Sunk Cost Hysteresis in Turkish Manufacturing Exports

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Kurmaş Akdoğan[1] & Laura M. Werner[2,3]

ABSTRACT:

This article examines hysteresis in export entry-exit decisions of the Turkish manufacturing sector using the Preisach method. As the argument goes, sunk costs imply threshold levels of the exchange rate affecting the export market entry-exit behaviour of firms. The wait-and-see behaviour of firms in between these thresholds results in hysteresis in export markets at the aggregated level. Our results suggest sunk cost hysteresis for five subsectors of the Turkish manufacturing sector: clothing, textiles, machinery and equipment, tobacco products and communication equipment. The article also provides a more detailed look on the determinants of hysteresis behaviour in the clothing sector.

KEYWORDS: Hysteresis, Exports, Preisach method, Nonlinearity, Path-dependency.

JEL: C19, F14, L60

ÖZET:

Bu çalışma, Türk imalat sanayisi firmaların ihracata giriş-çıkış kararlarında histerezis davranışının etkisini Preisach yöntemi kullanarak incelemektedir. Batık maliyetlerin varlığı, firmaların ihracata giriş-çıkış kararlarını etkileyen belirli eşik kur seviyeleri olduğunu ima etmektedir. Firmaların bu eşikler içinde bekle-gör davranışı göstermeleri ihracatta histerezis davranışına işaret olarak kabul edilmektedir. Sonuçlar, ihracat histerezisinin Türk imalat sanayi altındaki beş sektör için geçerli olduğunu göstermektedir: hazır giyim, tekstil, makine-teçhizat, tütün ürünleri ve haberleşme araçları. Çalışmada ayrıca hazır giyim sektöründeki histerezis davranışının belirleyicileri ayrıntılı olarak incelenmektedir.

ANAHTAR SÖZCÜKLER: Histerezis, İhracat, Preisach yöntemi, Doğrusal Olmayan Modeller, Patika-bağımlılığı.

JEL: C19, F14, L60

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Non-Technical Summary

This article examines the sunk-cost hysteresis behaviour in the export markets for seventeen subsectors of the Turkish manufacturing sector. Firms may face sunk costs while entering or exiting the export market. Gathering information about foreign demand, health and security standards of destinations; organization of transportation, distribution and selling; costs for advertising and establishing a brand name; hiring and training additional workers; or severance payments (during exit) are examples of these costs. These sunk costs imply *threshold* levels of the exchange rate that determine the timing of the entry or exit. As the argument goes, the wait-and-see behaviour of individual firms in between these thresholds results in *hysteresis* in export markets at the aggregated level.

This study employs Preisach method to aggregate the impact of the wait-and-see behaviour of individual firms in the aforementioned exchange rate band of inaction. Through this method, small, innocuous changes in the exchange rate which do not affect the exporting status of the firms are filtered. The filtered real exchange rate series is employed in the conventional empirical export estimation in the following stage. The estimation assumes that the hysteretic system depends on selected past values, suggesting a non-linear function. Comparing the results of this equation with the conventional benchmark, we examine whether the remanence due to firm-level heterogeneity helps us to capture the sunk-cost hysteresis for the particular sector.

The results suggest hysteresis for five sectors: clothing, textiles, machinery and equipment, tobacco products and communication equipment. Accordingly, once the hysteresis behaviour in the export market is considered, the theoretical relationship between exports and exchange rate holds in these five sectors. The article further presents an in-depth analysis of the dynamics of the production and export behaviour of the clothing sector for the existence of sunk costs hysteresis.

1. Introduction

Turkey showed a strong export performance and increasing export orientation in the last two decades. Exports display a fivefold increase in US dollar terms and the composition of exports has shifted from sectors that produce consumption goods towards sectors that produce intermediate goods. The literature suggests different factors for this proliferation in exports including structural reforms based on the outward-oriented strategies started in 1980s, higher integration to world markets, and the corresponding influx of foreign capital. However, the role of a competitive exchange rate on the surge of exports is the subject of an ongoing debate. The literature documents that the exchange rate elasticity of exports has significantly decreased over time for many countries, including Turkey[4].

Among alternative rationales provided by the literature to account for the weak relationship between exchange rates and exports, one strand of literature highlights *sunk costs* of entry and exit. There are many occasions a firm may face sunk costs when entering an export market. Information about foreign demand, or health and security standards of destinations has to be gathered. Transporting, distribution and selling have to be organized. There may be costs for advertising and establishing a brand name as well as for hiring and training additional workers. Exiting a market can also involve sunk costs such as severance payments.[5] As the argument goes, existence of sunk costs implies *threshold* levels of the exchange rate for a firm to enter into (and exit from) the export market. In between these thresholds, there is a *band of inaction* where the firm does not change its export status, e.g. an exporting firm with high sunk costs might bear with temporary losses as long as the variable costs are covered. This *wait-and-see* behaviour of individual firms results in *hysteresis* in export markets at the aggregated level.

Measuring hysteresis is not straightforward since the adjustment of exports could differ in size and speed depending on the firm characteristics. Firms might have different exchange rate thresholds beyond which their export market activity would change. One of the methods used in the previous literature to aggregate the impact of the aforementioned wait-and-see behaviour of individual firms in exports market is the Preisach method. Accordingly, the innocuous changes in the exchange rate which do not affect the exporting behaviour of the firms are disregarded through the use of a filtered series in the empirical estimation for exports.

Using this method, this article analyses the hysteresis behaviour in export markets of seventeen subsectors of the Turkish manufacturing sector. The results suggest hysteresis for five sectors: clothing, textiles, machinery, tobacco products and communication equipment[6]. Accordingly, once the hysteresis behaviour in the export market is taken into account the theoretical relationship between exports and exchange rate holds in these five sectors. The article further presents an in-depth analysis of the dynamics of the production and export behaviour of the clothing sector for the existence of sunk costs hysteresis.

The plan of the study is as follows. The next section presents a review of the literature on export market hysteresis methods as well as the corresponding literature on Turkish exports. The third and fourth sections, respectively, describe data and the Preisach method. The fifth section documents the results. The sixth section provides a detailed analysis of hysteresis dynamics in the Turkish clothing sector. The seventh section discusses policy implications of the results and concludes.

[4] Cross-country panel results of Ahmed et al. (2015) explain the decreasing exchange rate elasticity with higher participation in global value chains.

5 See Baldwin, 1990; Bernard and Wagner, 2001; Roberts and Tybout, 1997)

[6] The full names of subsectors and descriptions of abbreviations can be found in Table 2 in the Appendix.

2. Literature Review

Kemp and Wan (1974) lay the foundation of hysteresis in trade studies. They show that adding adjustment costs of hiring and firing induce multiple long-run equilibria in a closed economy. This behaviour is similar to hysteresis as it is known in physics e.g. in magnetics. Hysteresis in trade, on the other hand, is usually caused by sunk costs. It is referred to as *export persistence*, meaning that exporters stay in export markets despite unfavourable conditions such as home currency appreciations. Dixit (1989a; 1989b), Baldwin (1990), and Baldwin and Krugman (1989) studied the impacts of sunk costs for market entry and exit theoretically. Roberts and Tybout (1997), and Bernard and Wagner (2001) test the sunk cost hysteresis hypothesis and find evidence that prior market experience influences the export decisions for Colombian and German firms, respectively. Using Spanish firm-level data, Campa (2004) and Máñez et al. (2008) find hysteresis in Spanish manufacturing exports due to sunk costs which affect small firms in particular.

Belke and Göcke (2001) provide an estimation procedure to test for hysteresis in trade. They derive a hysteresis variable from the exchange rate and include it in an empirical estimation model. The advantage of this approach is the sufficiency of aggregated export data which are more available than firm-level data. A further characteristic of a hysteresis system is that large shocks which neutralize each other do not bring the system back to its initial point. This characteristic property is called *remanence*. Piscitelli et al. (2000) apply another approach which builds on the algorithm of Preisach (1935) to derive a hysteresis variable. In Hallett and Piscitelli (2002) both methods are compared and the latter one is favoured. However, in Belke et al. (2013; 2014 and 2015) an improved version of the Belke-Göcke-algorithm is used and hysteresis is found for German and other European Area member countries' exports. Werner (2017) examines European wine exports to the US applying the method of Belke and Göcke (2001) as well as the Preisach method published by Piscitelli et al. (2000) and receives similar results with both approaches. De Prince and Kannebley Junior (2013) study hysteresis in prices and quantities of Brazilian imports and combine the Piscitelli et al. (2000) method with panel cointegration testing.

Other researchers use time series methods to search for hysteresis. Kannebley (2008) applies threshold cointegration and identifies hysteresis in Brazilian exports. Many time series analysts define hysteresis as zero-root dynamics where all past events influence the current state of the output variable and there is no remanence property. In contrast to this, we use the term hysteresis as it is defined in physics which means there is a selective memory and remanence. Thus, the output depends only on the non-dominated past extremum values of the input. The output of the hysteretic system turns into a non-linear function of the input variable. The assumed source of the non-linearity, which is captured by remanence, is the firm-level heterogeneity, i.e. different threshold levels of firms. Amable et al. (1994 and 2004), O'Shaughnessy (2000), Göcke (2002) or Setterfield (2009) discuss the differences of these approaches in more detail.

Timoshenko (2015) begins her framework with the same hysteresis model of non-ideal relay as we do. To identify the source of state dependence, she distinguishes between sunk costs and learning-by-exporting which could cause hysteresis. Studying Colombian plant-level data she finds that learning, i.e. being exporting in previous periods, has a stronger effect on export persistence than sunk costs especially in industries with differentiated products. She argues that exporters continue exporting because they do not want to lose their export experience if it tends to depreciate rapidly[7].

Meinen (2015) controls for aspects like learning and finds that destination specific sunk costs matter, albeit differently across sectors. In addition, import experience from a specific market is able to facilitate exports to this destination[8]. Studying the Danish furniture industry, he shows that a firm which already exports has a higher probability of a further export market expansion than a non-exporting firm. Examining Swedish food chain data, Gullstrand and Persson (2015) suggest evidence that firms stay longer on core markets in line with the hysteresis literature but are more willing to exit peripheral markets as argued by trade duration literature. Padmaja and Sasidharan (2017) analyse Indian firm-level data of manufacturing firms and find evidence that sunk costs matter for the export participation decision. Controlling for firm characteristics, they show that large, foreign owned, or multiproduct firms face less sunk costs than small, single product, or domestically-owned firms. They find persistence in exports, using discrete-duration survival analysis. The longer a firm exports, the lesser is the risk of exit from the export market. Kongsted (2012) analyses the optimal trade taxation considering the existence of sunk costs in export markets. He suggests infrequent revisions to the trade policy against exogenous exchange rate shocks.

To the best of our knowledge, our study is the first one that tests for the existence of export market hysteresis in Turkey, using the Preisach method. Similar to Piscitelli et al. (2000), we employ the *Preisach variable* (PV), a variable that filters the small changes in the exchange rate in the conventional export equation, as will be defined in detail in the following chapters. In terms of empirical modelling, our results corroborate those of Belke et al. (2013), Belke et al. (2015), and Roberts and Tybout (1997) in the sense that sunk costs should be taken into account for measuring hysteresis behaviour in the export markets.

Recent studies on Turkish exports suggest that the external demand is the main determinant of exports while relative prices are mostly insignificant, in line with the literature on many other countries. Uz (2010) and Saygılı and Saygılı (2011) show that exchange rate sensitivity of Turkish exports is very low. The latter study further argues that the impact of external demand is not stable over time. Çulha and Kalafatçılar (2014) show that exports to developed countries have a significant relationship with foreign income while exports to emerging markets are more responsive to real exchange rate changes[9]. Toraganlı and Yalçın (2016) show that the firms with higher foreign exchange denominated debt to exports are more sensitive to the changes in the exchange rate, pointing out the importance of liability dollarization and currency mismatch in financing decisions of SMEs in particular. Our results support Uz (2010) and Saygılı and Saygılı (2011) both of which point out the external demand, rather than the real exchange rate, as the main determinant of Turkish manufacturing sector exports.

The literature on export market participation decisions of the Turkish manufacturing sector consists of a number of sectoral as well as firm-level analyses. Özler et al. (2009) examine Turkish manufacturing firms and show that sunk costs of entry are higher than that of re-entry, indicating a positive but diminishing effect of the export history on entry decisions. Aldan and Günay (2008) provide support for the self-selection hypothesis showing that the presence of larger and more productive firms in export markets would be an outcome of their higher capability to bear the sunk costs of entrance.

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[7] Roberts and Tybout (1997) also state that a Colombian firm with two years absence of exporting has to pay similar re-entry costs than a new exporter.

[8] In a recent study, Choquette (2019) shows that pre-entry import-based market experience increases the probability to exit because it reduces sunk entry costs and invites managers to experiment.

[9] Bozok et al. (2015) also disaggregate among export regions and show that while income is significant for all regions, relative prices are only significant for selected regions.

Demirhan (2016a) further underlines the existence of a learning effect, in addition to the self-selection hypothesis for Turkish exporters. Corroborating with the findings of Özler et al. (2009), she also suggests the significance of previous export experience in export propensity. Demirhan (2016b) further delves into the entry and exit decisions of exporting firms in Turkish manufacturing sectors using duration models. She shows that firms waiting time to be an exporter gets smaller with size, productivity, quality-orientation, ease of financing and capital intensity. Partially in contrast to these results, Gezici et al. (2018) argue that financing constraints of Turkish manufacturing firms do not present a significant obstacle for export market entry.

Demirhan and Ercan (2018) analyse the impact of economic crises on export behaviour of the Turkish manufacturing firms. According to their results, export propensity increased in 1994 due to devaluation and contracting demand. However, while similar conditions resulted in an increase in export volume, the accompanying credit crunch was a major obstacle for new entrants in the 2001 crisis. The 2008 crisis, on the other hand, highlights a contraction both in export propensity and export volume due to the collapse in global trade. Our results corroborate with those of Özler et al. (2009) and Demirhan (2016a and b) in the sense that the previous export experience is an important determiant of the entry and exit behavior in certain sectors.

3. Data

The quarterly sectoral export volume indices which are classified in Broad Economic Classification are taken from Turkish Statistical Institute for the 2006Q1-2018Q2 period. The manufacturing sector has 17 subsectors as presented in Table 2 in the Appendix.

The CPI based real effective exchange rate (REER) is measured as the weighted geometric average of the domestic prices relative to the prices of the principal trade partners and taken from the Central Bank of the Republic of Turkey database. An increase in REER suggests appreciation of the domestic currency in real terms, indicating higher value of Turkish goods in terms of foreign goods. Hence, the expected sign of the coefficient in the export specification is negative according to economic theory.

The foreign demand variable is the export-weighted global growth. This index is calculated by multiplying the real growth of country *i* with the weights of this country in Turkish exports (w_i) at time t (Çıplak et al., 2011):

$$GG_{exp,t} = \sum_{i=1}^{n} w_i y_{t,i}$$

In the export estimation, higher global demand would indicate higher exports and hence the expected sign of this coefficient is positive.

The quarterly real GDP is calendar adjusted, measured as a chain linked volume index and provided by Turkish Statistical Institute. Most of the series suffer from the unit root problem and display seasonal patterns. Considering this, year-on-year changes are used for all dependent and independent variables in the estimations.

4. Method

We apply the Preisach procedure (Preisach, 1935) provided by Piscitelli et al. (2000) to derive a hysteresis variable, namely, *Preisach variable*, (*PV)*. This variable is kind of a filtered exchange rate which only reflects the large changes. More precisely, the non-dominated local minima and maxima are described by this variable. Small changes of the exchange rate are smoothed out. Also, there is a special kind of memory process applied which is typical for hysteresis.

To explain the Preisach variable, we start with the non-ideal relay which displays the simplest hysteresis model (e.g. Göcke, 2002). We assume that the dependent variable is the exporting behaviour of a firm which takes only two states: exporting (1) and not exporting (0). The independent variable is the exchange rate. Fluctuations of the exchange rate are expressed by back and forth movements on the horizontal axis. Movements to the right are interpreted as depreciations of the home currency. Therefore, if the exchange rate starts at a low value and increases steadily, it will, at some point in time, reach the export market entry trigger α and thus incentivize the firm to start exporting (Figure 1). We assume that a firm which enters an export market has to pay sunk costs. If the exchange rate increases/depreciates further, the firm will stay in the export market. However, the exchange rate can also appreciate which means a movement to the left on the horizontal axis. If the exchange rate falls below the entry trigger the firm will stay in the export market because it has already paid the irrevocable market entry costs. But, if the exchange rate decreases more and more, there will be a value at which the variable costs of exporting are not covered anymore and the firm will pay the market exit costs and abandon the market. This value is the exit trigger β at which the firm switches from state 1 to state 0 (Figure 1). Thus, between the exit trigger and the entry trigger there is a *band of inaction*. Knowing that the exchange rate is currently in this band does not suffice to determine if the firm is exporting or not. It is important to know in which state the firm has been in the previous period because if the firm has been in state 0, a movement in the band of inaction which does not exceed the entry trigger, lets the firm stay in its non-exporting state. Analogous considerations can be done if the exchange rate alters within the band of inaction and the firm was in state 1 in the previous period. As long as the exchange rate is not less than the exit trigger, the firm still exports.

INSERT FIGURE 1 ABOUT HERE

Mathematically we can express the non-ideal relay $F_{\alpha,\beta}(x(t))$ which depends on the market entry trigger α and the market exit trigger $\beta < \alpha$, as well as on the exchange rate $x(t)$ at time t as:

$$F_{\alpha,\beta}\big(x(t)\big) = \begin{cases} 1, \text{ if } x(t) \geq \alpha - (\alpha - \beta)F_{\alpha,\beta}\big(x(t-1)\big) \\ 0, \text{otherwise} \end{cases},$$

see Timoshenko (2015).

Therefore, the non-ideal relay is able to model the exporting hysteresis behaviour of one firm in a simple way. The next step is to aggregate heterogeneous firms with different entry and exit trigger values.

The aggregation process of five firms with different entry and exit triggers is presented in Figure 2 as an example. If the movement of the exchange rate starts in P_0 none of the firms is exporting. The increase of the exchange rate to P_1 triggers the entry values of firms (a) and (c). A following decrease to P_2 does not undercut one of the exit triggers of firms (a) or (c) and therefore does not affect the number of firms in the export market. In contrast to this, an increase to P_3 exceeds the entry trigger values of all five firms in the example. Therefore, all five firms export until a following decrease of the exchange rate back to P_2 affects the exit trigger values of firms (e) and (d). Note that firm (b) is still in the export market after the movement from P_3 to P_2 .Therefore, a temporary increase of the exchange rate (from P_2 to P_3) raises the number of firms in the export market from two to three. This shows the remanence property.

INSERT FIGURE 2 ABOUT HERE

The second characteristic hysteresis property, the selective memory, is illustrated in Figure 3. Figure 3 shows the aggregation process of heterogeneous firms via the Preisach triangle. This aggregation procedure was invented by Preisach (1935).

INSERT FIGURE 3 ABOUT HERE

We assume that the different entry and exit triggers of the firms are distributed uniformly among the Preisach triangle which is depicted in Figure 3. This assumption is technically convenient as we assume that the weight function $\omega(\alpha, \beta) \equiv 1$ for all α and β, but it does not alter the results meaningfully as was shown by Piscitelli et al. (2000). We write the exit trigger values on the horizontal axis and the entry trigger values on the vertical axis in the diagrams in Figure 3. Then, all firms lie in the Preisach triangle which is bordered by the entry = exit trigger line, the vertical axis and the maximum of the exchange rate in the considered time period. To illustrate the aggregation process, let us assume that we start at a low value of the exchange rate at which no firm exports. An increase of the exchange rate up to a local maximum M_1 will exceed entry triggers of some firms. These firms will start to export. They can be identified by the triangle S^+ which arises when we move upwards on the vertical axis (Figure 3a).

Next, the exchange rate will decrease to a local minimum value m_1. Firms whose exit triggers are undercut will exit the export market. They can be found in Figure 3b by projecting the previous local maximum M_1 from the vertical axis to the horizontal axis. The movement from M_1 to m_1 is retraced on the horizontal axis. The exiting firms are represented by the small triangle which is cut from the previous triangle of active firms. The active firms are now depicted by a trapezoid S^+ (Figure 3b).

The next example shows how local maxima and minima are erased from the memory process (Belke et al. 2014; Göcke 2002; Mayergoyz 2003). A strong increase of the exchange rate, retraced by a vertical move on the vertical axis up to a higher local maximum than the last one $M_2 > M_1$, erases all previous local maxima and minima from the memory process. A large upwards movement means a huge shift to the right in all firm's non-ideal relays which means that all the firms whose entry triggers are exceeded will now start to export or remain in the export market (Figure 3c). The next decrease of the exchange rate results in a trapezoid of active firms as described above (Figure 3d). The following increase, which is assumed to be not as strong as the second one, up to M_3 adds a further triangle to the trapezoid when moving upwards on the vertical axis again (Figure 3e).

Further fluctuations of the exchange rate result in a staircase function which divides the Preisach triangle in two parts (Figure 3f). In the upper part S^- lie firms which are not active in the export market whereas in the lower part S^+ all exporting firms are pictured. As $F_{\alpha,\beta}\big(x(t)\big) = 0$ for all inactive firms in S^-, it is sufficient to integrate over all active firms in S^+ where $F_{\alpha,\beta}\big(x(t)\big) = 1$, thus:

$$PV\big(x(t)\big) = \iint_{\alpha \geq \beta} \omega(\alpha, \beta) F_{\alpha,\beta}\big(x(t)\big) d\alpha d\beta$$

$$= \iint_{S^+} \omega(\alpha, \beta) F_{\alpha,\beta}\big(x(t)\big) d\alpha d\beta + \iint_{S^-} \omega(\alpha, \beta) F_{\alpha,\beta}\big(x(t)\big) d\alpha d\beta$$

$$= \iint_{S^+} \omega(\alpha,\beta) d\alpha d\beta \approx \sum_{k=1}^{n(t)} \iint_{Q_k(t)} \omega(\alpha,\beta) d\alpha d\beta = \sum_{k=1}^{n(t)} Q_k(t)$$

Every step of the staircase function is built by a trapezoid $Q_k(t)$, thus the Preisach variable *PV* at time *t* is the sum of all $n(t)$ trapezoids which represent the active firms at time t. Only non-dominated local extremum values matter for the memory process which is selective, non-linear and with remanence (Hallett and Piscitelli, 2002; Mayergoyz, 2003).

The result of the Preisach algorithm can be found in Figure 4 which shows REER and the Preisach variable. One can see that the Preisach variable is kind of a filtered version of REER. Small changes of REER which should not change the exporting behaviour of firms are filtered out as e.g. between 2007Q4 and 2008Q3.

INSERT FIGURE 4 ABOUT HERE

In our analysis, the set of equations[10] is estimated for each subsector of the Turkish manufacturing sector:

$$X_{ti,\,yoy} = C + \alpha_1\, REER_{t,yoy} + \alpha_2\, GG_{t,yoy} + \alpha_3\, GDP_{t-1,yoy} + \varepsilon_{ti} \quad (1)$$

$$X_{ti,\,yoy} = C + \alpha_1\, REER_{t,yoy} + \alpha_2\, REER_{t-1,yoy} + \alpha_3\, REER_{t-2,yoy} + \alpha_4\, GG_{t,yoy} + \alpha_5\, GDP_{t-1,yoy} + \varepsilon_{ti} \quad (2)$$

$$X_{ti,yoy} = C + \alpha_1\, PV_{t,yoy} + \alpha_2\, GG_{t,yoy} + \alpha_3\, GDP_{t-1,yoy} + \varepsilon_{ti} \quad (3)$$

In the equations, *X* stands for the export volume, *C* is the constant term, *REER* is the real effective exchange rate, *GG* is the export-weighted global growth, *GDP* is the gross domestic product, *PV* is the Preisach variable and ε is the error term where subscript *t* and *i* denote the time and sector components. The impacts of crises are captured by two dummies in our estimations. One of them is the 2008 global crises (denoted by *FC*) which reduced both the export volume and new entrances in export markets (Demirhan and Ercan, 2018) as mentioned in the literature section. We also use a dummy to capture the impact of the failed coup d'état on 15th July 2016. This dummy is shown as 2016Q4 in the estimations. For each subsector, the first equation is the benchmark equation with REER. In the following equation, we add two previous periods of REER to allow for linear dynamics. In the third equation we replace REER with the Preisach variable.

Our approach includes two further technical departures from the previous literature. First, as suggested in Belke et al. (2013), the usual remedy of taking differences of non-stationary variables is problematic in a hysteresis analysis since the procedure deals with path-dependent effects determined by the levels of the forcing variable. In our analysis, first, the Preisach variable is derived from the level of the exchange rate. Later on, we take year-on-year (y-o-y) differences of this variable and use it in our estimations. The y-o-y difference also helps us to account for the seasonality problem in the export series.[11]

The second nuisance is on the correlation between the Preisach variable and the forcing variable. As described above, the Preisach variable is a filtered version of the exchange rate and could reveal high

[10] We run further specifications as robustness checks where we include the nominal effective exchange rate instead of REER and alternative definitions of exports (real, nominal, excluding gold) instead of the volume index. Results are available upon request.

[11] Another solution for this problem is using fully modified least squares (FM-OLS) proposed by Phillips and Hansen (1990), and implemented by Mota et al. (2012).

correlation with REER if the band of inaction is small. Considering the impact of correlation between independent variables on the results, unlike the previous literature, we use REER and Preisach variable in separate estimations.

As discussed in the introductory section, our main focus is on the estimation of the hysteresis hypothesis. Sunk-costs hysteresis in the export behaviour is suggested by significant lags in the second estimation; and by a significant coefficient of the Preisach variable in the last one. The difference between the second and the third equations lies in the remanence argument. The second equation models the persistence in the impact of REER on the exports in a linear way, with no structure imposed on the relationship between the lags. The third equation assumes that the hysteretic system depends on selected past values suggesting a non-linear function of the memorized input. Piscitelli et al. (2000) tell two basic requirements for such a system to display remanence (and other characteristics of hysteresis): non-linearity and heterogeneous behaviour of the elements that make up the system (in our case, firms). Hence, if the second equation does not argue any contemporaneous or lagged impact of REER on exports, but the third one does, we conclude that remanence due to firm-level heterogeneity helps us to capture the sunk-cost hysteresis for the particular sector.[12]

The motivation for using the explanatory variables, *REER* and *GG*, are discussed in previous sections in line with the previous literature. The literature also suggests including variables to capture domestic growth measuring the impact of two counteracting forces in export supply estimations (Goldstein and Khan, 1985). On the one hand, an increase in trend income could result in an increase in total factor productivity, factor supplies or better infrastructure; increasing the supply of exports. On the other hand, if domestic demand is the leading factor for higher income, then exporting firms might prefer to direct their sales towards the domestic market to reap potential profits, resulting in lower exports. Hence, the coefficient of GDP could be positive or negative depending on the strength of these counteracting factors.

5. Results

The estimation results for the manufacturing sector and its subsectors are provided in Table 1. For each subsector, the first column includes the estimations with REER, the second column presents the estimations with REER and its lags and the third column documents the estimations with the Preisach variable.

The estimation results for the manufacturing sector as a whole (Columns 1 to 3 of Table 1) suggest that the global growth variable is significant while the domestic demand indicator is insignificant. On the other hand, the REER coefficient has a positive sign, suggesting a positive relationship between the appreciation of the domestic currency and exports. This might stem from the high share of imported intermediate inputs in production as discussed in Cosar (2012)[13,14]. Moreover, the lags of the REER coefficients are not significant. Overall, these results for the aggregate manufacturing sector are in line with the previous literature stating that the main determinant of the exports in the manufacturing sector is global growth and the exchange rate is mostly insignificant (Uz, 2010; Saygılı and Saygılı, 2011; Bozok et al., 2015; Çulha and Kalafatçılar, 2014).

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[12] Firm-level heterogeneity is usually handled through fixed-effect estimations in panel applications. However, if researchers do not have access to firm-level data; the procedure used in our article could be preferred.

[13] The share of intermediate goods in total imports is 76 percent as of 2018 (Ministry of Trade, 2018).

[14] The argument may hold for the textiles, paper and vehicles sector in the REER estimations and the other non-metallic mineral products in Preisach variable estimations, which show significant but positive REER coefficients.

The rest of Table 1 presents the sectoral results. In the following three paragraphs, we examine the estimations with REER and its lags (in the first and second columns of each subsector). A first look at the results suggests that neither the contemporaneous nor the lagged coefficients of REER are significant in nine subsectors: food, wood, coke, chemicals, rubber, metals, fabric metal, electric, and furniture. Among these nine subsectors the global growth variable is positive and significant for coke, chemicals and rubber indicating that the external demand is the main determinant of exports in these sectors, in line with the previous literature. The domestic demand variable is positive and significant for food, paper, fabric metal and machinery, suggesting that higher income would lead to higher productivity; eventually resulting in higher exports, in these sectors. Regarding the two dummies used in the estimations, at least one of them is significant for six subsectors over the sample: food, tobacco products, machinery, other, coke, other and furniture.

A second group consists of four sectors for which not the contemporaneous but the lagged value of REER is negative and significant: tobacco products, textiles, machinery and equipment and communication equipment. Moreover, for clothing both REER and its second lag are significant in the second equation. For these sectors, the hypothesis of hysteresis in export behaviour holds, indicating that it takes a certain amount of time to see the impact of the exchange rate on the volume of exports. In these sectors with the exception of clothing and machinery and equipment neither the global growth nor the domestic GDP coefficient is significant. Hence, the lagged impact of REER seems to be the only determinant explaining export volumes. However, in the clothing sector the global demand seems to explain some of the variation in exports whereas in the machinery and equipment sector the domestic demand might play a role. Among these sectors, tobacco products, textile and clothing are relatively labor intensive sectors. That could be one of the reasons for the price elasticity of exports to be higher relative to the other sectors.

The results of the Preisach analysis are documented in the third column for each subsector. The Preisach variable is significant and negative for only two sectors: clothing and communication, supporting the hypothesis of hysteresis in exports for these two sectors. As discussed before, the difference between the second and the third equations is on the treatment of the persistence of the impact of exchange rate on exports. While the second equation assumes a linear structure, the third one presumes a non-linear form through selected past values (large changes). The displayed remanence is motivated by heterogeneous behaviour of firms against changes in the exchange rate due to their sunk-costs.

One possible reason for the absence of the significance of the Preisach variable in most sectors (i.e, probable absence of hysteresis) could be the strength of the supply chain relationship. If the foreign buyer could not tolerate an interruption at any stage of the production, she would be very selective at including a new firm into the production chain. Large and experienced domestic firms have a greater chance of signalling such reliable connections. These firms, on the other hand, are usually less credit-constrained, in the sense that they can raise funds in foreign currency and could hedge themselves against changes in the exchange rate. Hence, the production processes for many of these large and capital-intensive firms are less dependent on exchange rate changes. This argument is in line with the self-selection hypothesis in the export entry decision as described in the second section (Aldan and Günay, 2008; Demirhan, 2016a).

For the two sectors which present negative and significant coefficients for the Preisach variable, the share of communication equipment and clothing in total manufacturing of exports is around 1 percent and 8 percent, respectively. The next section provides a more detailed look on *clothing,* the larger one in terms of the percentage of exports, and discusses the determinants of sunk cost hysteresis behaviour in this sector.

6. Sunk-Cost Hysteresis Dynamics in Turkish Clothing Sector

The significance of the Preisach variable for *clothing* could be motivated with an in-depth analysis of the production layers specific to this sector. To this aim, we first provide a general description of the sector and depict the historical developments over time. Later on, we discuss the presence and the scope of sunk costs in this particular sector in four premises.

Clothing constitutes the sixth largest subsector of the total manufacturing sector, producing 6 percent of the total manufacturing sector value added[15]. On the other hand, the share of employment in the *clothing* sector in the total manufacturing sector is 18 percent while the average wages in *clothing* are 28 percent lower than the average wage level in Turkey.[16] Moreover, the labour informality rate is around 35 percent in the sector, much higher than that of the 20 percent average of the manufacturing sector.[17] These figures indicate that *clothing* is a relatively labour-intensive sector with low productivity and high degree of informality.

Initially, the comparative advantage in *clothing* (and textiles as well) makes it one of the locomotive sectors for the export boom that started in the 1980s. However, the 2000s revealed a global shift of production towards China and neighbouring Asian developing economies in this sector due to relatively lower production costs and preferential trade agreements with major importer economies. The share of Turkey in total world clothing exports was around 3.5 percent for 2006-2014.[18] However the share of exports of *clothing* in the exports of the total manufacturing sector in Turkey displayed a steady decline in the last two decades from 24 percent in 1996 to 8 percent in 2018.

Textile and clothing were the main sectors of the export boom starting at 1980s, at times when the government was active in bilateral trade agreements to increase exports of the manufacturing sector (Şenses, 1989). Hence, most of these firms have very long experience and network connections (foreign as well as domestic) to set up new companies against a rise in foreign demand. Moreover, as discussed above some of these new establishments could be a re-entry in the sector. Hence, as Özler et al. (2009) and Demirhan (2016a) suggest, previous export experience is important in export propensity of Turkish firms.

The textile and clothing sectors have multi-layered production structures in Turkey. Many major foreign brands have strong connections with some middle/large sized Turkish firms. These domestic firms with large-scale production units also act as *intermediaries* which might, at times, extend the production process to some *subcontractors* in their region. If the cyclical increase in the foreign demand could not be covered by an increase in production via the intensive margin, these firms might extend some of the demand to subcontractors. Furthermore, if there are not enough subcontractors avaliable in the market, these experienced large firms (which are in urgent need of meeting the cyclical excess demand) could assist the establishment of new small enterprises.[19] These textile/garment

[15] 2017 figures.

[16] TURKSTAT-Labor Force Survey.

[17] Unfortunately, all around the world, this sector is one of the most problematic ones in terms of the working conditions. OECD (2018) provides a due dilligence report specifically designed for the enterprises and subcontractors in this sector to meet their responsibilities against their workers and the society.

[18] ITC TradeMap (https://www.trademap.org).

[19] For example, in a news article in summer 2014, the head of Turkish Fashion and Apparel Federation, Nedim Örün, tells: "At the moment, we work in full capacity… There are new opportunities for the subcontracting clothing units which have been shut down previously. If they fired their workers but the machinery and equipment is still there, we would like to rent these machines and use them in production

workshops usually employ less than 20 workers and are set up by previous workers/employers in the sectors. As documented before, the average wage level in these sectors is lower than the average wage level in Turkey and the informality rate is much higher than the manufacturing sector average. Taymaz and Kılıçaslan (2005) document that among all manufacturing sectors, subcontractors pay the lowest wage in the textile and clothing industries. Saraçoğlu and Kızılırmak (2016) conduct a survey in two cities (Denizli and Gaziantep) with high number of textile and clothing subcontractors. They document that the subcontracting firms are relatively young ones which mostly rent the property and use unregistered workers, mostly lacking quality certificates.

Second, compared to other sectors, the importance of plant size is relatively lower in export propensity in the textile and clothing industry (Özler et al., 2009). This is also one of the determinants of the low sunk costs of entry in this sector, increasing the probability of establishing a new small firm to benefit from exporting.

The third point that would help us to motivate lower sunk costs in the last decade would be related to financing conditions. In fact, Özler et al. (2009) show that the role of imported machinery and equipment is relatively important in the textile and clothing sector for capital stock, in comparison to other sectors. This dependency on foreign inputs was less of a significant obstacle for Turkish firms in the last decade due to the presence of a relatively low interest rate environment in the period which might have led to easier financing conditions for new firms[20].

The fourth point is directly related to our analysis of exchange rates. The significance of the Preisach variable suggests that the exporting behaviour in the *intensive and extensive margin* depends on the REER, once we consider the sunk costs. The increase in foreign demand might be a result of the price advantage due to a depreciation of Turkish lira in real terms over the last decade. Many large foreign brands have alternative producers/intermediaries in different countries. After the increase in the share of Asian countries in the textile and clothing production around the world in the first decade of the century, many important brands have suppliers in Asian countries in addition to the previous exporters such as Turkey. These large firms with brands observe the exchange rate developments all over the world and easily direct their production from one country to the other by their already established intermediary contractors in these countries and their market power in these low cost, labour intensive industries.

If we substitute the REER by the Preisach variable and thus allow for hysteresis, our results point out a negative relationship between the real effective exchange rate and clothing exports in Turkey. This relationship holds for many other developing countries for which the clothing (or textile) exports are a significant part of total exports. Kaplinsky and Morris (2008) provide an example of the negative effect of currency appreciation on textiles and clothing in some African countries. They argue that the African Growth and Opportunities Act introduced in 2000 has initially led to an increase in textile and clothing exports in many African countries. However, the appreciation in South African Rand led to lower exports in countries that were linked to Rand (South Africa, Lesotho and Swaziland) mostly through the rising labor costs channel. On the other hand, in the same era which displayed the end of the Multi Fibre Arrangement system, the competitiveness through currency depreciation helped Cambodian clothing exports (Beresford, 2009). In a similar manner a negative relationship between

again." The article titled "Textile Subcontractors are in Black Market" is available at https://www.konfeksiyonteknik.com.tr/fason-atolyeler-karaborsa/ (09.08.2019). The original statements are in Turkish and translated by us.

[20] Another development is the increasing availability of leasing opportunities which constitutes around 6-7 percent of the total machinery and equipment in textile sector. Detailed data on sectoral leasing is available at Association of Financial Institutions.

REER and clothing is suggested for China (Thorbecke and Zhang, 2009) and Slovak Republic (Smith et al., 2014).

On the other hand, Bahmani-Oskoee and Hegerty (2009) argue that devaluation periods are also associatied with increasing uncertainty which in turn have negative impacts on Mexican textile exports. Similarly, REER is insignifcant for explaining Ethiopian leather product exports (Gorfu, 2018) or Indian textile and clothing exports (Beena and Mallick, 2010). Also, empirical studies show that among the countries for which textile and clothing constitutes an important part of the exports, REER seems to have a relatively minor impact of the changes in total exports in Nepal (Paudel and Burke, 2015) and Madagascar (Eyraud, 2009) which is similar to our results in the first specification.

7. Conclusion

To sum up, this article argues that taking the sunk costs into account would help us to observe the impact of exchange rate changes in the export behaviour of Turkish manufacturing firms in selected sectors. The employed Preisach method provides a complementary approach to the lagged estimations in time-series applications while measuring sunk costs, since it considers firm-level heterogeneity through a non-linear aggregation method.

Our study contributes to the previous literature on exporter sunk costs as well as the studies on Turkish exports. Firstly, our results underline the importance of considering sunk costs in measuring the hysteresis behaviour in the export market in line with Belke et al. (2013), Belke et al. (2015), and Roberts and Tybout (1997). Secondly, our results corroborate those of Uz (2010) and Saygılı and Saygılı (2011) in the sense that the external demand, rather than the real exchange rate, is the main determinant of Turkish manufacturing sector exports. Thirdly, we argue that the sunk costs of entry and exit are determined by previous export experience in the clothing sector, similar to Özler et al. (2009) and Demirhan (2016a and b). We believe that further research could use firm-level data and address sunk costs of different manufacturing sectors more directly.

References

AHMED, S., APPENDINO, M., & RUTA, M. (2015), *"Depreciations without exports? Global value chains and the exchange rate elasticity of exports",* The World Bank.

ALDAN, A., & GÜNAY, M. (2008), "Entry to Export Markets and Productivity: Analysis of Matched Firms in Turkey*", CBRT Working Papers,* 08/05.

AMABLE, B., HENRY, J., LORDON, F., & TOPOL, R. (1994), "Strong hysteresis versus zero-root dynamics", *Economics Letters*, *44*(1-2), 43-47.

AMABLE, B., HENRY, J., LORDON, F., & TOPOL, R. (2004), "Complex remanence vs. simple persistence: are hysteresis and unit-root processes observationally equivalent?", In *Economic Complexity* (pp. 67-89). Emerald Group Publishing Limited.

BAHMANI-OSKOOEE, M., & HEGERTY, S. W. (2009), "The effects of exchange-rate volatility on commodity trade between the United States and Mexico", *Southern Economic Journal*, 1019-1044.

BALDWIN, R. (1990), "Hysteresis in trade", In *Hysteresis Effects in Economic Models* (pp. 19-34), Physica-Verlag HD.

BALDWIN, R., & KRUGMAN, P. (1989), "Persistent trade effects of large exchange rate shocks", *The Quarterly Journal of Economics*, 104(4), 635-654.

BEENA, P. L., & MALLICK, H. (2010), “Exchange rate and export behaviour of India textiles & clothing sector: an enquiry for major destination countries”, *Center for Development Studies Working Papers*, No: 425.

BELKE, A., & GÖCKE, M. (2001), “Exchange rate uncertainty and employment: an algorithm describing ‘play’”, *Applied Stochastic Models in Business and Industry*, 17(2), 181-204.

BELKE, A., GÖCKE, M., & GÜNTHERr, M. (2013), Exchange rate bands of inaction and play-hysteresis in German exports—Sectoral evidence for some OECD destinations. *Metroeconomica*, *64*(1), 152-179.

BELKE, A. H., GÖCKE, M., & WERNER, L. (2014), “Hysteresis Effects in Economics–Different Methods for Describing Economic Path-dependence”. *Ruhr Economic Paper*, 468 (2014).

BELKE, A., GÖCKE, M., & WERNER, L. (2015), „Exchange Rate Volatility and other Determinants of Hysteresis in Exports-Empirical Evidence for the Euro Area”, *Review of Economic Analysis*, *7*(1), 24-53.

BERESFORD, M. (2009), “The Cambodian clothing industry in the post-MFA environment: A review of developments”, *Journal of the Asia Pacific Economy*, *14*(4), 366-388.

BERNARD, A. B., & WAGNER, J. (2001), “Export entry and exit by German firms”, *Weltwirtschaftliches Archiv*, *137*(1), 105-123.

BOZOK, İ., DOĞAN, B. S., & YÜNCÜLER, C. (2015), “Estimating Income and Price Elasticity of Turkish Exports with Heterogeneous Panel Time-Series Methods”*, CBRT Working Papers*, No. 15/26.

CAMPA, J. M. (2004), “Exchange rates and trade: How important is hysteresis in trade?”, *European Economic Review*, *48*(3), 527-548.

CHOQUETTE, E. (2019), “Import-based market experience and firms’ exit from export markets”, *Journal of International Business Studies*, 50(3), 423-449.

COŞAR, E. E. (2012), “Price and income elasticities of Turkish export demand: a panel data application”, *Central Bank Review*, *2*(2), 19-53.

ÇIPLAK, U., EREN, O., ÖĞÜNÇ, F., & SAYGILI, M. (2011), “Turkiye’nin İhracati İçin Alternatif Dış Talep Göstergeleri”, *CBRT Research Notes in Economics*, 11/07.

ÇULHA, O. Y., & KALAFATÇILAR, M. K. (2014), “A Glance at Income and Price Elasticity of Turkey’ s Exports: the Importance of Regional Disparities”, *CBRT Research Notes in Economics*, *5*, 1-14.

DEMİRHAN, A. A. (2016a), “Export Behavior of the Turkish Manufacturing Firms”, *Emerging Markets Finance and Trade*, *52*(11), 2646-2668.

DEMİRHAN, A. A. (2016b), “To be exporter or not to be exporter? Entry–exit dynamics of Turkish manufacturing firms”, *Empirical Economics*, *51*(1), 181-200.

DEMİRHAN, A. A., & ERCAN, H. (2018), “Export Behavior of Turkish Manufacturing Firms Under Crises”, *CBRT Working Papers*, 18/02.

DE PRINCE, D., & KANNEBLEY J. S., (2013), “Strong hysteresis in Brazilian imports: a panel cointegration approach”, *Journal of Economic Studies*, *40*(4), 528-548.

DIXIT, A. (1989a), “Hysteresis, import penetration, and exchange rate pass-through”, *The Quarterly Journal of Economics*, *104*(2), 205-228.

DIXIT, A. (1989b), “Entry and exit decisions under uncertainty”, *Journal of Political Economy*, *97*(3), 620-638.

EYRAUD, L. (2009), *Madagascar: A Competitiveness and Exchange Rate Assessment* (No. 9-107), International Monetary Fund.

GEZİCİ, A., ORHANGAZİ, Ö., & YALÇIN, C. (2018), “Exports and Financing Constraints Evidence from Turkey”, *Review of Middle East Economics and Finance*, 14(1).

GÖCKE, M. (2002), “Various concepts of hysteresis applied in economics”, *Journal of economic surveys*, 16(2), 167-188.

GOLDSTEIN, M., & KHAN, M. S. (1985), “Income and price effects in foreign trade”, *Handbook of international economics*, *2*, 1041-1105.

GORFU, L. (2018), “Determinants Of Export Performance Of Leather And Leather Products Sector In Ethiopia”, Doctoral dissertation, Addis Ababa University.

GULLSTRAND, J., & PERSSON, M. (2015), “How to combine high sunk costs of exporting and low export survival”, *Review of World Economics*, *151*(1), 23-51.

HALLETT, A. H., & PISCITELLI, L. (2002), “Testing for hysteresis against nonlinear alternatives”, *Journal of Economic Dynamics and Control*, *27*(2), 303-327.

KANNEBLEY J. S. (2008), “Tests for the hysteresis hypothesis in Brazilian industrialized exports: a threshold cointegration analysis”, *Economic Modelling*, 25(2), 171-190.

KAPLINSKY, R. and MORRIS, M. (2008), “Do the Asian Drivers undermine the export-oriented industrialisation in SSA?”, *World Development*, 36(2) pp. 254–273.

KEMP, M. C., & WAN, H. Y. (1974), “Hysteresis of long-run equilibrium from realistic adjustment costs”, In *Trade, Stability, and Macroeconomics*, (pp. 221-242),

KONGSTED, H. C. (2012), “Trade policy dynamics, entry costs, and exchange rate uncertainty”, *Journal of International Trade & Economic Development*, 21(2), 197-216.

MÁÑEZ, J. A., ROCHINA-BARRACHINA, M. E., & SANCHIS, J. A. (2008), “Sunk costs hysteresis in Spanish manufacturing exports”, *Review of World Economics*, *144*(2), 272-294.

MAYERGOYZ, I. D. (2003), “Mathematical models of hysteresis and their applications”, Academic Press.

MEINEN, P. (2015), “Sunk costs of exporting and the role of experience in international trade”, *Canadian Journal of Economics/Revue canadienne d'économique*, *48*(1), 335-367.

MINISTRY OF TRADE (2018), “Foreign Trade and Main Economic Indicators Bulletin”, Ankara.

MOTA, P. R., VAREJÃO, J., & VASCONCELOS, P. B. (2012), “Hysteresis in the dynamics of employment”, *Metroeconomica*, *63*(4), 661-692.

OECD (2018), “OECD Due Diligence Guidance for Responsible Supply Chains in the Garment and Footwear Sector”, *OECD Publishing*, Paris. http://dx.doi.org/10.1787/9789264290587-en

O’SHAUGHNESSY, T. (2000), “Hysteresis in an open economy model”, *Scottish Journal of Political Economy*, 47(2), 156-182.

ÖZLER, Ş., TAYMAZ, E., & YILMAZ, K. (2009), “History matters for the export decision: Plant-level evidence from Turkish manufacturing industry”, *World Development*, *37*(2), 479-488.

PADMAJA, M., & SASIDHARAN, S. (2017), “Sunk Costs, Firm Heterogeneity, Export Market Entry and Exit: Evidence from India”, *Journal of Quantitative Economics*, *15*(2), 367-393.

PAUDEL, R. C., & BURKE, P. J. (2015), “Exchange rate policy and export performance in a landlocked developing country: The case of Nepal”, *Journal of Asian Economics*, *38*, 55-63.

PHILLIPS, P. C., & HANSEN, B. E. (1990), “Statistical inference in instrumental variables regression with I (1) processes”, *The Review of Economic Studies*, *57*(1), 99-125.

PISCITELLI, L., CROSS, R., GRINFELD, M., & LAMBA, H. (2000), "A test for strong hysteresis", *Computational Economics*, 15(1-2), 59-78.

PREISACH, F. (1935), "Über die magnetische Nachwirkung", *Zeitschrift für Physik*, 94(5-6), 277-302.

ROBERTS, M. J., & TYBOUT, J. R. (1997), "The decision to export in Colombia: an empirical model of entry with sunk costs", *American Economic Review*, 545-564.

SARAÇOĞLU, D.S, and KIZILIRMAK, B. (2016), "Subcontracting and firm characteristics: Evidence from two new local industrial districts in Turkey." *METU Studies in Development* 43, no. 2, 635.

SAYGILI, H., & SAYGILI, M. (2011), "Structural changes in exports of an emerging economy: Case of Turkey", *Structural Change and Economic Dynamics*, 22(4), 342-360.

SETTERFIELD, M. (2009), "Path dependency, hysteresis and macrodynamics", In *Path dependency and macroeconomics,* (pp. 37-79), Palgrave Macmillan, London.

ŞENSES, F. (1989), "The Nature and Main Characteristics of Recent Turkish Growth in Export of Manufactures", *Developing Economies*, 27(1), 19-33.

SMITH, A., PICKLES, J., BUČEK, M., PÁSTOR, R., & BEGG, B. (2014), "The political economy of global production networks: regional industrial change and differential upgrading in the East European clothing industry", *Journal of Economic Geography*, *14*(6), 1023-1051.

TAYMAZ, E., & KILIÇASLAN, Y. (2005), "Determinants of subcontracting and regional development: an empirical study on Turkish textile and engineering Industries", *Regional Studies*, 39(5), 633-645.

TGSD, (2016), Horizon 2030: A Roadmap for Turkish Clothing Sector, Turkish Clothing Manufacturing Association, İstanbul.

THORBECKE, W., & Zhang, H. (2009), "The effect of exchange rate changes on China's labour-intensive manufacturing exports", *Pacific Economic Review*, *14*(3), 398-409.

TIMOSHENKO, O. A. (2015), "Learning versus sunk costs explanations of export persistence", *European Economic Review*, 79, 113-128.

TORAGANLI, N., & YALÇIN, C. (2016), "Exports, Real Exchange Rates and External Exposures: Empirical Evidence from Turkish Manufacturing Firms", *CBRT Working Papers*, 16/24.

UZ, I. (2010), "Bilateral trade elasticities of Turkey", *International Journal of Applied Economics*, *7*(1), 28-46.

WERNER, L. M. (2017), "Identifying hysteresis non-linearities in trade: Evidence from European wine exports to the U.S.", *American Association of Wine Economists Working Paper* No. 215, 1-37.

Table 1: Outcomes for manufacturing sector and three subsectors

	Dependent variable:											
	manufacturing			manuFoodBev			manuTobacco			manuTextiles		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
REER	0.213*	0.239*		-0.138	-0.129		-0.024	-0.357		0.196*	0.167	
	(0.113)	(0.130)		(0.128)	(0.150)		(0.388)	(0.436)		(0.098)	(0.111)	
REER(t-1)		-0.048			-0.019			0.890			0.099	
		(0.159)			(0.183)			(0.532)			(0.135)	
REER(t-2)		-0.087			-0.016			-0.787*			-0.204*	
		(0.128)			(0.146)			(0.426)			(0.108)	
PV			0.009			-0.001			-0.019			0.004
			(0.007)			(0.007)			(0.022)			(0.006)
GG	1.277*	1.404*	1.457**	-1.295	-1.255	-1.606*	0.082	-1.127	0.821	0.892	0.813	1.220*
	(0.705)	(0.753)	(0.709)	(0.797)	(0.864)	(0.798)	(2.421)	(2.514)	(2.371)	(0.615)	(0.638)	(0.630)
GDP	0.204	0.173	0.132	0.755**	0.743*	0.883**	1.012	1.664	0.703	0.355	0.432	0.221
	(0.324)	(0.346)	(0.327)	(0.366)	(0.397)	(0.368)	(1.112)	(1.154)	(1.094)	(0.282)	(0.293)	(0.291)
FC	0.604	0.104	2.357	0.615	0.534	-0.049	3.705	-2.454	1.654	2.487	1.053	3.702
	(3.396)	(3.552)	(3.496)	(3.841)	(4.079)	(3.931)	(11.665)	(11.862)	(11.689)	(2.962)	(3.012)	(3.106)
2016Q4	0.557	0.272	0.093	6.580*	6.509*	7.649**	-24.390**	-24.429**	-27.337**	0.770	0.508	-0.302
	(3.134)	(3.169)	(3.209)	(3.545)	(3.638)	(3.609)	(10.767)	(10.580)	(10.729)	(2.734)	(2.686)	(2.851)
Constant	1.218	1.374	-0.388	4.472	4.484	5.164	5.956	9.632	7.507	-2.656	-1.929	-3.840
	(3.132)	(3.206)	(3.190)	(3.543)	(3.680)	(3.588)	(10.759)	(10.703)	(10.668)	(2.732)	(2.717)	(2.835)
Observations	50	50	50	50	50	50	50	50	50	50	50	50
R^2	0.406	0.424	0.383	0.311	0.312	0.293	0.147	0.219	0.161	0.404	0.454	0.358
Adjusted R^2	0.338	0.328	0.313	0.233	0.198	0.213	0.050	0.089	0.066	0.336	0.363	0.285

Residual Std. Error	6.727 (df = 44)	6.779 (df = 42)	6.854 (df = 44)	7.610 (df = 44)	7.783 (df = 42)	7.708 (df = 44)	23.111 (df = 44)	22.636 (df = 42)	22.918 (df = 44)	5.869 (df = 44)	5.747 (df = 42)	6.090 (df = 44)
F Statistic	6.009*** (df = 5; 44)	4.416*** (df = 7; 42)	5.468*** (df = 5; 44)	3.980*** (df = 5; 44)	2.726** (df = 7; 42)	3.655*** (df = 5; 44)	1.515 (df = 5; 44)	1.680 (df = 7; 42)	1.689 (df = 5; 44)	5.965*** (df = 5; 44)	4.997*** (df = 7; 42)	4.911*** (df = 5; 44)

Note: *p<0.1; **p<0.05; ***p<0.01

Table 1, continued (1): Outcomes for four subsectors

	Dependent variable:											
	manuClothing			manuWood			manuPaper			manuCoke		
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
REER	0.201	0.320**		-0.204	0.048		0.337**	0.295		-0.088	-0.061	
	(0.136)	(0.119)		(0.275)	(0.298)		(0.159)	(0.184)		(0.388)	(0.455)	
REER(t-1)		-0.217			-0.550			0.131			-0.091	
		(0.145)			(0.364)			(0.224)			(0.555)	
REER(t-2)		-0.400***			-0.233			-0.211			0.187	
		(0.116)			(0.292)			(0.180)			(0.445)	
PV			-0.021***			-0.019			0.015			0.028
			(0.007)			(0.015)			(0.009)			(0.022)
GG	0.981	1.556**	2.402***	1.425	2.511	1.698	-0.472	-0.605	-0.225	5.860**	5.933**	4.435*
	(0.847)	(0.686)	(0.783)	(1.717)	(1.722)	(1.678)	(0.993)	(1.060)	(1.001)	(2.425)	(2.625)	(2.352)
GDP	0.270	0.133	-0.319	-0.177	-0.553	-0.294	0.736	0.836*	0.639	-1.104	-1.175	-0.511
	(0.389)	(0.315)	(0.361)	(0.788)	(0.790)	(0.774)	(0.456)	(0.487)	(0.462)	(1.114)	(1.205)	(1.085)
FC	4.674	2.379	3.271	0.210	-0.594	-2.561	0.225	-1.293	3.096	1.048	2.360	3.625
	(4.079)	(3.238)	(3.861)	(8.271)	(8.123)	(8.269)	(4.785)	(5.001)	(4.933)	(11.683)	(12.386)	(11.590)
2016Q4	0.454	-0.844	-4.921	2.568	1.003	1.255	5.025	4.808	4.437	-25.807**	-25.568**	-20.283*
	(3.765)	(2.888)	(3.544)	(7.634)	(7.245)	(7.590)	(4.416)	(4.460)	(4.528)	(10.783)	(11.048)	(10.639)
Constant	-5.471	-4.753	-4.727	4.398	4.087	6.744	7.311	8.113*	4.698	-4.931	-5.597	-6.708
	(3.762)	(2.922)	(3.524)	(7.629)	(7.329)	(7.547)	(4.413)	(4.512)	(4.502)	(10.776)	(11.176)	(10.578)
Observations	50	50	50	50	50	50	50	50	50	50	50	50
R^2	0.248	0.580	0.340	0.059	0.197	0.079	0.186	0.212	0.153	0.308	0.311	0.332

Adjusted R^2	0.163	0.510	0.265	-0.048	0.063	-0.026	0.093	0.081	0.056	0.229	0.196	0.257
Residual Std. Error	8.081 (df = 44)	6.180 (df = 42)	7.571 (df = 44)	16.386 (df = 44)	15.501 (df = 42)	16.214 (df = 44)	9.480 (df = 44)	9.543 (df = 42)	9.672 (df = 44)	23.146 (df = 44)	23.637 (df = 42)	22.725 (df = 44)
F Statistic	2.905** (df = 5; 44)	8.296*** (df = 7; 42)	4.535*** (df = 5; 44)	0.556 (df = 5; 44)	1.467 (df = 7; 42)	0.756 (df = 5; 44)	2.009* (df = 5; 44)	1.618 (df = 7; 42)	1.584 (df = 5; 44)	3.908*** (df = 5; 44)	2.704** (df = 7; 42)	4.383*** (df = 5; 44)
Note:												*p<0.1; **p<0.05; ***p<0.01

Table 1, continued (2): Outcomes for four further subsectors

	Dependent variable:											
	manuChemicals			manuRubber			manuOther			manuMetals		
	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
REER	0.093	0.126		0.056	0.107		0.243**	0.269**		0.491	0.420	
	(0.143)	(0.168)		(0.121)	(0.135)		(0.102)	(0.119)		(0.700)	(0.821)	
REER(t-1)		-0.075			-0.093			-0.054			0.146	
		(0.205)			(0.165)			(0.145)			(1.002)	
REER(t-2)		-0.005			-0.166			-0.035			0.132	
		(0.164)			(0.132)			(0.116)			(0.803)	
PV			-0.001			-0.0005			0.012**			0.027
			(0.008)			(0.007)			(0.006)			(0.040)
GG	1.530*	1.666*	1.808**	1.842**	2.085**	2.009**	-0.685	-0.572	-0.559	-3.770	-4.091	-3.657
	(0.894)	(0.967)	(0.887)	(0.757)	(0.781)	(0.749)	(0.637)	(0.686)	(0.639)	(4.371)	(4.736)	(4.318)
GDP	0.298	0.245	0.183	0.245	0.187	0.177	0.310	0.273	0.261	0.206	0.303	0.167
	(0.410)	(0.444)	(0.409)	(0.348)	(0.358)	(0.346)	(0.292)	(0.315)	(0.295)	(2.008)	(2.174)	(1.992)
FC	2.746	2.810	3.021	2.820	1.870	2.990	-5.954*	-6.113*	-3.759	-24.215	-23.551	-19.429
	(4.306)	(4.563)	(4.371)	(3.647)	(3.683)	(3.694)	(3.068)	(3.237)	(3.151)	(21.061)	(22.346)	(21.285)
2016Q4	5.331	5.177	4.339	0.082	-0.462	-0.511	7.086**	6.905**	6.869**	-3.494	-2.924	-3.372
	(3.974)	(4.070)	(4.012)	(3.366)	(3.285)	(3.390)	(2.832)	(2.888)	(2.892)	(19.439)	(19.932)	(19.537)
Constant	-1.760	-1.877	-2.098	-1.660	-1.366	-1.868	7.366**	7.370**	5.389*	34.889*	34.780*	30.636
	(3.972)	(4.117)	(3.990)	(3.364)	(3.323)	(3.371)	(2.830)	(2.921)	(2.876)	(19.426)	(20.164)	(19.426)
Observations	50	50	50	50	50	50	50	50	50	50	50	50

R^2	0.374	0.378	0.368	0.447	0.501	0.445	0.226	0.237	0.200	0.083	0.085	0.082
Adjusted R^2	0.303	0.274	0.297	0.385	0.418	0.382	0.138	0.110	0.110	-0.022	-0.067	-0.022
Residual Std. Error	8.531 (df = 44)	8.707 (df = 42)	8.571 (df = 44)	7.225 (df = 44)	7.028 (df = 42)	7.242 (df = 44)	6.079 (df = 44)	6.178 (df = 42)	6.178 (df = 44)	41.726 (df = 44)	42.644 (df = 42)	41.733 (df = 44)
F Statistic	5.263*** (df = 5; 44)	3.644*** (df = 7; 42)	5.134*** (df = 5; 44)	7.126*** (df = 5; 44)	6.022*** (df = 7; 42)	7.051*** (df = 5; 44)	2.568** (df = 5; 44)	1.862 (df = 7; 42)	2.206* (df = 5; 44)	0.793 (df = 5; 44)	0.561 (df = 7; 42)	0.790 (df = 5; 44)
Note:												*p<0.1; **p<0.05; ***p<0.01

Table 1, continued (3): Outcomes for three further subsectors

	Dependent variable:								
	menuFabricMetal			manuMachinery			manuElectric		
	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)
REER	0.202	0.244		0.076	0.114		0.044	0.032	
	(0.135)	(0.156)		(0.110)	(0.118)		(0.144)	(0.167)	
REER(t-1)		-0.086			-0.054			0.050	
		(0.191)			(0.144)			(0.204)	
REER(t-2)		-0.075			-0.223*			-0.156	
		(0.153)			(0.116)			(0.163)	
PV			0.011			-0.004			0.003
			(0.008)			(0.006)			(0.008)
GG	-0.014	0.174	0.044	0.609	0.810	0.958	1.389	1.374	1.375
	(0.843)	(0.903)	(0.835)	(0.684)	(0.682)	(0.677)	(0.899)	(0.963)	(0.888)
GDP	1.041**	0.984**	1.021**	0.961***	0.931***	0.817**	0.344	0.385	0.351
	(0.387)	(0.414)	(0.385)	(0.314)	(0.313)	(0.312)	(0.413)	(0.442)	(0.410)
FC	-4.381	-4.754	-2.446	-4.350	-5.713*	-4.424	-5.732	-6.792	-5.249
	(4.064)	(4.259)	(4.114)	(3.296)	(3.218)	(3.336)	(4.332)	(4.544)	(4.375)
2016Q4	5.493	5.163	5.495	3.292	2.696	1.999	-4.277	-4.525	-4.173
	(3.751)	(3.799)	(3.777)	(3.042)	(2.870)	(3.062)	(3.998)	(4.053)	(4.016)
Constant	3.339	3.396	1.615	3.296	3.812	3.241	4.362	4.873	3.942

	(3.748)	(3.843)	(3.755)	(3.040)	(2.904)	(3.045)	(3.996)	(4.100)	(3.993)
Observations	50	50	50	50	50	50	50	50	50
R^2	0.419	0.434	0.416	0.579	0.645	0.578	0.412	0.427	0.412
Adjusted R^2	0.352	0.340	0.350	0.531	0.585	0.530	0.345	0.331	0.346
Residual Std. Error	8.051 (df = 44)	8.128 (df = 42)	8.067 (df = 44)	6.530 (df = 44)	6.141 (df = 42)	6.541 (df = 44)	8.582 (df = 44)	8.671 (df = 42)	8.578 (df = 44)
F Statistic	6.334*** (df = 5; 44)	4.605*** (df = 7; 42)	6.272*** (df = 5; 44)	12.109*** (df = 5; 44)	10.886*** (df = 7; 42)	12.042*** (df = 5; 44)	6.162*** (df = 5; 44)	4.469*** (df = 7; 42)	6.177*** (df = 5; 44)
Note:									*p<0.1; **p<0.05; ***p<0.01

Table 1, continued (4): Outcomes for three further subsectors

	Dependent variable:								
	manuCommunication			manuVeh			manuFurniture		
	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)
REER	-0.393	-0.392		0.289	0.482*		-0.084	-0.378	
	(0.532)	(0.541)		(0.219)	(0.249)		(0.416)	(0.479)	
REER(t-1)		0.244			-0.463			0.747	
		(0.660)			(0.304)			(0.585)	
REER(t-2)		-1.660***			0.104			-0.440	
		(0.529)			(0.243)			(0.468)	
PV			-0.070**			0.014			0.021
			(0.029)			(0.013)			(0.023)
GG	1.171	1.520	3.096	6.110***	6.882***	6.264***	3.934	2.816	2.830
	(3.318)	(3.122)	(3.096)	(1.365)	(1.435)	(1.356)	(2.597)	(2.764)	(2.544)
GDP	1.411	1.643	0.601	-0.159	-0.487	-0.218	-0.228	0.311	0.231
	(1.524)	(1.433)	(1.428)	(0.627)	(0.659)	(0.625)	(1.193)	(1.269)	(1.174)
FC	1.150	-9.800	-7.608	6.734	7.976	9.333	42.038***	38.286***	43.872***
	(15.988)	(14.729)	(15.257)	(6.578)	(6.771)	(6.682)	(12.515)	(13.042)	(12.538)
2016Q4	-3.627	-6.826	-11.681	5.920	5.266	5.646	-4.589	-4.135	-0.328

	(14.757)	(13.138)	(14.004)	(6.071)	(6.039)	(6.133)	(11.551)	(11.633)	(11.509)
Constant	-16.197	-11.249	-9.148	-12.336**	-13.414**	-14.678**	-40.196***	-37.714***	-41.430***
	(14.746)	(13.290)	(13.925)	(6.067)	(6.110)	(6.098)	(11.543)	(11.768)	(11.444)
Observations	50	50	50	50	50	50	50	50	50
R^2	0.113	0.333	0.209	0.668	0.688	0.664	0.279	0.306	0.291
Adjusted R^2	0.012	0.222	0.119	0.630	0.636	0.626	0.197	0.190	0.210
Residual Std. Error	31.675 (df = 44)	28.108 (df = 42)	29.915 (df = 44)	13.032 (df = 44)	12.921 (df = 42)	13.100 (df = 44)	24.794 (df = 44)	24.889 (df = 42)	24.584 (df = 44)
F Statistic	1.123 (df = 5; 44)	3.001** (df = 7; 42)	2.325* (df = 5; 44)	17.679*** (df = 5; 44)	13.240*** (df = 7; 42)	17.405*** (df = 5; 44)	3.399** (df = 5; 44)	2.647** (df = 7; 42)	3.608*** (df = 5; 44)

Note: *p<0.1; **p<0.05; ***p<0.01

Appendix

Table 2: Manufacturing subsectors and descriptions of abbreviations

Abbreviation	(Sub-)sector
manufacturing	Manufacturing
manuFoodBev	Manufacture of food products and beverages
manuTobacco	Manufacture of tobacco products
manuTextiles	Manufacture of textiles
manuClothing	Manufacture of wearing apparel; dressing and dyeing of fur
manuWood	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials.
manuPaper	Manufacture of paper and paper products
manuCoke	Manufacture of coke, refined petroleum products and nuclear fuel
manuChemicals	Manufacture of chemicals and chemical products
manuRubber	Manufacture of rubber and plastics products
manuOther	Manufacture of other non-metallic mineral products
manuMetals	Manufacture of basic metals
manuFabricMetal	Manufacture of fabricated metal products, except machinery and equipment
manuMachinery	Manufacture of machinery and equipment n.e.c.
manuElectric	Manufacture of electrical machinery and apparatus n.e.c.
manuCommunication	Manufacture of radio, television and communication equipment and apparatus
manuVeh	Manufacture of motor vehicles, trailers and semi-trailers
manuFurniture	Manufacture of furniture; manufacturing n.e.c.

Figure 1: Non-ideal relay hysteresis model

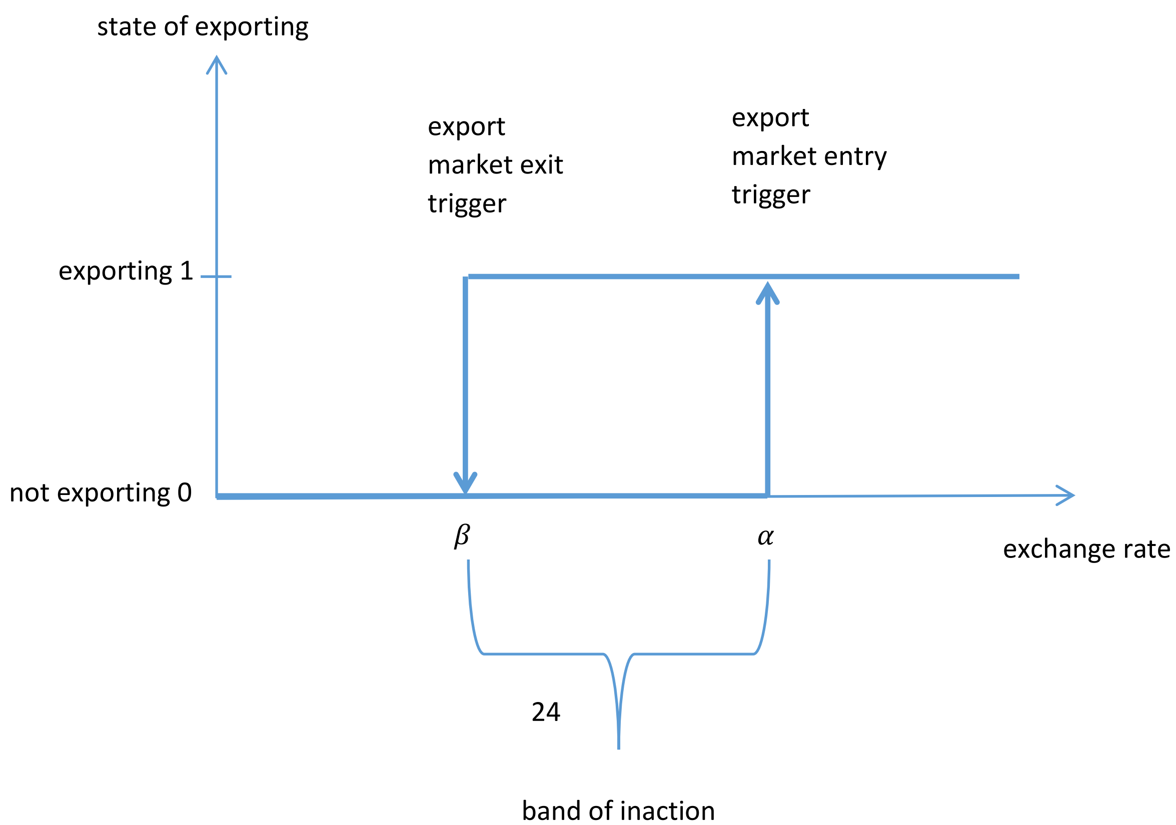


Figure 2: Aggregation of five non-ideal relays

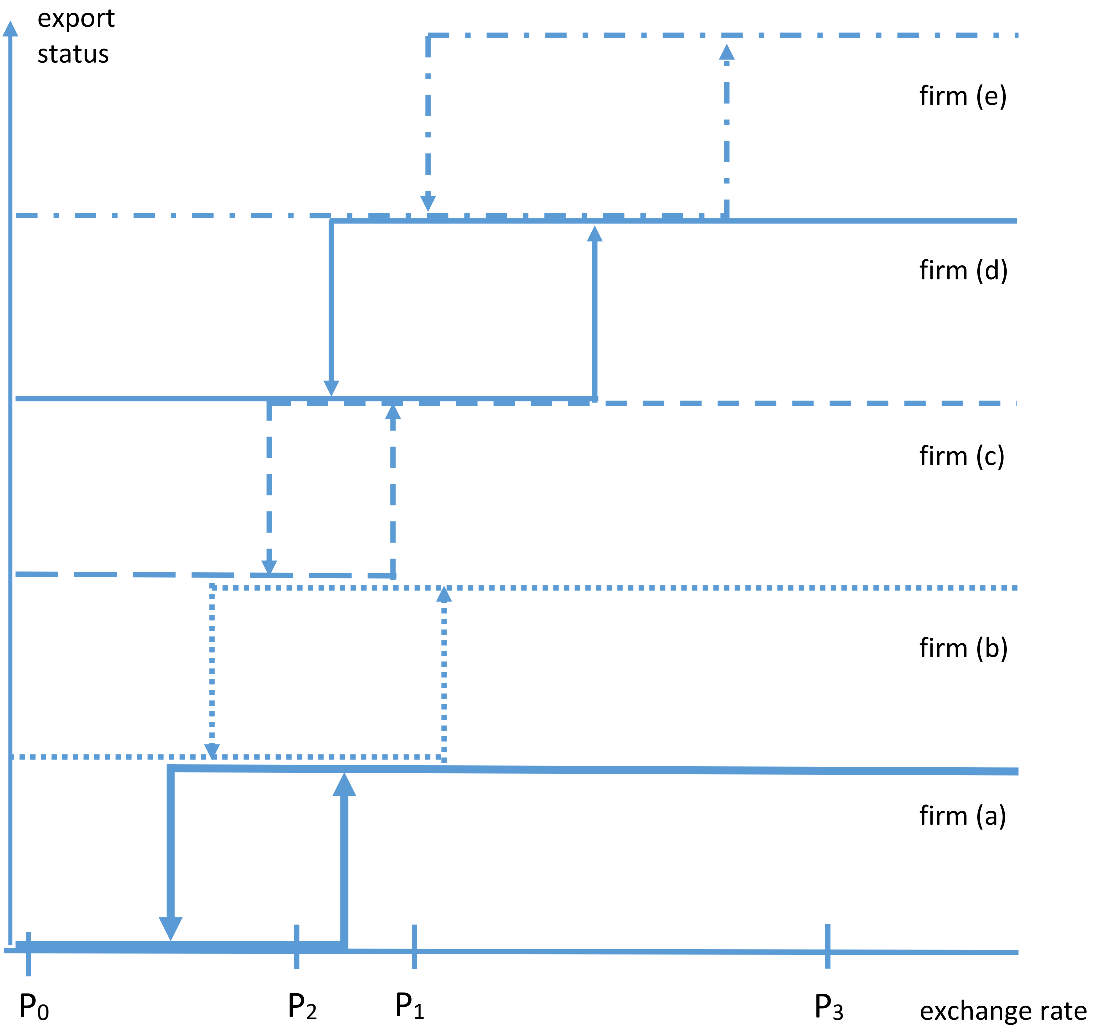


Figure 3: Preisach triangle and aggregation procedure

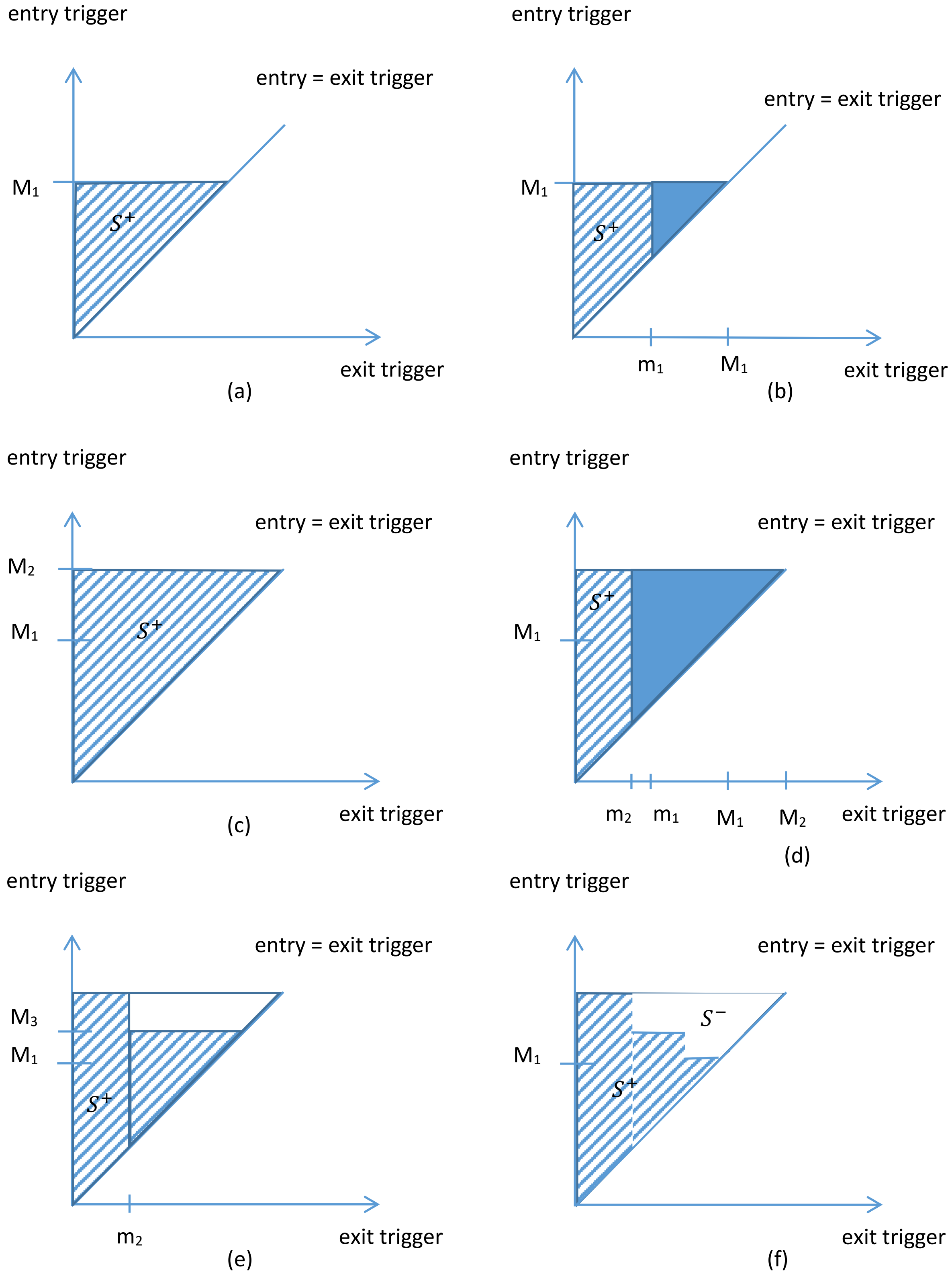
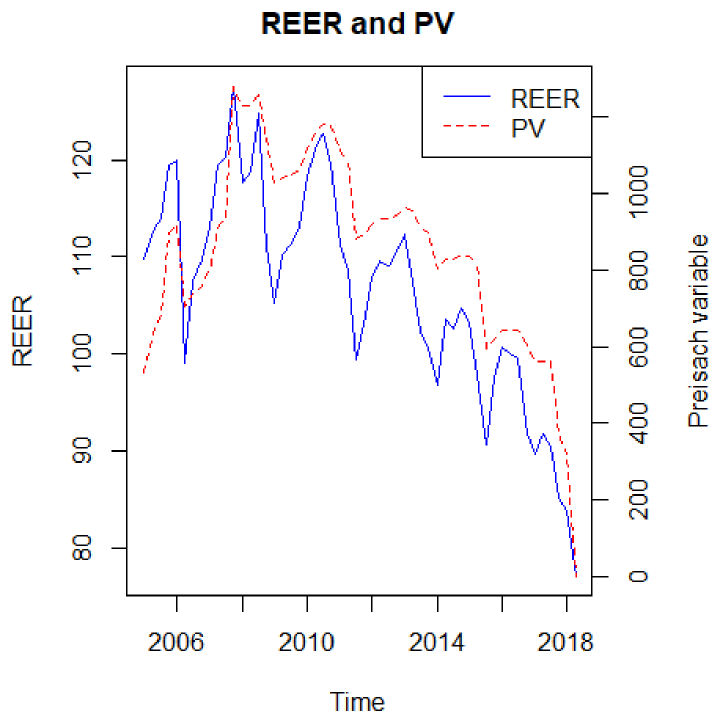


Figure 4: Comparison of REER and Preisach variable



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