of exporters is unchanged. All domestic exporters experience an increase in their marginal cost, whereas their foreign competitors do not. Since the price set by a firm depends on both its marginal cost and the prices set by its direct competitors, we expect that domestic exporters will not be able to pass through the entire exchange rate shock into prices. Moreover, the discipline imposed by the presence of foreign firms on export prices is more stringent for high quality firms than for low quality firms.

Proposition 3 *Exchange rate shocks are only partially passed through into prices.*

$$0 < \frac{d\ln p_n}{d\ln\omega} < 1$$

Moreover, if an equilibrium exists, the pass-through of exchange rate shocks into prices is higher for low quality goods than for high quality goods,

$$i < j \Rightarrow \frac{d\ln p_i}{d\ln\omega} < \frac{d\ln p_j}{d\ln\omega}$$

Proof. See appendix C. ■

This result relies on the fact that trade barriers are different for goods of different quality, so that the composition of exporters matters. Under our assumption that only low quality firms export, high quality exporters face relatively more competition from foreign firms (roughly $\frac{3}{4}$) than low quality exporters (roughly $\frac{1}{2}$). Roughly $\frac{3}{4}$ of the competitors of high quality exporters (n close to $\bar{n}$) are local foreign firms, whereas only $\frac{1}{2}$ of the competitors of low quality exporters (n large) are local foreign firms: for n close to $\bar{n}$, all firms below $\bar{n}$ are foreign, but only half of the firms above $\bar{n}$; for n large, half of the firms above and below are foreigners. This heterogeneity in the relative distribution of home and foreign firms is the key ingredient that generates different levels of exchange rate pass-through and pricing-to-market for firms with different quality.

When the home currency appreciates, many of the competitors of low quality exporters are also hit by a negative cost shock. So low quality exporters can pass through a relatively large fraction of their cost shock into prices without losing too much market share. On the other hand, few competitors of low quality exporters face the same cost shock, so that they can pass through a smaller fraction of the exchange rate shock into prices.

The selection of goods of different quality into the export market naturally generates pricing-to-market, because exporters face different sets of competitors at home and abroad.

Proposition 4

- *Firms price-to-market: in response to a negative exchange rate shock, home firms increase their export prices less than their domestic prices,*

$$\frac{d\ln p_n^X}{d\ln\omega} < \frac{d\ln p_n^D}{d\ln\omega}$$

where p_n^X and p_n^D are respectively the export price and the domestic price set by a firm with quality q_n (both in units of the same international numéraire).

- *The degree of pricing-to-market increases with quality: the difference in domestic and export price is larger for high quality than for low quality goods,*

$$i < j \Rightarrow \frac{p_i^X}{p_i^D} > \frac{p_j^X}{p_j^D}$$

- *The pass-through of exchange rate shocks into export prices relative to domestic prices is larger for low quality goods,*

$$i < j \Rightarrow \frac{d\ln\left(p_i^X/p_i^D\right)}{d\ln\omega} < \frac{d\ln\left(p_j^X/p_j^D\right)}{d\ln\omega}$$

Proof. See appendix D. ■

If high quality firms face more competition from foreign firms abroad than low quality firms, the exact opposite holds true at home. Only the low quality foreign firms are able to enter the home market. So high quality domestic firms face few foreign exporters at home, whereas low quality domestic firms face many foreign exporters at home. When all domestic firms are hit by a negative cost shock (an appreciation of the home currency), high quality firms are able to pass on a large fraction of their cost increase into domestic prices, whereas low quality firms can only pass through a smaller fraction of this cost shock. So to summarize, high quality firms adjust their prices at home a lot, but their prices abroad a little, and the opposite holds true for low quality firms. Therefore, in response to exchange rate shocks, low quality firms adjust their export price relative to their domestic price more than high quality firms. The difference between high and low quality firms in the pass-through of exchange rate shocks into relative prices is even larger than the difference in the pass-through into export prices.

In the next section, we allow for the set of exporters to adjust in response to exchange rate shocks. We consider the behavior of prices when entry is endogenous. This is a simple formalization of the long run adjustment of prices to exchange rate shocks.

2.5 Short run versus long run

TO BE DONE...

To summarize, we derive three main predictions from our theoretical model of quality pricing-to-market. First, the exchange rate pass-through into export prices is larger for low quality goods than for high quality goods. Second, the exchange rate pass-through into export prices relative to domestic prices is also larger for low quality goods than for high quality goods. Finally, in the long run, the difference in exchange rate pass-through between high and low quality goods is dampened. In the next section, we test these predictions on a panel of car prices.

3 Empirical analysis

In this section, we test the main predictions of our model. We find a significant and large difference in exchange rate pass through and pricing to market between goods of different quality.

The structure of this section is the following. We begin with a description of the data, we construct quality indices, and we show that in our sample, low quality cars are more likely to be exported. We then document our three main findings. First, in the short run, the pass-through of exchange rate shocks into export prices is larger for low quality cars than for high quality cars. Second, the same holds for the relative price of the same car in the domestic market and the export market. Third, we document that in the long run, pass-through rates for high and low quality cars are more similar than in the short run.

3.1 Data description

The data on car prices, quantities, and quality attributes used in this study is from Goldberg and Verboven (2001) and (2005). Their data set also includes relevant macroeconomic information such as exchange rates and inflation rates.[13] It covers cars sold on five European Markets (Belgium, France, Germany, Italy, and the UK) in the period from 1970 to 1999. Although we only have prices for cars sold in these markets, the cars originate from 14 countries.

Before describing the data in more detail, we first construct a measure of car quality. Following Goldberg and Verboven (2005), we construct hedonistic indices of quality that relate the price of a car to its characteristics such as weight, horse power, and fuel efficiency. Since customers are willing to pay a higher price for more of an attribute such as "maximum speed", these attributes reveal a car's quality.

In Table 1, the dependent variable is the natural logarithm of the car price net of VAT and in Special Drawing Rights.[14] All car prices in our sample are for the basic configuration of each car model, i.e. the cheapest version actually offered on a market. We estimate random effects panels since including fixed effects by car model would account for nearly all of the quality variation in our sample. We also control for the market and year the car was sold in, and the level of consumer prices.

In Table 1, and unless otherwise stated also in the rest of the paper, we take the model definition "co" of Goldberg and Verboven. But in order to properly reflect changes in the exchange rate, we count a car model as a new observation when the location of production changes.[15] In the panel, a group is defined as one car model sold in one market so that we have 1554 groups and 379 car models (not every model is sold on all 5 markets). In the dataset of Goldberg and Verboven, "co" denotes a car model, "loc" the location of production, and "ma" the market where the car is sold. Our groups in the panel are hence uniquely defined by co_loc_ma.

In Column 1 of Table 1, we regress the logarithm of a car's price on a Luxury Dummy that equals 1 if the car is either counted as "Intermediate Class" or "Luxury Class" in official car guides. The interpretation of the coefficient of the luxury dummy is the following. If two car models are sold on the same market and in the same year, yet one is a Luxury or Intermediate car while the other one is not, the price differential is on average 0.698 log points (2 fold).

In Column 2 of Table 1, we relate car prices to "measurable" measures of quality. We include horsepower, fuel efficiency, cylinder volume, size, weight, and maximum speed. All measures have the expected sign except height, which has a negative coefficient because expensive sport cars tend

[13] The data is described in detail in Goldberg and Verboden (2005). It can be accessed on P. Goldberg's webpage.

[14] Special Drawing Rights (SDRs) are a basket of major currencies with weights updated every 5 years.

[15] This happens in less than 20 instances and does not affect our results. Moreover, a change of the production location is mostly a Japanese firms re-locating production to Europe. In the sample of cars that are both produced and sold in our five markets, there are only 3 car models that are counted twice.

to be flat. Conditional on the other car characteristics, a one KW stronger engine is associated with a 0.55% higher price. The overall fit of the model is very good, with an R^2 of 92.6%, but we can do even better by also including "soft" car attributes such as the car brand. In Column 3, we thus add brand dummies and class dummies to the estimation.

We next predict two indexes of car quality. We predict "Quality Index 1" from Column 2 of Table 1. Since conditional on the car characteristics, where and when a car is sold should not influence its quality, and since the level of consumer prices does not affect the quality of a car, we partial out these variables when predicting the quality index. We next predict "Quality Index 2" from the model in Column 3 of Table 1. For Quality Index 2, we again partial out the effect of when, where, and at what level of consumer prices a car was sold, but we include the brand and class dummies. After predicting, we normalize both indices of quality.

In Table 2, we describe the summary statistics of our sample of cars. The structure of Table 2 is the following. We first summarize the whole sample in Panel A and then split this sample up into cars that are produced in one of our five markets (BEL, FRA, GER, ITA, and UK) and sold in the market of production (Panel B), cars that are produced in one of the five markets and exported to at least one of the other four markets (Panel C), and cars that are sold in at least one of the five markets, but that are produced somewhere else (Panel D).

For these four groups of cars, we report the summary statistics for the quantity sold, prices, and quality. In addition to the usual statistics (un-weighted mean, un-weighted standard deviation, minimum, and maximum), we also report the relative average quality of our two quality indexes. For the index of relative average quality, we first quantity weigh each index, and then demean quality by year. This measure of quality displays the relative quality of cars compared to other cars sold in the same year. We consider this measure the relevant one since our model does not imply anything about absolute quality and pass-through, but about pass-through of low compared to high quality cars.[16]

Are low quality cars indeed exported more often? If this is true, cars sold in the market of production are of higher than average quality. This is not true when considering the un-weighted quality average in Column 2 of Table 2. Cars that are sold in the market of production (Panel B) are on average of slightly negative quality, which corresponds to a below average quality since we have normalized these variables. However, one car model is in some instances only sold 51

[16] We still use the quality indices "Quality Index 1" and "Quality Index 2" in the empirical analysis below. If we did include the demeaned car quality rather than the absolute level, we could not properly account for changes in the relative quality of a model.

times, while other models sell over 400,000 units on one market and one year. When evaluating the relative quality index weighted by quantity in Column 1, we find that indeed, cars produced and sold domestically are of higher quality than the average car sold in our five market, of higher quality than the average card produced in our five market and exported to the other four markets (Panel C), and of much higher quality than the average car produced outside of the five markets.

We provide further evidence that low quality cars are traded more than high quality cars in Table 3. We list the import share by year and class in our five markets. For each year and class, the import share is defined as 1 minus the ratio of "the number of cars produced in one of the 5 markets & sold in the same market" over "number of car sold in the five markets." There are 5 car classes (subcompact, compact, intermediate, standard, and luxury). Throughout Table 3, it is evident that smaller (and thus lower "quality" cars) are traded much more. In the rightmost Column of Table 3, we present the ratio of the import share of subcompact and compact cars over the import ratio of intermediate and luxury cars. In all but one year, the latter ratio is larger than 1. On the bottom of Table 3, we present the average import penetration. This average is the un-weighted average of yearly averages, i.e. the simple average of the column above. The average import share for subcompact cars (42%) is nearly double the import share for luxury cars (28.6%) and much higher than the import penetration of the other car market segments.

We present some more information about our data in Table 4. The upper part of Table 4 presents summary statistics for the annualized change in the natural logarithm of a model's price, changes in the exchange rates, and annual CPI inflation. We also display the annual change in the logarithm of the relative price. The relative price is the ratio of the price of a car in the importer market divided by the price of the same car in the market of production. In the main specifications that we present below, we focus on car models that are produced in Belgium, Italy, Germany, France, or the UK and sold on one of the other four markets. We thus present the summary statistics only for this group of observations.[17]

There are no outliers for the annual exchange rate fluctuation or for the annual inflation rates. However, some of the year to year price changes (and more so for relative price changes) are quite large. The lower part of Table 4 lists any observation where either the nominal or the real price changed by more than 0.5 log points (a 64% change) from year to year. Such a large price change does never occur for the same model. The underlying reason for these fluctuations is that

[17] When using the full sample, we drop all cars from former Yugoslavia that went through a hyperinflation episode during the early 90's.

the base model is sometimes discontinued in some markets, while other versions are still offered. Since Goldberg and Verboven always use the price of the base model that is actually available on a market (and do not treat this as a new model) the price can jump from year to year. However, and after discussing this with the authors, we include these observations in the main regression because of the following reason. When we observe a drastic change in the nominal price, the car quality also changes considerably in the same year. All regressions presented below account for that change in quality, and hence the quality adjusted price change is much smoother. In addition, we provide some robustness tests where we exclude these outliers in table A1.

3.2 Quality and nominal price pass-through

In this section, we document that short term pass-through rates of exchange rate changes into nominal prices are higher for low quality cars than for high quality cars. To our knowledge, these predictions are novel to the literature on pricing-to-market and on exchange rate pass-through.[18] Demonstrating that this effect is statistically significant and economically large provides the sharpest distinction of our theory against competing models of price setting in an open economy.

Our empirical estimates suggest that this differential effect is economically large: the short term pass-through rate is below 10 percent for the top decile of car quality, while it is around 20 percent for the lowest decile of car quality.

We present our main empirical finding in Table 5. Throughout the table, the dependent variable is the change in the natural logarithm of the car price in the respective market. All specifications include fixed effects and report robust standard errors. In Columns 1 to 6, we include fixed effects for all model and market combinations. The exchange rate is always the bilateral year end value from Goldberg and Verboven.

In Column 1 of Table 5, we include only the exchange rate change and the CPI-inflation to the regressions. The (contemporaneous) pass-through rate is estimated at 13.1%. We add car quality (Quality Index 1) in Column 2. Although quality itself is a significant determinant of price changes, this does not affect the pass-through rate by much, which is estimated to be 14%. Because we include fixed effects for each model sold on each market, the coefficient of quality has to be interpreted with care: if the quality of a model does not change during its life cycle, the

[18] One exception to this is an interesting finding of Gagnon and Knetter (1995) of the differential pass though rate for large engine and small engine cars.

fixed effects absorb all the variation associated with quality differences between cars. However, car manufacturers often upgrade the engine and other features of a model during its life cycle, and therefore the quality of a model can change slightly. Thus, the coefficient of "Quality Index 1" has the interpretation of how much a change in the quality of a car affects its price during its life cycle.

In Column 3 of Table 5, we allow pass through rates to be quality dependent and add the interaction of Quality Index 1 and the exchange rate change. While the average pass-through rate is not much affected (it does not stay exactly the same since we have standardized quality for the sample of all cars but use only cars from our five markets), the interaction is negative, significant, and economically large. A one standard deviation difference in quality is associated with a 6.3 percentage point different pass-through rate. For example, compare the 10th percentile of car quality to the 90th percentile. The respective percentiles are -1.26 and 1.37, so that the pass through rate of these two car qualities is 21.8% versus 5.3%. Accounting for car quality has a large effect on pass-through rates, as implied by our theory.

We next provide some robustness tests for this result. Inflation, average car quality, and car prices might all be subject to a common trend that is somehow driving our results. We thus include a year trend to the equation in Column 4. While the year trend is significant, this does not affect any other coefficient in our model (in fact the interaction coefficient is larger and significant at higher levels). The trend itself has a negative coefficient, which might reflect the productivity advances in the car industry. Next, in Column 5, we take into account that car prices are auto-correlated and add the lagged price change to the estimation. Indeed, prices are mean reverting, but accounting for the mean reversion results in a larger coefficient for the interaction of quality and exchange rate changes. The same is true in Column 6, where we add both the lagged price and the year trend.

Goldberg and Verboven have two different definitions of a car model. In our main specification, we use their narrow model definition "co." Their second model definition, "zcode" is somewhat broader than the main definition. For example, Daimler Benz discontinued the Mercedes 300 in 1992/3 and introduced the similar Mercedes E Class shortly thereafter. Our main definition classifies these two cars as two different models, but zcode counts them as one. Because car companies offer both the new and the old model of a car in the same year and on the same market, zcode does not uniquely define observations. We thus include market dummies and model dummies (by zcode) as fixed effect in Column 8. For better comparability, we also present the same specification (fixed effects by markets and models, but not all combinations) for our main model definition "co" in Column 7. Again, the interaction of exchange rate changes and car quality is negative, significant, and the coefficient is large.

In Table 5, we only use those cars that are produced in the five markets under consideration. This is done in order to ensure that we can compare our results of nominal and relative price pass-through: when we estimate relative prices pass through, we need a price in the home market which we do not have for cars that are produced outside of Belgium, France, Italy, Germany and the UK. However, these five markets are closely integrated, and more important, the integration of these five markets has increased substantially over the last 30 years.

In Table 6, we repeat all the specifications of Table 5, but we include the full sample of cars. Indeed, the point estimates are lower than in the restricted sample of Table 5, but they are still large in magnitude and statistically significant. For example, again comparing the 10th and the 90th percentile of car quality (-1.26 and 1.37) and using the coefficients from Column 3 of Table 6, we find that pass-through rates are 18.8% as compared to 9.4%, i.e. exactly twice as large for low quality goods. The interaction coefficient is significant, and this is also true for all the robustness tests in Table 6.

We present a further robustness test in Table 7, where we repeat our results for quality index 2, in the construction of which we also uses brand and class dummies. We again use the sample restricted to cars produced in our five markets. We repeat every specification of Table 5, but use Quality Index 2 and the interaction of this variable with exchange rate changes. All results are significant, but the effects are somewhat smaller in magnitude than when using our alternative measure of quality. For example, in the basic specification of Column 3 of Table 7, the interaction coefficient is estimated to be -0.044. Again comparing the 10th percentile (-1.27 for Quality Index 2) of quality to the 90th (1.45), short term pass through rates are estimated at 19.8% versus 7.8%.

We conclude that pass through rates in our sample of European cars vary considerably with quality, and that the more open market segment (low quality cars) is characterized by a much higher rate of pass through.

3.3 Relative Pass Through Rates and Quality

In this section, we evaluate the response of the relative price of the same car in the importer market and the exporter market to exchange rate movements. We test whether this "relative pass-through rate" is higher for low quality than for high quality cars.

This additional test is needed to distinguish our theory from a simple alternative theory where high and low quality cars have differently shaped demand curves, but where this has nothing to do with international trade. If indeed the latter theory were hold, a change in the cost of production should increase the price of the same car in the importer market and the exporter market in the same direction, and we should thus find a smaller (or no) difference in the relative pass-through rate for low and high quality cars than when looking at nominal pass-through rates. In contrast, we document that there is a significant differential of relative pass-through rates for high and low quality cars and that the magnitude of this difference is even larger than the differential effect we document for nominal prices.

In Table 8, we repeat the specifications we estimated for nominal pass-through rates of Table 5 looking at relative rather than absolute pass-through. Throughout Table 8, the dependent variable is the change in the natural logarithm of the relative price of a car. The relative price of a car is the ratio of the nominal price in the importer market over the nominal price in the country where the car is produced. Instead of testing how absolute nominal prices responds to changes in the exchange rate, we test how relative nominal prices react to the exchange rate.

In Column 1 of Table 8, to reflect the fact that we are looking at relative prices, we do not include consumer price inflation at home in the estimation, but relative inflation, i.e. the change in the natural logarithm of the ratio of CPI(importing nation)/CPI(exporting nation). The relative pass through-rate is estimated at 16.5%, somewhat higher than the nominal rate in Table 5. This difference between relative and nominal pass through nearly vanishes once we also control for quality in Column 2. Again, to reflect the fact that we consider not the absolute but the relative price, we include an index of the relative quality (Quality Index 1 in the Importer Country–Quality Index 1 in the Exporter Country) to the regressions. This index varies quite a lot since manufacturers introduce different model configurations to different markets in different years.

Next, in Column 3 of Table 8, we document our main finding for relative price pass-through. Low quality cars are characterized by a much higher degree of relative pass through. This finding is even more pronounced than for nominal pass through. A one standard deviation in quality is associated with a 9.1 percentage points lower rate of pass through. The fact that the relative pass-through-differential is larger for than the nominal pass-through-differential is in accordance with our theory. We predict that following an adverse exchange rate shock in the home market, high-quality producers can pass on costs at a higher rate because they face little import competition. On the other side, low-quality domestic firms tend to face more foreign competition, and they can thus only pass on a smaller fraction of cost changes. Since we predict that in the export market, it is lower quality cars that can pass on more of a cost change, we predict a larger differential effect for relative pass-through rates than for nominal pass-through rates.

To establish the robustness of this result, we add a time trend (Column 4), the lagged change in the price (Column 5), both (Column 6), and we use the alternative definition of car models (Columns 7 and 8). We present one additional robustness test in Column 9, where instead of only controlling for relative quality and relative inflation, we add quality in the importing market and quality in the exporter market separately, and we also add the two measures of consumer prices separately. In Table 9, we repeat these specifications, but we use our second measure of quality (Quality Index 2). In all specifications except in Column 9, relative exchange rate pass through is significantly higher for low quality cars, and in Column 9 our specification is only marginally not significant.

We thus conclude that in response to an exchange rate shock, the ratio of the relative nominal prices in the importing nation and in the home country (exporter) moves more for low quality cars.

3.4 Long Run Pas Through

Finally we estimate pass-through rates over a longer horizon. We show that pass-through rates for different car qualities tend to be more similar in the long run than in the short run. This finding is in accordance with our theory, which predicts that following an exchange rate shock, in the long run there is exit or entry of relatively high quality exporters. Since this entry or exit affects the market for higher quality (i.e. the highest quality that is still exported) cars much more than the market for low quality cars, our model predicts that the increase in pass-through (i.e. Long Run ERPT minus Short Run ERPT) should be higher for high quality cars. We again document that this finding is true when using either nominal prices or relative prices. Unfortunately, our findings do not have much statistical power.

We present our results for long run pas-through of nominal prices in Table 9. We include up to four lags of exchange rate changes and the respective interaction. We control for inflation and lagged car quality (coefficients not reported) and always include the same number of lags as for the exchange rate. In Column 1 of Table 10, we repeat the basic specification of Column 3 in Table 5. In Columns 2 to 5, we successively add one lag at a time. We report the sum of all coefficients for exchange rate pass-through and the sum of all coefficients for the interaction of

Quality Index 1 and the exchange rate changes. We also report the p-values corresponding to the null hypothesis that the sum of either of the main effect coefficients or of the interaction effect coefficients is equal to 0.

We find that exchange rate pass through (main effect) is substantially larger in the long run than in the short run, and when including all 4 lags (Column 5) it is estimated at 46.3%. The sum of the pass through coefficients is always jointly significantly different from 0.

However, we do not find that the difference in pass through coefficients (interaction) is increasing when we add more lags. Rather, the sum of the coefficients is higher (less negative) when adding more lags, never significant for Columns 2 to 5, and even positive when including four lags. Moreover, although we always estimate that the instantaneous interaction is negative (but not always significant), the sum of the lagged interactions is either positive or very close to 0.

In Table 11, we repeat this finding for relative prices. Again, we first reproduce the basic regression from Table 7, Column 3, and we then add successively more lags. We report the sum of the average pass-through, the p-value corresponding to the test of the sum of exchange rate pass-through coefficients being 0. We also report the sum of the interaction effects and the corresponding p-value. Again, we find that relative pass-through is substantially larger in the long run than in the short run (56% versus 14.4%) and that it is significant. The interaction of exchange rates and quality is again estimated negatively for the contemporaneous relation, yet there is no clear relation when looking at the lagged relation. (There is one outlier, which is when we include 3 lags, when the interaction is estimated to be -16.7%. We do not know why the third lag is significantly negative.)

Summarizing, we find strong evidence that there is a differential pass-through rate for cars of different quality, we also show that this finding cannot be explained by an ad-hoc model of pass-through featuring different curvature of demand for low versus high quality cars. We also provide some evidence that the timing of pass-through is as implied by our model. Our findings are economically large and can easily explain large variation in pass through rates for different goods.

4 Conclusion

TO BE DONE...

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Appendix

A Proof of Proposition 1 (autarky equilibrium)

Proof. Guessing a sequence $(u_n = p_n - \alpha c_n)_{n>1}$, such that,

$$2u_n = \frac{\gamma}{1+\gamma}u_{n-1} + \frac{1}{1+\gamma}u_{n+1}$$

we can solve for α,[19]

$$\alpha = \frac{1+\gamma}{2\left(1+\gamma\right) - \left(\gamma^{\theta} + \gamma^{1-\theta}\right)}$$

We can introduce the following quadratic equation,

$$2\left(1+\gamma\right)X = \gamma + X^2$$

whose roots are,

$$\begin{aligned}\lambda &= 1+\gamma-\sqrt{1+\gamma+\gamma^2}\\ \mu &= 1+\gamma+\sqrt{1+\gamma+\gamma^2}\end{aligned}$$

Note that,

$$0 < \lambda < 1 \text{ and } \mu > 1$$

The sequence $(u_n)_{n>1}$ has a closed form solution of the form,

$$u_n = A\lambda^{n-2} + B\mu^{n-2}$$
$$\Rightarrow p_n = A\lambda^{n-2} + B\mu^{n-2} + \alpha c_n$$

From the transversality condition, we know that $\lim_{n\to\infty} p_n = 0$ so that it must be that,

$$B = 0$$

Otherwise, we would get $\lim_{n\to\infty} p_n = \pm\infty$. Plugging $p_2 = A + \alpha c_2$ and $p_3 = A\lambda + \alpha c_3$ into the first order conditions for p_1 and p_2 in Eq. (6), we get a system of two linear equations with two unknowns, p_1 and A. Solving for A, we get,

$$A = \frac{\left(1-\gamma\right)\gamma q_1 - \left(\gamma q_1\right)^{\theta}\left(\gamma^{1-\theta}\left(2\alpha-1\right) + \alpha\left(\gamma+2\right)\right)}{2\left(1+\gamma+\sqrt{1+\gamma+\gamma^2}\right) - \gamma}$$

■

[19] Note that $\alpha > 1$ iif γ is small enough, otherwise $\alpha < 0$. The larger θ, the lower the threshold above which γ becomes negative.

B Proof of Proposition B (trade equilibrium)

Proof.

- For $n < \bar{n}$, the price sequence is defined as in the autarky equilibrium, and the closed form solution has the same form as in autarky,

$$p_n^* = A \times \lambda^{n-2} + \alpha \times c_n$$

- Foreign low quality goods prices ($n > \bar{n}$) depend on imported goods prices (above and below), which themselves depend on foreign local prices. Using the first order conditions in Eq. (9) to express p_n^* as a function of p_{n-1}^* and p_{n+1}^*, we get,

$$2\left(2\left(1+\delta\right)^2-\delta\right)p_n^* = c_n\left(1+\delta\right)\left(2\left(1+\delta\right)+\omega\left(1+\delta^{1-2\theta}\right)\right)+\delta^2 p_{n-1}^* + p_{n+1}^*$$

Guessing a sequence $\left(u_n = p_n^* + \alpha_T^* c_n\right)_{n>\bar{n}}$, such that,

$$2\left(2\left(1+\delta\right)^2-\delta\right)u_n = \delta^2 u_{n-1} + u_{n+1}$$

we get the following solution for α_T,

$$\alpha_T^* = \frac{\left(1+\delta\right)\left(2\left(1+\delta\right)+\omega\left(1+\delta^{1-2\theta}\right)\right)}{2\left(2\left(1+\delta\right)^2-\delta\right)-\left(\gamma^\theta+\gamma^{1-\theta}\right)}$$

Once again, provided that neither δ is too small nor θ is too large, $\alpha_T > 1$ (otherwise, it becomes negative).We can introduce the following quadratic equation,

$$2\left(2\left(1+\delta\right)^2-\delta\right)X = \delta^2 + X^2$$

which has the following roots,

$$\begin{aligned}\lambda_T &= 2\left(1+\delta\right)\left(1+\delta-\sqrt{1+\delta+\delta^2}\right)-\delta \\ \mu_T &= 2\left(1+\delta\right)\left(1+\delta+\sqrt{1+\delta+\delta^2}\right)-\delta\end{aligned}$$

Note that,

$$0 < \lambda_T < 1 \text{ and } \mu_T > 1$$

The solution to the price sequence will have the following form,

$$p_n^* = A_T^*\lambda_T^{n-2} + B_T^*\mu_T^{n-2} + \alpha_T^* c_n$$

From the transversality condition, $\lim_{n\to\infty} p_n^* = 0$, we get,

$$B_T = 0$$

otherwise, we would violate the transversality condition and get $\lim_{n\to\infty} p_n^* = \pm\infty$. The constant A_T^* is found by noting that the price of the threshold quality $\bar{n}$ is defined both by the sequence of prices below, and the sequence of prices above. So we need,

$$p_{\bar{n}} = A_T^* \lambda_T^{\bar{n}-2} + \alpha_T^* c_{\bar{n}} = A\lambda^{\bar{n}-2} + \alpha c_{\bar{n}}$$

which gives the solution,

$$A_T^* = A\left(\frac{\lambda}{\lambda_T}\right)^{\bar{n}-2} + (\alpha - \alpha_T^*)\frac{c_{\bar{n}}}{\lambda_T^{\bar{n}-2}}$$

- Low quality export prices ($n > \bar{n}$) depend on foreign prices (above and below), which themselves depend on export prices. Using the first order conditions in Eq. (9) to express p_n as a function of p_{n-1} and p_{n+1}, we get,

$$2\left(2(1+\delta)^2 - \delta\right)p_n = c_n(1+\delta)\left(2\omega(1+\delta) + \delta + \delta^{2\theta}\right) + \delta^2 p_{n-1} + p_{n+1}$$

Guessing a sequence $(u_n = p_n + \alpha_T c_n)_{n>\bar{n}}$, such that,

$$2\left(2(1+\delta)^2 - \delta\right)u_n = \delta^2 u_{n-1} + u_{n+1}$$

we get the following solution for α_T,

$$\alpha_T = \frac{(1+\delta)\left(2\omega(1+\delta) + \delta + \delta^{2\theta}\right)}{2\left(2(1+\delta)^2 - \delta\right) - (\gamma^\theta + \gamma^{1-\theta})}$$

Note that $\alpha_T > 0$ only if δ is not too small and/or θ is not too large. Moreover, α_T is not monotonic in δ (for δ close to 1, it is decreasing in δ), and not necessarily above 1 (for ω close to 1, θ small, and δ intermediate, it may be below 1). We can introduce the following quadratic equation,

$$2\left(2(1+\delta)^2 - \delta\right)X = \delta^2 + X^2$$

which has the following roots,

$$\begin{aligned}\lambda_T &= 2(1+\delta)\left(1+\delta-\sqrt{1+\delta+\delta^2}\right) - \delta \\ \mu_T &= 2(1+\delta)\left(1+\delta+\sqrt{1+\delta+\delta^2}\right) - \delta\end{aligned}$$

Note that,

$$0 < \lambda_T < 1 \text{ and } \mu_T > 1$$

The solution to the price sequence will have the following form,

$$p_n = A_T \lambda_T^{n-2} + B_T \mu_T^{n-2} + \alpha_T c_n$$

From the transversality condition, $\lim_{n\to\infty} p_n = 0$, we get,

$$B_T = 0$$

otherwise, we would violate the transversality condition and get $\lim_{n\to\infty} p_n = \pm\infty$. The constant A_T is found by noting that the price of the threshold quality $\bar{n}$ is defined both by the sequence of prices below, and the sequence of prices above. So we need,

$$p_{\bar{n}} = A_T \lambda_T^{\bar{n}-2} + \alpha_T c_{\bar{n}} = A_T \lambda_T^{\bar{n}-2} + \alpha_T \times c_{\bar{n}}$$

which gives the solution,

$$A_T = A \left(\frac{\lambda}{\lambda_T}\right)^{\bar{n}-2} + (\alpha - \alpha_T)\frac{c_{\bar{n}}}{\lambda_T^{\bar{n}-2}}$$

■

C Proof of Proposition 3 (exchange rate pass-through)

PTM

Lemma 3 ***Proof.*** *Relative prices at home and abroad is defined as:*

$$\begin{aligned}\frac{p(q_n)^*}{p(q_n)} &= \frac{A_T^* \times \lambda_T^{n-2} + \alpha_T^* \times c_n}{A_T \times \lambda_T^{n-2} + \alpha_T \times c_n} \\ &= \frac{\alpha_T^*}{\alpha_T}\left(1 + \frac{\frac{\alpha_T}{\alpha_T^*}A_T^* - A_T}{A_T \times \lambda_T^{n-2} + \frac{\alpha_T}{\alpha_T^*} \times c(q_n)} \times \lambda_T^{n-2}\right)\end{aligned}$$

to establish that $\frac{p(q_n)^*}{p(q_n)}$ *is increasing in* q*, it suffices to show that* $A_T < \frac{\alpha_T}{\alpha_T^*} A_T^*$*, which is always true.* ■

ERPT

Proof. Differentiating the expression for export prices in Eq. (10), we get that exchange rate shocks are only partially passed through into export prices,

$$\frac{d\ln p_n}{d\ln\omega} = \frac{1}{1+\frac{\delta+\delta^2}{2\omega(1+\delta)}} \cdot \frac{1}{1+\frac{A_T}{\alpha_T}\cdot\frac{\lambda_T^{n-2}}{c_n}} \in (0,1)$$

Moreover, for δ not too small ($\delta > .6$) and for θ not too large ($\theta < 3$)),

$$2\left(1+\delta\right)\left(1+\delta-\sqrt{1+\delta+\delta^2}\right)-\delta < \delta^{2\theta}$$

so that $\left(\lambda_T^{n-2}/c_n\right)$ decreases with n. If an autarky equilibrium exists (see proposition A), this condition is satisfied. Intuitively, if δ is too small, firms are too far apart and have too much local monopoly power, so that high quality firms have "too much" freedom in setting their mark-ups. When firms have "too much" monopoly power, and/or when the marginal cost increases too fast with quality, high quality firms may respond to exchange rate shocks more than low quality firms.

If $\left(\lambda_T^{n-2}/c_n\right)$ decreases with n, the exchange rate pass through is larger for low quality goods,

$$i < j \Rightarrow \frac{d\ln p_i}{d\ln\omega} < \frac{d\ln p_j}{d\ln\omega}$$

■

D Proof of proposition 4 (pricing-to-market)

Proof.

- TO BE DONE...
- ...
- ...

■

Table 1 - Quality Attributes and Prices: Random Effects Estimations

	(1)	(2)	(3)
	Luxury Dummy	*Quality Index 1*	*Quality Index 2*
	Dependent variable is Ln price in SDR, net of taxes		
Luxury Dummy (Cla= 4,5)	0.698		
	[0.017]**		
Horsepower (in kW)		0.0055	0.0047
		[0.0003]**	[0.0003]**
Fuel efficiency (L/100 km)		-0.0143	-0.0138
		[0.0016]**	[0.0016]**
Cylinder volume (in l)		0.18467	0.16784
		[0.0122]**	[0.0119]**
Weight (in t)		0.2145	0.10811
		[0.0282]**	[0.0282]**
Length (in m)		0.2316	0.1474
		[0.0149]**	[0.0169]**
Width (in m)		0.0464	-0.1031
		[0.0547]	[0.0539]
Height (in m)		-0.4514	-0.3620
		[0.0603]**	[0.00058639]**
Maximum speed (km/hour)		0.0013	0.0011
		[0.0003]**	[0.0003]**
Trend (year)	y	y	y
CPI Inflation	y	y	y
Market Dummies	y	y	y
Class Dummies			y
Brand Dummies			y
Observations	11510	11510	11510
Number of Groups	1554	1554	1554
R-Sq.within	82.8%	84.6%	84.8%
R-Sq. between	82.1%	94.4%	96.3%
R-Sq. total	81.9%	92.9%	94.5%

Notes for Table 1: The dependent variable is the Ln(price) in Special Drawing Rights and net of taxes. All models include a year trend, CPI inflation, and import market dummies. A group is identified by a model (co_loc) sold on one market. The measure of fueld efficiency used is Li (average of Li1, Li2, Li3); robust standard errors in paranthesis; * significant at 5%; ** significant at 1%

Table 2 - Data Description (Cars and Quality)

	(1)	(2)	(3)	(4)	(5)
Variable	***Relative Avg.***	***ean (not weighte***	***Std. Dev.***	***Min***	***Max***
Panel A: All models, all markets, and all years					
(11510 Model-Market-Years, 1554 Model -Years, and 379 Models)					
Price in SDR		6627	4512	681	39665
Quality Index 1	0	0	1	-2.247	3.927
Quality Index 2	0	0	1	-1.949	3.855
Quantity (per Market and Year)		19868	37771	51	433694
Pael B:Models sold in market of production (2097 Model -Years and 255 Models)					
Price in SDR		6214	4330	681	35398
Quality Index 1	**0.019**	-0.055	1.005	-2.247	3.927
Quality Index 2	**0.038**	-0.006	0.993	-1.949	3.855
Quantity per Market and Year		65505	65660	300	433694
Panel C: Models Produced in BEL, FRA, GER, ITA, or UK and Exported					
(6161 Model-Market-Years, 833 Model - Years, and 241 Models)					
Price in SDR		6518	4698	691	39665
Quality Index 1	**0.007**	-0.009	1.022	-2.247	3.927
Quality Index 2	**0.012**	0.047	1.013	-1.949	3.854
Quantity per Market and Year	-	10726	15196	51	175812
Panel D: Models Produced Outside of BEL, FRA, GER, ITA, or UK					
(3252 Model Market Years, 466 Model-Years, and 110 Models)					
Price in SDR		7099	4223	963	34561
Avg. Quality Index 1	**-0.123**	0.052	0.950	-2.020	3.396
Avg. Quality Index 2	**-0.243**	-0.086	0.973	-1.913	2.956
Quantity per Market and Year	-	7759	13602	53	157612

Notes: In Table 2, there are in total 379 models, of which 14 are only exported and not sold in the home market. The quality indexes are predicted from the respective model in Table 1 partialing out the effect of inflation, year, and market. The quality indexes are also standardized. For the Relative Avg. Quality Index, we weight each car quality by the quantity sold and then demean this average by year (but not by market).

Table 3 - Import Penetration by Year and Class

Year	Market Share of Imported Cars (total import share in 5 markets)					Ratio of Import
	Subcompact	Compact	Intermediate	Standard	Luxury	Share of Cla
	(Cla=1)	(Cla=2)	(Cla=3)	(Cla=4)	(Cla=5)	(1+2) / Cla (4+5)
70	26.5%	26.7%	24.9%	16.5%	14.1%	1.74
71	28.4%	25.1%	28.4%	22.3%	14.9%	1.44
72	31.0%	23.8%	32.1%	22.2%	15.8%	1.44
73	30.8%	20.6%	24.9%	27.5%	22.6%	1.03
74	31.8%	25.0%	29.6%	32.6%	19.3%	1.09
75	30.8%	29.8%	38.5%	26.6%	18.6%	1.34
76	34.5%	31.5%	35.1%	27.0%	19.2%	1.43
77	32.8%	30.8%	31.2%	25.9%	19.1%	1.41
78	34.1%	33.7%	38.3%	27.4%	17.6%	1.50
79	30.0%	43.3%	32.8%	29.3%	21.5%	1.44
80	32.8%	37.3%	34.3%	39.4%	20.4%	1.17
81	30.8%	38.0%	34.7%	41.9%	21.9%	1.08
82	31.7%	36.8%	32.0%	44.5%	25.0%	0.99
83	34.2%	37.2%	33.8%	41.6%	25.5%	1.06
84	39.5%	37.4%	35.7%	41.0%	27.9%	1.11
85	42.2%	39.4%	33.9%	43.1%	30.3%	1.11
86	42.4%	37.9%	33.5%	43.4%	32.7%	1.05
87	41.4%	37.9%	33.5%	41.8%	33.2%	1.06
88	43.7%	36.6%	36.8%	43.4%	34.3%	1.03
89	44.6%	38.5%	34.9%	42.8%	38.5%	1.02
90	46.3%	41.7%	36.8%	40.1%	38.2%	1.12
91	51.0%	45.7%	44.4%	38.4%	35.8%	1.30
92	51.8%	42.5%	44.6%	37.7%	51.4%	1.06
93	55.2%	41.3%	48.3%	38.5%	36.6%	1.28
94	54.2%	42.2%	52.8%	40.0%	38.2%	1.23
95	58.7%	41.5%	52.7%	37.6%	40.3%	1.29
96	60.5%	45.8%	50.2%	39.0%	38.3%	1.38
97	63.8%	47.7%	55.1%	43.4%	33.9%	1.44
98	62.9%	47.4%	56.5%	42.5%	36.2%	1.40
99	62.6%	49.9%	55.1%	44.1%	37.4%	1.38
Average	**42.0%**	**37.1%**	**38.5%**	**36.1%**	**28.6%**	**1.25**

Notes: Table 3 reports the import share by class and year. The import share is defined as 1 minus the ratio of total sales of domestically produced cars in the five markets over total sales in the 5 markets (for each class and each year separately). The far right column displays the ratio of the import market share of compact and subcompact cars (Class 1 and 2) divided by the same market share for Intermediate and Luxury cars (Class 4 and 5). The average reported at the bottom of Table 3 displays unweighted averages, i.e. the simple arithmetic average of the respective Column above.

Table 4 - Summary Statistics of Yearly Fluctuations and List of Outliers

Sample consists of all car models that are produced in BEL, FRA, ITA, Ger, and UK and exported to the other 4 markets

	Observations	**Mean**	**St Dev.**	**Min**	**Max**
dExrate =ΔLn(Bilateral Exchange Rate)	5216	-0.0005858	0.0703469	-0.266955	0.266955
dPrice = ΔLn(Car Price in Local Currency)	5216	0.0700733	0.0869908	-0.8905315	0.8134804
dPrice_Relative= ΔLn(Price Import Market/ Price Home Market), Prices in local currencies	4976	-0.0041548	0.1012984	-0.9666461	0.7753934
dCPI = ΔLn(CPI Importer)	5216	0.0592325	0.0440829	-0.0024832	0.2170054
dCPI_Relative= ΔLn(CPI Import Market / CPI Home Market)	5216	0.0004058	0.0435519	-0.1593031	0.1593031

List of Observations with |dPrice|>0.5 or |dPrice_Relative|>0.5

Year	Importer (ma)	Exporter (loc)	Car Model	dPrice	dPrice_Relative	Change of Q1	Level of Q1
74	Italy	Germany	Opel Record	0.6032	0.4798	0.0000	0.3566
75	Italy	Germany	Opel Record	0.5163	0.4440	0.4816	0.8382
75	Belgium	Italy	Fiat 124	0.5991	0.1291	0.5722	0.0898
75	France	Italy	Fiat 124	0.5728	0.1028	0.5722	0.0898
75	UK	Italy	Fiat 124	0.6705	0.2005	0.5722	0.0898
76	UK	Germany	VW Beetle 1200	0.3793	0.5065	0.0000	-1.0821
77	UK	Italy	Fiat Argenta	0.5054	0.1929	0.4228	0.8267
79	Belgium	Germany	VW Beetle 1200	0.6118	na	0.3029	-0.7792
81	Germany	France	Peugeot 504	0.7080	0.6024	0.5107	0.8290
84	Italy	Germany	Audi 100/200	0.7056	0.6729	0.7017	1.3252
93	Belgium	Italy	Lancia Delta	0.8135	0.7754	1.5782	1.6892
94	Belgium	Italy	Lancia Delta	-0.8905	-0.9666	-1.6259	0.0632
95	Belgium	France	Renault 19	-0.1199	-0.6930	0.0000	-0.2130
95	Germany	France	Renault 19	0.0123	-0.5608	-0.2066	0.0171

Notes: The upper part of Table 4 presents summary statistics for changes of exchange rates, prices, and CPI inflation. The summary statistics are presented for all cars that are produced in BEL, FRA, ITA, GER, and the UK and that are sold on at least one of four possible export markets in our sample; when presenting the summary statistics for relative prices, we drop the models that are not sold in the country of production and thus have no "Home Market Price"; In the lower part of Table 3, we list outliers that had year-top-year price changes of more than 0.5 log points or relative price changes of more than 0.5 log points.

Table 5 - Nominal Exchange Rate Pass Through (Fixed Effects using Quality 1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Sample: All Models that are produced in & exported to BEL, FRA, ITA, GER and UK *Dependent Variable is the Change of Ln Car Price (Local Currency, net of Taxes)*							
dExrate = % Change of Exrate	0.131 [0.022]**	0.141 [0.021]**	0.139 [0.022]**	0.139 [0.021]**	0.145 [0.023]**	0.142 [0.022]**	0.142 [0.020]**	0.136 [0.019]**
dExrate* Quality Index 1			-0.063 [0.022]**	-0.067 [0.021]**	-0.078 [0.023]**	-0.085 [0.022]**	-0.059 [0.020]**	-0.055 [0.019]**
Quality Index 1		0.075 [0.011]**	0.075 [0.011]**	0.113 [0.014]**	0.085 [0.012]**	0.144 [0.016]**	0.071 [0.009]**	0.041 [0.007]**
Trend (year)				-0.003 [0.001]**		-0.005 [0.001]**		
Lag 1 of % Price Change					-0.25 [0.035]**	-0.257 [0.034]**		
CPI Inflation (Importing nation)	0.739 [0.043]**	0.946 [0.051]**	0.941 [0.051]**	0.811 [0.049]**	1.172 [0.062]**	0.935 [0.060]**	0.911 [0.043]**	0.924 [0.042]**
Market Dummies	na	na	na	na	na	na	y	y
Observations	5216	5216	5216	5216	4423	4423	5216	5216
Number of groups	736	736	736	736	653	653	212	150
R-squared (within)	0.09	0.12	0.12	0.13	0.18	0.2	0.18	0.19

Notes for Table 5: specifications (1) to (6) include fixed effects by Market-Co-Location (all combinations) where "Co" is the narrow car model definition of P. Goldberg and Verboven (2005); (7) includes fixed effects for Markets and Co separately; (8) includes fixed effects by Markets and zCode, where "zCode" is the wide definition of a car model in P. Goldberg and Verboven (2005). In Columns (2) to (8), the respective quality index is included to capture changes of the quality of a car during the lifecycle of a model; the interpretation of the quality index coefficient is the effect a change in a model's quality has on the price; robust standard errors reported in parentheses * significant at 5%; ** significant at 1%

Table 6 - Nominal Exchange Rate Pass Through (Fixed Effects using Quality 1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Sample: All Models that are produced in & exported to BEL, FRA, ITA, GER and UK ***Dependent Variable is the Change of Ln Car Price (Local Currency, net of Taxes)***							
dExrate = % Change of Exrate	0.134 [0.013]**	0.14 [0.013]**	0.143 [0.013]**	0.139 [0.013]**	0.141 [0.014]**	0.133 [0.013]**	0.142 [0.012]**	0.14 [0.012]**
dExrate* Quality Index 1			-0.036 [0.015]*	-0.039 [0.015]**	-0.041 [0.015]**	-0.048 [0.015]**	-0.037 [0.014]**	-0.031 [0.013]*
Quality Index 1		0.058 [0.007]**	0.059 [0.007]**	0.1 [0.010]**	0.068 [0.008]**	0.134 [0.011]**	0.05 [0.006]**	0.032 [0.005]**
Trend (year)				-0.004 [0.000]**		-0.006 [0.000]**		
Lag 1 of % Price Change					-0.256 [0.025]**	-0.267 [0.024]**		
CPI Inflation (Importing nation)	0.702 [0.037]**	0.892 [0.043]**	0.89 [0.042]**	0.712 [0.043]**	1.13 [0.050]**	0.826 [0.050]**	0.878 [0.036]**	0.895 [0.035]**
Market Dummies							y	y
Observations	7898	7894	7894	7894	6641	6641	7894	7894
Number of groups	1140	1140	1140	1140	981	981	304	224
R-squared (within)	0.08	0.1	0.1	0.12	0.16	0.2	0.15	0.16

Notes for Table 6: specifications (1) to (6) include fixed effects by Market-Co-Location (all combinations) where "Co" is the narrow car model definition of P. Goldberg and Verboven (2005); (7) includes fixed effects for Markets and Co separately; (8) includes fixed effects by Markets and zCode, where "zCode" is the wide definition of a car model in P. Goldberg and Verboven (2005). In Columns (2) to (8), the respective quality index is included to capture changes of the quality of a car during the lifecycle of a model; the interpretation of the quality index coefficient is the effect a change in a model's quality has on the price; robust standard errors reported in parentheses * significant at 5%; ** significant at 1%

Table 7 - Nominal Exchange Rate Pass Through (Fixed Effects using Quality 2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Sample: all Models that are produced in & exported to BEL, FRA, ITA, GER and UK						
	Dependent Variable is the Change of Ln Car Price (Local Currency, net of Taxes)						
dExrate = % Change of Exrate	0.141	0.142	0.141	0.149	0.146	0.144	0.139
	[0.021]**	[0.021]**	[0.021]**	[0.023]**	[0.022]**	[0.020]**	[0.019]**
dExrate* Quality Index 2		-0.044	-0.048	-0.055	-0.064	-0.044	-0.041
		[0.021]*	[0.021]*	[0.022]*	[0.022]**	[0.019]*	[0.019]*
Quality Index 2	0.108	0.107	0.156	0.123	0.198	0.1	0.06
	[0.014]**	[0.014]**	[0.019]**	[0.017]**	[0.022]**	[0.013]**	[0.009]**
Trend (year)			-0.003		-0.005		
			[0.000]**		[0.001]**		
Lag 1 of % Price Change				-0.252	-0.26		
				[0.035]**	[0.034]**		
CPI Inflation	0.95	0.948	0.812	1.187	0.942	0.915	0.931
(Importing nation)	[0.050]**	[0.050]**	[0.049]**	[0.062]**	[0.059]**	[0.043]**	[0.041]**
Market Dummies						y	y
Observations	5216	5216	5216	4423	4423	5216	5216
Number of groups	736	736	736	653	653	212	150
R-squared (within)	0.12	0.12	0.14	0.18	0.21	0.18	0.19

Notes for Table 7: specifications (1) to (5) include fixed effects by Market-Co-Location (all combinations) where "Co" is the narrow car model definition of P. Goldberg and Verboven (2005); (6) includes fixed effects for Markets and Co separately; (7) includes fixed effects by Markets and zCode, where "zCode" is the wide definition of a car model in P. Goldberg and Verboven (2005). In Columns (1) to (7), the respective quality index is included to capture changes of the quality of a car during the lifecycle of a model; the interpretation of the quality index coefficient is the effect a change in a model's quality has on the price; robust standard errors reported in parentheses * significant at 5%; ** significant at 1%

Table 8 - Relative Exchange Rate Pass Through (Fixed Effects Results for Quality 1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Sample: all models that are produced in & exported to BEL, FRA, ITA, GER and UK								
	Dependent Variable is the percentage change (dLn) of the ratio of importer over exporter price (local currencies)								
dExrate = % Change of Exrate	0.165 [0.027]**	0.147 [0.025]**	0.144 [0.025]**	0.145 [0.025]**	0.141 [0.027]**	0.141 [0.027]**	0.158 [0.023]**	0.151 [0.023]**	0.15 [0.026]**
dExrate * Quality Index 1			-0.091 [0.024]**	-0.09 [0.024]**	-0.08 [0.026]**	-0.08 [0.026]**	-0.083 [0.022]**	-0.087 [0.021]**	-0.068 [0.024]**
Difference in Relative Quality 1 (Importer Q1-Exporter Q1)		0.233 [0.017]**	0.235 [0.017]**	0.234 [0.017]**	0.226 [0.017]**	0.226 [0.017]**	0.236 [0.015]**	0.237 [0.015]**	
Trend (year)				0.001 [0.000]		0 [0.000]			
Lag 1 of Change in Ln (Relative Price)					-0.269 [0.024]**	-0.269 [0.024]**			
Change in Ln Relative CPI (Importer Infl. - Exporter infl.)	0.796 [0.057]**	0.78 [0.055]**	0.757 [0.055]**	0.778 [0.057]**	1.007 [0.061]**	1.013 [0.065]**	0.761 [0.048]**	0.802 [0.044]**	
Quality 1 Exporter									-0.178 [0.019]**
Quality 1 Importer									0.175 [0.020]**
Change in Ln CPI Importer									0.7 [0.063]**
Change in CPI Exporter									-0.909 [0.076]**
Market Dummies	na	na	na	na	na	na	y	y	na
Observations	4976	4976	4976	4976	4174	4174	4976	4976	4976
Number of groups	719	719	719	719	626	626	204	144	719
R-squared (within)	0.06	0.2	0.21	0.21	0.29	0.29	0.25	0.26	0.13

Notes for Table 8: in all specifications, the dependent variable is the change in the natural logarithm of the relative car price in local currencies (Importer Price divided by Exporter Price); the independent variable "Change in Ln CPI" measures the change in the ln of the ratio of importer CPI to the exporter CPI; in Columns (2) to (9), the relative quality index is included to reflect changes of the relative quality of a car during the lifecycle of a model; the interpretation of the relative quality index coefficient is the effect a relative change in a model's quality (in the importer relative to the exporter) has on the relative price; Columns (1) to (6) and (9) include fixed effects by Market-Co-Location (all combinations); (7) includes fixed effects for Markets and Co; (8) includes fixed effects for Market and zCode; robust standard errors reported in parentheses * significant at 5%; ** significant at 1%

Table 9 - Relative Exchange Rate Pass Through (Fixed Effects Results for Quality 2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Sample: all models that are produced in & exported to BEL, FRA, ITA, GER and UK								
	Dependent Variable is the percentage change (dLn) of the ratio of importer over exporter price (local currencies)								
dExrate = % Change of Exrate	0.165 [0.027]**	0.147 [0.025]**	0.149 [0.025]**	0.149 [0.025]**	0.146 [0.027]**	0.146 [0.027]**	0.162 [0.023]**	0.155 [0.023]**	0.153 [0.026]**
dExrate * Quality Index 2			-0.072 [0.024]**	-0.07 [0.024]**	-0.058 [0.026]*	-0.057 [0.026]*	-0.066 [0.022]**	-0.071 [0.021]**	-0.047 [0.024]
Difference in Relative Quality 2 (Importer Q2-Exporter Q2)		0.29 [0.021]**	0.292 [0.021]**	0.291 [0.021]**	0.281 [0.021]**	0.28 [0.021]**	0.294 [0.019]**	0.295 [0.019]**	
Trend (year)				0.001 [0.000]		0 [0.000]			
Lag 1 of Change in Ln (Relative Price)					-0.27 [0.024]**	-0.27 [0.024]**			
Relative CPI Inflation (dCPI Importer Infl. - Exporter ir	0.796 [0.057]**	0.779 [0.055]**	0.765 [0.055]**	0.786 [0.057]**	1.016 [0.061]**	1.022 [0.065]**	0.769 [0.048]**	0.809 [0.044]**	
Quality 2 Exporter									0.218 [0.025]**
Quality 2 Importer									-0.22 [0.023]**
Change in Ln CPI Importer									0.709 [0.063]**
Change in CPI Exporter									-0.917 [0.076]**
Market Dummies	na	na	na	na	na	na	y	y	na
Observations	4976	4976	4976	4976	4174	4174	4976	4976	4976
Number of groups	719	719	719	719	626	626	204	144	719
R-squared (within)	0.06	0.2	0.2	0.21	0.28	0.28	0.25	0.26	0.12

Notes for Table 9: in all specifications, the dependent variable is the change in the natural logarithm of the relative car price in local currencies (Importer Price divided by Exporter Price); the independent variable "Change in Ln Relative CPI" measures the change in the ln of the ratio of importer CPI to the exporter CPI; in Columns (2) to (9), the relative quality index is included to reflect changes of the relative quality of a car during the lifecycle of a model; the interpretation of the relative quality index coefficient is the effect a relative change in a model's quality (in the importer relative to the exporter) has on the relative price; Columns (1) to (6) and (9) include fixed effects by Market-Co-Location (all combinations); (7) includes fixed effects for Markets and Co; (8) includes fixed effects for Market and zCode; robust standard errors reported in parentheses * significant at 5%; ** significant at 1%

Table 10 - Nominal Exchange Rate Pass Through in the Long Run

	(1)	(2)	(3)	(4)	(5)
	Sample: All models that are produced in & exported to BEL, FRA, ITA, GER and UK				
	Dependent Variable is the Change of Ln Car Price (Local Currency, net of Taxes)				
dExrate = Change Ln Exrate	0.139	0.132	0.133	0.13	0.144
	[0.022]**	[0.022]**	[0.024]**	[0.028]**	[0.032]**
L1. dExrate		0.08	0.08	0.09	0.088
		[0.020]**	[0.022]**	[0.025]**	[0.029]**
L2.dExrate			0.108	0.11	0.145
			[0.020]**	[0.021]**	[0.024]**
L3.dExrate				-0.055	-0.038
				[0.025]*	[0.028]
L4. dExrate					0.124
					[0.035]**
dExrate * Quality1	-0.063	-0.07	-0.06	-0.045	-0.048
	[0.022]**	[0.019]**	[0.023]**	[0.026]	[0.029]
L1. dExrate * Quality1		0.021	0.023	0.019	0.033
		[0.020]	[0.021]	[0.024]	[0.029]
L2. dExrate * Quality1			-0.004	0.005	0.028
			[0.019]	[0.021]	[0.023]
L3. dExrate * Quality1				-0.028	-0.012
				[0.023]	[0.025]
L4. dExrate * Quality1					0.013
					[0.031]
CPI Inflation (dLn CPI)	0.941	0.716	0.692	0.712	0.645
	[0.051]**	[0.066]**	[0.075]**	[0.085]**	[0.102]**
L1. CPI Inflation		0.07	-0.01	-0.115	-0.179
		[0.065]	[0.096]	[0.108]	[0.118]
L2. CPI Inflation			0.064	0.21	0.152
			[0.075]	[0.110]	[0.121]
L3.CPI Inflation				-0.177	0.008
				[0.085]*	[0.117]
L4. CPI Inflation					-0.242
					[0.091]**
Sum of all ERPT Coef.	**0.139**	**0.212**	**0.321**	**0.275**	**0.463**
P (Value (sum=0)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Sum of all Interactions Coef.	**-0.063**	**-0.049**	**-0.041**	**-0.049**	**0.014**
P Value (sum L0-l4=0)	**0.00**	**0.06**	**0.26**	**0.31**	**0.84**
P Value (sum L1-L.4=0)					
Observations	5216	4423	3730	3129	2595
Number of groups	736	653	578	519	443
R-squared (within)	0.12	0.29	0.3	0.31	0.32

Notes for Table 10: in all specifications, the dependent variable is the change in the natural logarithm of the car price in local currency; all regressions also control for the changes in model quality (Qualtiy Index 1included: Lag 0 in (1), Lag0-Lag1 in (2), Lag0-Lag2 in (3), Lag0-Lag3 in (4) and Lag0-Lag4 in (5)); All models include fixed effects by Market-Co-Location (all combinations); robust standard errors reported in parentheses * significant at 5%; ** significant at 1%.

Table A1 - Nominal Exchange Rate Pass Through (Fixed Effects using Quality 1, Excluding Outliers from Table 4)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Sample: All Models that are produced in & exported to BEL, FRA, ITA, GER and UK							
	Dependent Variable is the Change of Ln Car Price (Local Currency, net of Taxes)							
dExrate = % Change of Exrate	0.135	0.142	0.14	0.139	0.147	0.144	0.145	0.138
	[0.021]**	[0.021]**	[0.021]**	[0.021]**	[0.022]**	[0.021]**	[0.019]**	[0.018]**
dExrate* Quality Index 1			-0.052	-0.055	-0.062	-0.07	-0.05	-0.047
			[0.019]**	[0.019]**	[0.020]**	[0.019]**	[0.018]**	[0.017]**
Quality Index 1		0.059	0.059	0.092	0.065	0.117	0.056	0.031
		[0.008]**	[0.007]**	[0.010]**	[0.008]**	[0.011]**	[0.007]**	[0.005]**
Trend (year)				-0.003		-0.004		
				[0.000]**		[0.000]**		
Lag 1 of % Price Change					-0.226	-0.232		
					[0.020]**	[0.020]**		
CPI Inflation	0.709	0.873	0.87	0.763	1.067	0.866	0.852	0.863
(Importing nation)	[0.041]**	[0.043]**	[0.043]**	[0.046]**	[0.049]**	[0.053]**	[0.038]**	[0.036]**
Market Dummies							y	y
Observations	5202	5202	5202	5202	4409	4409	5202	5202
Number of groups	736	736	736	736	653	653	212	150
R-squared (within)	0.1	0.12	0.12	0.13	0.17	0.19	0.18	0.2

Notes for Table A1: specifications (1) to (6) include fixed effects by Market-Co-Location (all combinations) where "Co" is the narrow car model definition of P. Goldberg and Verboven (2005); (7) includes fixed effects for Markets and Co separately; (8) includes fixed effects by Markets and zCode, where "zCode" is the wide definition of a car model in P. Goldberg and Verboven (2005). In Columns (2) to (8), the respective quality index is included to capture changes of the quality of a car during the lifecycle of a model; the interpretation of the quality index coefficient is the effect a change in a model's quality has on the price; robust standard errors reported in parentheses * significant at 5%; ** significant at 1%