Hacettepe University Graduate School Of Social Sciences

Department of Economics

ESSAYS ON EXCHANGE RATE PASS-THROUGH

Yasemin ÇOLAK

Ph.D Dissertation

Ankara, 2023

ESSAYS ON EXCHANGE RATE PASS-THROUGH

Yasemin ÇOLAK

Hacettepe University Graduate School Of Social Sciences

Department of Economics

Ph.D Dissertation

Ankara, 2023

ACCEPTANCE AND APPROVAL

The jury finds that Yasemin Çolak has on the date of 02/01/2023 successfully passed the defense examination and approves his/her Ph.D Dissertation titled "Essays on Exchange Rate Pass-Through".

Prof. Dr. İbrahim ÖZKAN (Jury President)

Prof. Dr. Lütfi ERDEN (Main Adviser)

Prof. Dr. M. Necat COŞKUN

Prof. Dr. Burak GÜNALP

Prof. Dr. Tarkan Çavuşoğlu

I agree that the signatures above belong to the faculty members listed.

Prof. Dr. Uğur ÖMÜRGÖNÜLŞEN

Graduate School Director

YAYIMLAMA VE FİKRİ MÜLKİYET HAKLARI BEYANI

Enstitü tarafından onaylanan lisansüstü tezimin/raporumun tamamını veya herhangi bir kısmını, basılı (kağıt) ve elektronik formatta arşivleme ve aşağıda verilen koşullarla kullanıma açma iznini Hacettepe Üniversitesine verdiğimi bildiririm. Bu izinle Üniversiteye verilen kullanım hakları dışındaki tüm fikri mülkiyet haklarım bende kalacak, tezimin tamamının ya da bir bölümünün gelecekteki çalışmalarda (makale, kitap, lisans ve patent vb.) kullanım hakları bana ait olacaktır.

Tezin kendi orijinal çalışmam olduğunu, başkalarının haklarını ihlal etmediğimi ve tezimin tek yetkili sahibi olduğumu beyan ve taahhüt ederim. Tezimde yer alan telif hakkı bulunan ve sahiplerinden yazılı izin alınarak kullanılması zorunlu metinlerin yazılı izin alınarak kullandığımı ve istenildiğinde suretlerini Üniversiteye teslim etmeyi taahhüt ederim.

Yükseköğretim Kurulu tarafından yayınlanan ***"Lisansüstü Tezlerin Elektronik Ortamda Toplanması, Düzenlenmesi ve Erişime Açılmasına İlişkin Yönerge"*** kapsamında tezim aşağıda belirtilen koşullar haricince YÖK Ulusal Tez Merkezi / H.Ü. Kütüphaneleri Açık Erişim Sisteminde erişime açılır.

- o Enstitü / Fakülte yönetim kurulu kararı ile tezimin erişime açılması mezuniyet tarihimden itibaren 2 yıl ertelenmiştir. (1)
- o Enstitü / Fakülte yönetim kurulunun gerekçeli kararı ile tezimin erişime açılması mezuniyet tarihimden itibaren ... ay ertelenmiştir. (2)
- o Tezimle ilgili gizlilik kararı verilmiştir. (3)

04/01/2023

Yasemin ÇOLAK

1*"Lisansüstü Tezlerin Elektronik Ortamda Toplanması, Düzenlenmesi ve Erişime Açılmasına İlişkin Yönerge"*

(1) *Madde 6. 1. Lisansüstü tezle ilgili patent başvurusu yapılması veya patent alma sürecinin devam etmesi durumunda, tez **danışmanının** önerisi ve **enstitü anabilim dalının** uygun görüşü üzerine **enstitü** veya **fakülte yönetim kurulu** iki yıl süre ile tezin erişime açılmasının ertelenmesine karar verebilir.*

(2) *Madde 6. 2. Yeni teknik, materyal ve metotların kullanıldığı, henüz makaleye dönüşmemiş veya patent gibi yöntemlerle korunmamış ve internetten paylaşılması durumunda 3. şahıslara veya kurumlara haksız kazanç imkanı oluşturabilecek bilgi ve bulguları içeren tezler hakkında tez **danışmanının** önerisi ve **enstitü anabilim dalının** uygun görüşü üzerine **enstitü** veya **fakülte yönetim kurulunun** gerekçeli kararı ile altı ayı aşmamak üzere tezin erişime açılması engellenebilir.*

(3) *Madde 7. 1. Ulusal çıkarları veya güvenliği ilgilendiren, emniyet, istihbarat, savunma ve güvenlik, sağlık vb. konulara ilişkin lisansüstü tezlerle ilgili gizlilik kararı, **tezin yapıldığı kurum** tarafından verilir *. Kurum ve kuruluşlarla yapılan işbirliği protokolü çerçevesinde hazırlanan lisansüstü tezlere ilişkin gizlilik kararı ise, **ilgili kurum ve kuruluşun önerisi** ile **enstitü** veya **fakültenin** uygun görüşü üzerine **üniversite yönetim kurulu** tarafından verilir. Gizlilik kararı verilen tezler Yükseköğretim Kuruluna bildirilir.*
Madde 7.2. Gizlilik kararı verilen tezler gizlilik süresince enstitü veya fakülte tarafından gizlilik kuralları çerçevesinde muhafaza edilir, gizlilik kararının kaldırılması halinde Tez Otomasyon Sistemine yüklenir

** Tez **danışmanının** önerisi ve **enstitü anabilim dalının** uygun görüşü üzerine **enstitü** veya **fakülte yönetim kurulu tarafından karar verilir.***

ETİK BEYAN

Bu çalışmadaki bütün bilgi ve belgeleri akademik kurallar çerçevesinde elde ettiğimi, görsel, işitsel ve yazılı tüm bilgi ve sonuçları bilimsel ahlak kurallarına uygun olarak sunduğumu, kullandığım verilerde herhangi bir tahrifat yapmadığımı, yararlandığım kaynaklara bilimsel normlara uygun olarak atıfta bulunduğumu, tezimin kaynak gösterilen durumlar dışında özgün olduğunu, **Prof.Dr. Lütfi ERDEN** danışmanlığında tarafımdan üretildiğini ve Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü Tez Yazım Yönergesine göre yazıldığını beyan ederim.

Yasemin ÇOLAK

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Prof. Dr. Lütfi Erden, for his effort and patient guidance.

I am very thankful to Prof. Dr. A. Tarkan Çavuşoğlu for his support.

In addition, I would like to thank my family, my friends and my colleagues who were very supportive.

ABSTRACT

ÇOLAK, Yasemin. *Essays on Exchange Rate Pass-Through*, Ph.D Dissertation, Ankara, 2023.

This dissertation re-examines the exchange rate pass-through using two empirical methods; panel quantile regression and dynamical model averaging methods in two essays. The first essay tests the association between a high (low) inflation environment and the exchange rate pass-through degree, namely Taylor's hypothesis, applying quantile regression. This method allows us to capture the distributional heterogeneity that addresses whether the exchange rate pass-through degree depends on the inflationary environment. Results provide evidence in favor of Taylor's hypothesis. It is found that the higher the quantiles of inflation, the larger the exchange rate pass through. The second essay analyzes the exchange rate pass-through dynamics considering the time-varying parameters and model uncertainty. Our findings imply that the 2008 global crisis triggers a change in exchange rate pass-through dynamics. Pass through is found to be low but rising since the pandemic in all advanced countries. In addition, it has a positive relationship with average inflation rates and a weak positive relationship with trade openness in emerging countries.

Keywords

Exchange Rate Pass-Through, Time-Varying, Dynamic Model Averaging, Panel Quantile Regression, Taylor’s Hypothesis

ÖZET

ÇOLAK, Yasemin. *Döviz Kuru Fiyat Geçişkenliği Üzerine Amprik Çalışmalar*, Doktora, Ankara, 2023.

Bu çalışma, döviz kuru- fiyat geçişkenliği iki farklı ampirik yöntemle yeniden incelemeyi amaçlamaktadır. İlk çalışmada, düşük (yüksek) enflasyon ortamında döviz kuru fiyat geçişkenliğinin düşük (yüksek) olma eğiliminde olduğunu ileri sürerek döviz kuru geçişkenlik derecesi ile enflasyon ortamı arasındaki ilişkiden bahseden Taylor hipotezini test etmek için panel kantil regresyon yönteminden yararlanılmıştır. Çalışmada kullanılan tahmin yöntemi, doğrudan döviz kuru geçişkenlik derecesinin enflasyonist ortama bağlı olup olmadığı sorusunu katsayısındaki heterojenlik sayende direkt olarak inceleyebilmemizi sağlamaktadır. Bulgular, Taylor hipotezini destekler niteliktedir. Bulgular Taylor hipotezini destekler nitelikte enflasyon oranının düşük (yüksek) olduğu dilimlerde döviz kuru geçişkenliğinin düşük (yüksek) olduğunu göstermektedir. İkinci yöntemde, döviz kuru geçişkenliğinin zamanla değişen özelliği dikkate alınarak Dinamik Model Ortalamasından yararlanılmaktadır. Bulgular, döviz kuru geçişkenlik derecelerinin 2008 küresel krizi tarafından tetiklendiğine işaret etmektedir. Hesaplanan döviz kuru geçişkenlik dereceleri, tüm gelişmiş ülkelerde oldukça düşük olmasına rağmen pandemiden bu yana oldukça yükselme eğilimi göstermektedir. Ayrıca, ortalama enflasyon oranları ile pozitif bir ilişkiye sahipken, gelişmekte olan ülkelerde ticari açıklık ile zayıf bir pozitif ilişkiye sahiptir.

Anahtar Sözcükler

Döviz kuru fiyat geçişkenliği, Panel Kantil Regresyon, Dinamik Model Ortalaması, Taylor Hipotezi

TABLE OF CONTENTS

INTRODUCTION

The exchange rate movements and price instability are essential concerns for policymakers regarding financial stability and international trade. In the early 1970s, after the Bretton Woods System collapsed, most economies gradually abandoned fixed exchange rate regimes. Floating exchange rate regimes lead researchers to focus on the possible effects of change in the exchange rate on domestic prices. This effect is commonly called exchange rate pass-through (ERPT). ERPT degree contains valuable information that affects monetary policy implementation. A high ERPT degree reduces the efficiency of monetary policies and increases countries' vulnerability to exchange rate shocks which are imported from trade partners (Ghosh, 2013). However, a low ERPT gives more flexibility in conducting effective monetary policies and enables central banks to conduct independent monetary policies. The degree of ERPT has become a more crucial and popular issue especially since many central banks started implementing inflation targeting strategy from the 1990s onward.

ERPT is the transmission of exchange rate changes into import prices (Goldberg & Knetter, 1997). This definition refers to the first stage pass-through. Import price fluctuations may also cause consumer price changes, which refers to second-stage pass-through. Additionally, ERPT can be complete, incomplete, or delayed. "Law of One Price, LOP”, is the theoretical idea behind the complete pass-through. LOP asserts the price of identical goods in the common currency will be the same across countries. It holds with the assumption that both the transportation and distribution costs do not exist under profit maximization assumptions (Goldberg & Knetter,1997, Campa & Goldberg, 2005). The traditional open economy models identify pass-through as complete under the purchasing power parity and perfect competition framework. On the one hand, if the exporter country’s currency is used for pricing, “Producer Currency Pricing, PCP”, and identifies complete pass-through (“one-to-one”). In this case, exporters do not absorb prices into markups; therefore, they might adjust their prices . Since the markups will be equal to zero for the exporters under perfect competition, pass-through will be complete (see Goldberg & Knetter,1997). On the other hand, if the importer country's currency is used for pricing, “Local Currency Pricing, LCP”, pass-through is not expected in the short run. In LCP, exporters decide to absorb exchange rate changes into markups; thus, prices would remain unchanged. Krugman (1987) suggested a general case, “pricing-to-market”, where this absorbing behavior cause import price increase is lower than the decrease in the exchange rate. Hence, the “new open economy macroeconomic models, NOEMM”, posit incomplete pass-through (the degree is less than one).

Theoretical studies try to explain pass-through phenomenon from both micro and macro points of view. The main focus of micro-based approach is on the industrial organization framework. In the study aiming to explain incomplete pass-through from an industrial organization framework, Goldberg and Knetter (1997) gave an extensive overview of the literature. Krugman (1987), Dornbush (1987), Knetter (1993), Goldberg and Knetter (1997), Devereux and Engel (2001) were early studies investigating pass-through issue from a microeconomic viewpoint. In the 1980s, studies predominantly concentrated on price discrimination, product differentiation, and market segmentation which rely on the assumption that exporters have market power. Thus, the exporters respond to any increase in exchange rate by adopting markups to protect their market power.Devereux and Engel (2001) suggested that monetary stability and a country's currency stability let exporters decide the price. Accordingly, this behavior will lead exporters to set prices to the buyer country (LCP) when the buyer country has monetary stability. Dornbush (1987) model examined Cournot-type competition and hinges on product substitutability, import penetration, and the number of exporters. Froot and Klemperer (1989) made another explanation for exporters' behavior. They argued that if firms believe exchange rate changes permanently, they implement aggressive strategies to keep local market share. In contrast, if they believe the currency changes are temporary, the firms react less aggressively to prices. Imported products composition is also put forward (Campa & Goldberg, 2005). Composition shifts in the imports, such as energy and raw material, to manufactures mostly result in lowering the pass-through. Ghosh and Rajan (2007) carried out a study in Asian countries and focused on the product sharing (product fragmentation) process. According to Gust et al. (2006), the decrease in responsiveness of US import prices to exchange rate fluctuations is due to increasing trade integration. They commented the elasticity of demand changes with competitors' pricing behavior. Firms not only think about their marginal cost but also consider the competitors' pricing strategies. They would not want to diverge from the competitor's price, ending up with an incomplete pass-through.

Macro-based approaches to ERPT are based on the NOEMM. Obstfeld and Rogoff (1995) mentioned that imperfect competition and nominal rigidities are important to understand exchange rate behavior (Lane, 2001, Otani et al., 2003). Their model still considered the purchasing power parity with complete pass-through in the dynamic general equilibrium model. Further, Betts and Devereux (1996;2000) extended Obstfeld and Rogoff (1995) model by combining pricing-to-market and sticky prices. While the prices are set beforehand in the two models, pricing strategies differ. Though these studies are an early version of new open macroeconomic models, ERPT to consumer prices and the importance of inflation in monetary policy are leading concerns in the macroeconomic literature (Stulz, 2007). Devereux and Yetman (2010) proposed an open economy model considering staggered price setting by taking price stickiness as endogenous to monetary policy. Taylor (2000) utilizes a model under the assumption of monopolistic competition in which pricing decisions are made in staggered price settings and sticky prices. In staggered price setting, firms decide prices beforehand. If firms perceive any increase in marginal cost as temporary, especially in a low inflation environment, the pass-through degree will be low. The increase in the prices is temporary in the low inflation environment. Hence, Taylor (2000) states that a low/high inflation environment is associated with a lower/higher ERPT. It implies that ERPT is endogenous to inflationary environment.

Many empirical studies documented a decline in the ERPT through 1990s (see, for example, Bouakez & Rebei, ,2008i Campa & Goldberg, 2005, Chou, 2019, Gagnon & Ihrig, 2004, Ghosh, 2013, Jiménez-Rodríguez & Morales-Zumaquero, 2016, Otani et al., 2003, Marazzi et al., 2005, Frankel et al., 2012, Olivei, 2002, Ozkan & Erden, 2015, Sekine, 2006, Takhtamanova, 2010,). Taylor (2000) claims that the decrease in pass-through is related to "a reduction in the pricing power of firms". This study interprets this reduction in pricing power as a decline in inflation in the last few decades. Many studies highlight that Taylor's hypothesis hold (for example, Gagnon & Ihrig,2004, Choudri &

Hakura,2006, Shintani et al., 2013, Junttila & Korhonen, 2012, María-Dolores, 2009, Jooste & Jhaveri, 2014, Ozkan & Erden, 2015, Jiménez-Rodríguez & Morales-Zumaquero, 2016, Brun-Aguerre et al., 2012, Baharumshah et al., 2017, Chou, 2019). Overall, a limited but increasingly growing body of empirical literature focuses on Taylor's hypothesis. Over the past few decades, researchers have employed various approaches to studying ERPT. They focused on both first and second-stage pass-through. There were two types of models: the single equation model (Gosh 2013, Jiménez-Rodríguez & Morales-Zumaquero, 2016, Campa & Goldberg, 2005) and the multiple equation models where the VAR approaches were widely used to investigate ERPT (Stulz, 2007, McCarthy, 2007, Ca'Zorzi, 2007, Maria-Dolores, 2009, Ito & Sato, 2007, Jiménez-Rodríguez & Morales-Zumaquero, 2016, Coricelli et al. 2016). Structural VAR (Jiang & Kim, 2013, Vo et al., 2020). In addition, panel data models (Takhtamanova, 2010, Barhoumi, 2006) were also employed.

Furthermore, the growing body of empirical literature has investigated time-varying nature of ERPT. Several time-varying parameter (TVP) models, such as split sampling (Nogueira Junior et al., 2010, Takhtamanova, 2010, Campa & Goldberg, 2005, Gagnon & Ihrig, 2004, Choudri & Hakura, 2006); rolling window (Fleer et al., 2016, Brun-aguerre et al., 2012, Otani et al., 2003, Phuc & Duc, 2021), recursive estimation (Ghosh& Rajan 2009b); Kalman Filter (Ghosh & Rajan 2009a, Ghosh, 2013), TVP (Jiménez-Rodríguez et al. 2016, Hara et al., 2015); TVP-VAR (Jooste and Jhaveri, 2014). Chou (2019) estimate time-varying ERPT coefficients using quantile regression. Other techniques are such as DCC-GARCH (Ozkan & Erden, 2015); stochastic volatility model (Sekine, 2006) and trend interaction model (Frankel et al., 2012) are utilized. Identification of the non-linearity and asymmetrical relationship of ERPT is another focus of many researchers. To this end, they apply “Markov Switching” (Baharumshah et al. 2017); STAR (Shintani et al., 2013); TAR (Junttila and Korhonen, 2012); SETAR (Correa & Minella, 2010); logistic smooth transition (Kilic, 2016); non-linear autoregressive distributed lag (Delatte & López-Villavicencio, 2012, Kassi et al., 2019); asymmetrical error correction model (Yanamandra, 2015); vector error correction (Herzberg et al., 2003, Al-Abri & Goodwin, 2009); logic smooth transition model (Nogueira Junior & León-Ledesma, 2011).

In NOEMM, one of the frameworks to get ERPT coefficients is Phillips Curve (Takhtamanova, 2010, Correa & Minella, 2010, Delatte & López-Villavicencio, 2012, Jasova et al., 2019). Phillips Curve framework enables to control for other effects that influence inflation (Takhtamanova, 2010). Macroeconomic variables are included to model to control global shocks, such as oil prices that represents supply shocks, whereas output gap represents demand shocks. Another strand of literature investigates ERPT determinants. Average inflation, exchange rate volatility, and openness are the most prominent determinants that have been examined in recent years. The empirical literature has pointed out a mixed picture of the relationships between ERPT degree and these possible determinants. High exchange rate volatility, according to Mann (1986), may have an impact on how import or export prices are passed through. In the volatile exchange rate environment, exporters are encouraged to change prices to keep the profit margin unchanged. In another view, firms usually do not want to change prices quickly as they perceive the change in the exchange rate is temporary (Froot & Klemperer 1989, Taylor 2000, Krugman 1987). Nominal rigidities and a price discrimination framework, according to Corsetti, Dedola, and Leduc (2008), are crucial to understanding the connection between ERPT and excessive exchange rate volatility. Whereas there are some other studies documented negative (Goldfajn & Werlang 2000), Ozkan & Erden 2015) and no clear linkage (María-Dolores (2009, Choudhri & Hakura (2006) between exchange rate volatility and ERPT. Trade openness is another prominent macroeconomic variable that is discussed frequently. Increased trade openness is shown to have a positive or negative impact on the ERPT. The ERPT rises as trade openness increases because prices are more susceptible to global shocks. On the contrary, it could enhance domestic competition, resulting in lower ERPT (Phuc & Duc, 2021). While Goldfajn and Werlang (2000), Ghosh and Rajan (2009a), Ozkan and Erden, (2015), Chou (2019) asserts that there is a negative relationship, Ca'Zorzi (2007), McCarthy (2007), Takhtamanova (2010) reports a positive relationship between ERPT and openness. After pioneer study Taylor (2000), Takhtamanova (2010), Ozkan and Erden (2015), Frankel et al., (2012) and highlighted the linkage between ERPT degree and average inflation.

This disstertation consists of two chapters. In the first chapter, we explore the ERPT degree by focusing Taylor (2000) 's hypothesis that argues ERPT is low (high) in low (high) inflation states in the first chapter. To this end, a panel quantile regression is estimated to examine Taylor's hypothesis using panel data from 37 countries over the periods of 1996:1-2018:4. Panel quantile regression provides a convenient method to see if ERPT coefficients change over the quantiles of inflation rate and thus enables us to test Taylor's hypothesis in a single step. Unlike two-step approaches in previous empirical studies, panel quantile regression directly addresses whether the ERPT coefficient differs with respect to the quantiles of inflation rate without efficiency loss. The long and the short-run ERPT coefficients are obtained with an application of panel quantile regression. At low quantiles of the inflation rate, ERPT coefficients are lower, and they increase as the inflation rate increases to higher quantiles. These findings support Taylor's hypothesis.

In the second chapter, time-varying structure of ERPT is re-examined by adopting a distinct empirical route, the dynamic model averaging (DMA) method. Unlike the existing empirical strategies in the literature, we take into consideration model unceratinity to obtain time-varying degrees of ERPT. DMA allows predictors (hence models) and coefficients to vary over time. DMA is applied to quarterly time series data spanning from 1996:1-2021:3 for each of the 39 advanced and emerging economies in the sample. The short/long run ERPT over time are estimated within "the open economy Phillips curve" framework. In addition, the abovementioned prominent macroeconomic factors affecting ERPT, namely, openness, average inflation rate, and exchange rate volatility are discussed. Overall, ERPT degrees are found to be time-varying. The mean degree of ERPT over time and the range at which ERPT varies are estimated to be higher for emerging countries than developed countries. In contrast to developed countries, ERPT degrees of emerging economies exhibit a U-shaped trend, indicating a recent rising trend of price instability. The Pandemic also affects global price stability, and hence inflation increases in most countries resulting in noticeably high ERPT degrees observed for all countries. Additionally, the findings demonstrate a change in ERPT degree dynamics starting with the global crisis of 2008–2009.

CHAPTER 1

EXCHANGE RATE PASS-THROUGH: AN ANALYSIS OF A PANEL QUANTILE REGRESSION

1.1. INTRODUCTION

The transmission of the change in the exchange rate to domestic prices is a phenomenon known as exchange rate pass-through (ERPT). The degree of ERPT is essential for policy implementations of central banks. The degree of pass-through plays a crucial role in price stability and optimal exchange rate regimes. A low degree of ERPT allows maintaining an independent monetary policy and successfully implementing inflation targeting strategy.

A novel study by Taylor (2000) predicts that the exchange rate pass-through to domestic price will be higher in a high inflation environment where price fluctuations are likely to be perceived as permanent. Adopting a staggered price-setting model in a monopolistic competitive environment with rational expectations, Taylor (2000) indicates that any transfer to prices as a result of, for example, exchange rate movements depends on the pricing power of firms. In this model, firms make their pricing decisions four periods in advance. Thus, price decisions will depend on expectations. In case of a rise in marginal costs, firms pass through to prices based on firms' anticipation of whether the increase is permanent or not. Therefore, in anticipation of permanent increase, we expect to observe greater pass through. Especially in a high inflation environment, these changes tend to be more persistent, leading to higher pass through.

In the empirical literature, although there has been a growing body of studies investigating the ERPT phenomenon, there are limited number of studies empirically focusing on Taylor's hypothesis. The studies on single country experiences adopt nonlinear time series techniques such as Smooth Transition Autoregressive and Markov-Switching models using the inflation rate as a transitioning (regime shifting) variable (Baharumshah et al., 2017; Herzberg et al., 2003; Holmes, 2009; Junttila and Korhonen, 2012; Shintani et al., 2013). These studies find the ERPT coefficient is higher in high inflation regimes, providing evidence in favor of the Taylor's hypothesis. The studies on multi county experiences employ two step methodology to examine the Taylor's hypothesis. After obtaining time-varying ERPT coefficients for each country in the first step by applying split sample (Choudhri and Hakura, 2006), rolling regression (Brun-Aguerre et al., 2012), DCC-GARCH method (Ozkan and Erden, 2015) and quantile regression (Chou, 2019), these studies relate the ERPT with the average inflation rate among other variables in a panel regression in the second step. The results from the second stage regressions indicate that the ERPT degree responds positively to the average inflation rate, supporting the Taylor's hypothesis. However, the two-step approach is subject to serious econometric problems. The previous panel studies obtain ERPT coefficients of each country in the first step by assuming the degrees of ERPT of each country are identically and independently distributed. In the second step, they regress these estimated ERPT degrees on a set of explanatory variables along with the average inflation attempting to see the response of estimated ERPT degrees to average inflation. However, as most of the global shocks are transmitted through exchange rate fluctuations across countries, the assumption of independent ERPT degrees across countries is overly simplifying and contradictory, and thus may affect the second step analysis, resulting in efficiency losses. Given these considerations, the present study revisits the Taylor's hypothesis employing panel quantile regression to estimate the ERPT degrees and thus the impact of inflation states on ERPT degrees in a single step.

To this end, we use panel data from a sample of 37 countries over the quarterly periods of 1996:1-2018:4. The panel quantile regression serves as a convenient way to test the Taylor's hypothesis by allowing us to capture any heterogeneity in the ERPT coefficient at the conditional distribution of inflation rate. Therefore, we are able to directly address the question of whether the ERPT coefficient differs with respect to the quantiles of inflation rate. Another advantage of panel quantile regression is that heterogenous (nonlinear) ERPT parameter can be evaluated in a linear modeling framework by fitting not on conditional mean as in traditional regressions but on conditional quantiles of price fluctuations, yielding more precise estimates (Chou, 2019; Zhu et al., 2016).

1.2. Methodology

Following Koenker (2004), one can define a dynamic panel quantile regression as

$$Q_{y_{it}}(\tau | x_{it}, y_{it-1,} \eta_i) = \eta_i + \alpha(\tau) y_{it-1,} + x_{it}^T \beta(\tau) + u_{it} \quad (1)$$

where η_{i_i} represents the fixed effects, and u is the disturbance term. y_{it-1} is the lagged dependent variable. This specification is an extension of the general representation of Koenker and Bassett (1978)'s quantile regression. For a panelized version of the panel quantile regression with fixed effects taking into account of unobserved heterogeneity across cross section units, the loss function can be written as the following (Koenker, 2004);

$$min_{\alpha,\beta} \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{i=1}^{N} w_k \rho_{\tau_k} \left(y_{it} - \eta_i - \alpha(\tau) y_{it-1,} - x_{it}^T \beta(\tau_k) \right) + \lambda \sum_{i}^{N} \left| \eta_{i_i} \right| \quad (2)$$

where i is country index, k is quantile index, T is the total number of observations per countries, τ represents the τth quantile and ρ_{τ_k} represents loss function. w_k is the weights for panel quantiles. The weights are used as equal for all quantiles summing to 1.

After laying out the generic panel quantile regression, we consider an open economy Philips curve[1] to analyze the ERPT degree where inflation rate responds to demand and supply shocks as well as exchange rate fluctuations (See for example Takhtamanova, 2010). This serves as a suitable empirical framework as it accounts for supply and demand pressures as well as the effects of domestic and global shocks on inflation. Because of inflation inertia, we consider dynamic panel model including the lagged dependent variable as an explanatory variable. Accordingly, the model can be specified as follows:

[1]In the empirical ERPT literature, the studies use some form of Phillips curve or purchaing power parity relation derived mainly from the framework of new open economy macroeconomics models as empirical models (Choudhri and Hakura, 2006; Ghosh and Rajan, 2009).

$$Q_{y_{it}}\left(\tau|x_{it,}\eta_{i_i}, y_{it-1}, \varepsilon_{it}\right) = \eta_i + \beta_{1\tau}y_{it-1} + \beta_{2\tau}\Delta EXCHANGE\ RATE_{\ it} + \beta_{3\tau}GAP_{it} + \beta_{4\tau}\Delta OIL_{it} + \varepsilon_{it} \quad (3)$$

i represents country index, and t is the time and y_{it} denotes the inflation rate measured as the log difference of consumer price index (CPI). Δ is the (logarithmic) first difference operator and ε_{it} is the disturbance term. Exchange rate is bilateral rate quoted with US dollar as base currency. GAP is the output gap measured as the deviation of real GDP from its HP trend (Hodrick & Prescott, 1997). OIL denotes oil prices taken to represent supply shocks. $\beta_{2\tau}$ is a measure of the ERPT degree that might be heterogenous at conditional distribution of inflation rate.

1.3. Data

The data used for panel quantile regression analysis are obtained from various sources. The inflation rate (quarterly percentage change in CPI) and the exchange rates (domestic currency per US dollar) are taken from the International Financial Statistics (IFS) of IMF. Global prices of WTI crude oil (OIL) are obtained from the Federal Reserve Bank of St. Louis. The data on real GDP are gathered from OECD statistics to obtain the output gap, which is the deviation of real GDP from its HP trend. Based on the data availability at quarterly frequencies, our unbalanced panel data set covers 37 countries[2] over the quarterly periods of 1996:1- 2018:4.

Table 1 shows descriptive statistics of data. Our data set covers developed and emerging countries. To see the extent of variation in the inflation rates across the countries, we average the inflation rate over time for each country and identify the quantiles with respect to the average inflation into which each country falls. Table 2 represents the results. The developing countries (Colombia, Costa Rica, Russia and Turkey) have the highest mean inflation rate which fall top %10 quantile. Not surprisingly, countries display the lowest mean inflation rate are advanced countries (Switzerland, France, Japan

[2] Austria, Australia, Belgium, Brazil, Canada, Czech Republic ,Chile, Colombia, Costa Rica, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Luxembourg, Netherland, New Zealand, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, United Kingdom, Turkey.

and Sweden). On the other hand, there are 17 euro adopter countries out of our sample. The average inflation rates of Euro adopters over the sample period fall below 0.4 quantile. Except for the average inflation of late Euro adopters such as Estonia, Latvia, Slovenia, Slovakia.

Table 1. Descriptive Statistics

Variable	Mean	Std. dev.	Min.	25 %	Median	75 %	Max.
Inflation	0.918	1.836	-3.025	0.149	0.578	1.200	39.840
Exchange rate	0.496	5.128	-16.650	-2.620	0.133	2.986	64.471
Oil	1.196	15.380	-71.067	-5.001	3.010	10.876	32.873
Gap	-0.003	0.693	-7.460	-0.263	0.003	0.262	8.375

Table 2. Mean inflation rates

Country	Inflation Mean	Quantile
Austria	0.4603	0.3
Australia	0.5982	0.6
Belgium	0.4790	0.4
Brazil	1.5660	0.9
Canada	0.4589	0.3
Switzerland	0.1255	0.1
Chile	0.8609	0.7
Colombia	1.6881	Top %10
Costa Rica	1.9238	Top %10
The Czech Republic	0.7504	0.7

Germany	0.3586	0.2
Denmark	0.4403	0.2
Estonia	1.0679	0.9
Spain	0.5508	0.6
Finland	0.3679	0.2
France	0.3401	0.1
United Kingdom	0.5063	0.5
Greece	0.6171	0.6
Hungary	1.4873	0.9
Ireland	0.4613	0.3
Israel	0.6175	0.6
Iceland	1.0674	0.9
Italy	0.4513	0.2
Japan	0.0480	0.1
South Korea	0.6982	0.7
Luxembourg	0.4667	0.4
Latvia	1.0389	0.8
Netherland	0.4674	0.4
Norway	0.5284	0.5
New Zealand	0.4901	0.4
Poland	1.0156	0.8
Portugal	0.5113	0.4
Russia	3.5310	Top %10
Sweden	0.2788	0.1
Slovenia	0.9598	0..7
Slovakia	1.006	0.8
Turkey	5.665	Top %10

1.4. Empirical Results

As is well known, estimating dynamic panel regression such as (3) with fixed effects results in an endogeneity bias (called Nickell bias). However, when T is large relative to N as is the case in this study (T=92), it is shown that the bias is negligible (Judson and Owen, 1999). Further, according to the study by Galvao and Montes-Rojas (2010), one of the advantages of the shrinkage models such as the penalized dynamic panel quantile regression (3) is that it can reduce dynamic bias by shrinking the FE. Thus, they suggest the use of the panelized dynamic quantile model estimation to overcome the problem of dynamic bias resulting from endogeneity and/or weak instruments in instrumental variable (IV) estimation technique. Following the lead of the study by Galvo and Montes-Rojas (2010), we estimate the regression (3) by using a panelized version of the loss function, setting the penalty parameter λ to 1that shrinks the FE coefficients towards zero[3]. We choose k to be 9 ($\tau = 0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9$) in order to clearly see if there exists any distributional heterogeneity in ERPT degrees.

Table 3 presents the results. The columns give the results from quantile (0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9 respectively) estimation. As seen, all coefficients have the expected signs. The coefficients on the control variables representing demand and supply shocks are positive and significant at different quantiles. We observe a slight increasing pattern of the effects of oil price changes along with the quantiles. The positive coefficients of output gap in all quantiles indicate the impact on inflation rates of the demand pressure of overcapacity. It is also interesting to note that the coefficients of gap decline along with quantiles, getting almost 3 times as large at 0.1 quantile as it is at the 0.9 quantile. One explanation for this could be that the global shocks due to exchange rate fluctuations come to play more dominant role in affecting inflation than domestics demand pressures at high inflation states, and vice versa. The coefficients of the lagged inflation are insignificant at low quantiles while they become significant and are increasing starting from 0.4 quantile. This shows that inflation is not persistent when it is low but becomes rather persistent when it is high.

[3] We experience with λ=0 and 0.5. However, the main results remain the same.

In order to focus on the ERPT coefficients, we depict them at different quantiles in Figure 1. As seen, they are all positive and significant across the quantiles. The distributional heterogeneity in the ERPT seems to be present. More specifically, the results show the ERPT coefficient increases along with the quantiles ranging from 0.015 at the 10^{th} quantile to 0.053 at the 90^{th} quantile. ERPT coefficients are low at the low quantiles and get larger along with the higher quantiles of inflation. These results clearly lend support for the Taylor's hypothesis. The magnitude of ERPT degrees is quite close to those of previous panel data studies (Ozkan and Erden, 2015; Jimborean, 2013).

Table 3. Panel Quantile Regression Results

	Quantiles								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y_{t-1}	-0.023	0.075	0.120	0.173*	0.232**	0.299***	0.352***	0.411***	0.557***
	(0.099)	(0.105)	(0.101)	(0.105)	(0.113)	(0.111)	(0.122)	(0.133)	(0.127)
EXCHANGE RATE	0.015 **	0.019***	0.022***	0.024***	0.023***	0.024***	0.026***	0.032***	0.053***
	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)	(0.010)	(0.014)
GAP	0.102 ***	0.078***	0.079***	0.077***	0.074***	0.064***	0.061***	0.054***	0.036*
	(0.020)	(0.017)	(0.013)	(0.013)	(0.012)	(0.014)	(0.014)	(0.016)	(0.020)
OIL	0.017***	0.014***	0.0141**	0.015***	0.015***	0.015***	0.016***	0.017***	0.020***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)

Notes: *,**,*** denote the significance level %10,%5, %1 respectively. The standard errors are in parenthesis.

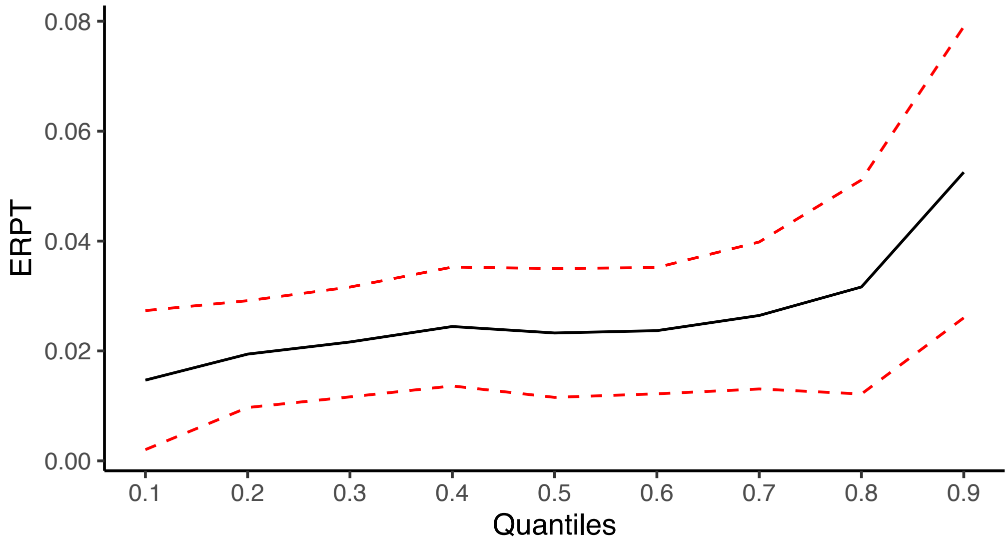


Figure 1. Estimated degrees of ERPT
Notes: The black line shows the ERPT coefficients from dynamic panel quantile estimation. The dashed lines represent 95% confidence interval.

It is important to verify the heterogeneity of coefficients across quantiles. One way to see whether there are significant differences in the degrees of ERPT is to estimate interquantile regressions. To see the coefficient differences between two quantiles, interquantile difference can be expressed as (Davino et al., 2013):

$$y\,(Q_2) - y\,(Q_1) = [\beta_0\,(Q_2) - \beta_0\,(Q_1)] + [\,(\beta_1\,(Q_2) - \beta_1\,(Q_1)]\,X = \gamma + \delta X \quad (4)$$

for any two quantiles Q_1 and Q_2, where $\delta = [\,(\beta_1\,(Q_2) - \beta_1\,(Q_1)]$ is the difference of slope coefficients in two quantiles. The rejection of the null H_0:δ=0 means heterogenous slopes between two quantiles.

We estimated 0.9-0.1, 0.9-0.5 and 0.5-0.1 interquantile regressions and the results are presented in Table 4. The differences, $y\,(Q_2) - y\,(Q_1)$, are provided by bootstrap procedure. All differences are statistically significant at 0.01 significance level. As seen, there exist distributional heterogeneity for the impacts of all variables.

Table 4. Interquantile differences

	Q0.9 - Q0.1	Q0.9 - Q0.5	Q0.5 - Q0.1
y_{t-1}	0.4204***	0.2266***	0.1939***
	(77.52)	(87.652)	(47.875)
	[0.4099,0.4311]	[0.2215,0.2316]	[0.1860,0.2019]
	0.0262***	0.0198***	0.0064***
EXCHANGE RATE	(41.516)	(38.675)	(20.304)
	[0.0250,0.0274]	[0.0188,0.0208]	[0.0058,0.0070]
	-0.0472***	-0.0269 ***	-0.0203***
GAP	(-33.484)	(-33.798)	(-20.623)
	[-0.0500,-0.0445]	[-0.0284,-0.0253]	[-0.022,-0.0184]
	0.0027***	0.0033***	-0.0006***
OIL	(20.233)	(28.065)	(-5.4267)
	[0.0025,0.0030]	[0.0031,0.0036]	[-0.0008,-0.0004]

Notes: t-stats are in parenthesis. %95 confidence intervals are shown in brackets. *** refers 0.01 significance level.

Since there are 17 Euro members out of 37 countries in our sample that adopted Euro at different dates during the sample periods of 1996-2018, it would be interesting to see if the ERPT degrees for Euro adopters differ. To this end, we define a dichotomous (dummy) variable that takes a value of zero for noneuro countries and a value of one for euro members, and include the interaction of dummy with exchange rate into the model. The results from this experiment show that the degree of ERPT ranges from 0.029 at 0.1 percentile to 0.062 at 0.9 percentile for noneuro countries while it ranges from 0.0 to 0.009 for euro adopters. In fact, the degrees of ERPT for euro adopters are very small and

Euro adopters have the lowest inflation rates in our full sample, resulting in the lowest ERPT degrees for Euro members. This finding supports our previous results on Taylor's hypothesis that predict low ERPT degrees in low inflation environments. One of the reasons for Euro countries to experience such low inflation rates and thus low ERPT could be monetary stability due to independent monetary policy for Euro adopters.

Further, to take into consideration the possibility of the delayed responses of inflation to exchange rate movements, and thus to analyze the long run ERPT degrees, we estimate the panel quantile regression with distributed lags (4 lags because of quarterly data). Table 6 presents the results with the bold row showing the long run ERPT degrees. As seen, the short run pass through follows a similar pattern as before, increasing along with the quantiles although a little smaller in magnitude. The long run ERPT degrees are higher in magnitude as expected. Although the long run ERPT degrees seem to be homogenous around 0.05 up until 0.7 quantile, they start to rise up dramatically to 0.075 at 0.8 and to 0.115 at 0.9 quantile. This means that Taylor's hypothesis still holds in the long run but we observe higher long run pass through only at the extreme (tail) rates of inflation.

Table 5. Panel Quantile Regression with dummy variable

	Quantiles								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y_{t-1}	-0.024	0.078	0.121	0.176	0.225**	0.293**	0.341***	0.405***	0.556***
	(0.101)	(0.112)	(0.109)	(0.109)	(0.115)	(0.115)	(0.123)	(0.133)	(0.126)
EXCHANGE RATE	0.029***	0.026***	0.028 ***	0.030***	0.031***	0.028***	0.034***	0.045***	0.062***
	(0.009)	(0.006)	(0.006)	(0.006)	(0.008)	(0.009)	(0.011)	(0.013)	(0.016)
EXCHANGE RATE* DUMMY	-0.029**	-0.020**	-0.023 ***	0.019***	-0.023 ***	-0.022**	0.025***	-0.037***	-0.053***
	(0.012)	(0.008)	(0.007)	(0.006)	(0.007)	(0.009)	(0.011)	(0.012)	(0.018)
GAP	0.099***	0.074***	0.078***	0.075***	0.076***	0.066***	0.060***	0.055***	0.038*
	(0.019)	(0.016)	(0.014)	(0.012)	(0.014)	(0.014)	(0.012)	(0.014)	(0.020)
OIL	0.016***	0.014***	0.013***	0.014***	0.015***	0.015***	0.016***	0.017***	0.020***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)

Notes: *,**,*** denote the significance level %10,%5, %1 respectively. The standard errors are in parenthesis.

Table 6. Panel Quantile Regression Results with lagged variables

Quantiles

	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
$\boldsymbol{y_{t-1}}$	-0.110 (0.102)	-0.035 (0.102)	0.053 (0.095)	0.095 (0.091)	0.140 (0.091)	0.195** (0.096)	0.247** (0.103)	0.312*** (0.121)	0.433*** (0.131)
Exchange rate	0.009* (0.005)	0.010** (0.005)	0.014*** (0.005)	0.015*** (0.005)	0.019*** (0.006)	0.018*** (0.006)	0.019*** (0.006)	0.026*** (0.009)	0.040*** (0.012)
$\boldsymbol{Exchange\ rate_{-1}}$	0.012** (0.005)	0.007 (0.004)	0.010** (0.004)	0.007 (0.005)	0.009 (0.006)	0.009 (0.006)	0.010 (0.006)	0.013* (0.007)	0.015 (0.011)
$\boldsymbol{Exchange\ rate_{-2}}$	0.006 (0.008)	0.008* (0.005)	0.006* (0.003)	0.006** (0.003)	0.003 (0.003)	0.004 (0.004)	0.006 (0.005)	0.009 (0.007)	0.030*** (0.010)
$\boldsymbol{Exchange\ rate_{-3}}$	0.011** (0.004)	0.011*** (0.004)	0.009** (0.003)	0.012*** (0.003)	0.011*** (0.004)	0.010*** (0.003)	0.007** (0.003)	0.010** (0.005)	0.009 (0.007)
$\boldsymbol{Exchange\ rate_{-4}}$	0.013*** (0.004)	0.010*** (0.003)	0.005* (0.003)	0.008** (0.003)	0.013*** (0.003)	0.012*** (0.004)	0.014*** (0.004)	0.018*** (0.005)	0.020*** (0.008)
$\sum_{j=0}^{4} Exchange\ rate_{it-j}$	**0.051*** (0.014)**	**0.046*** (0.012)**	**0.045*** (0.012)**	**0.047*** (0.013)**	**0.056*** (0.015)**	**0.052*** (0.014)**	**0.056*** (0.017)**	**0.075*** (0.021)**	**0.115*** (0.029)**

gap	0.058** (0.028)	0.038* (0.022)	0.034* (0.020)	0.017 (0.016)	0.012 (0.013)	0.032** (0.014)	0.032* (0.018)	0.002 (0.017)	-0.034** (0.021)
gap_{-1}	0.041** (0.021)	0.039** (0.017)	0.038** (0.018)	0.062*** (0.020)	0.048*** (0.017)	0.024 (0.017)	0.012 (0.020)	0.027 (0.025)	0.052 (0.037)
gap_{-2}	0.012 (0.030)	0.007 (0.020)	-0.003 (0.018)	-0.012 (0.020)	0.018 (0.021)	0.024 (0.020)	0.021 (0.021)	0.032 (0.022)	0.038 (0.031)
gap_{-3}	-0.036 (0.025)	0.012 (0.016)	0.019 (0.014)	0.017 (0.015)	0.010 (0.018)	0.010 (0.020)	0.015 (0.018)	0.005 (0.025)	-0.004 (0.038)
gap_{-4}	0.030 (0.021)	-0.010 (0.018)	-0.004 (0.015)	-0.000 (0.013)	-0.000 (0.012)	0.001 (0.012)	0.006 (0.012)	0.027 (0.017)	0.018 (0.028)
oil	0.016*** (0.002)	0.014*** (0.002)	0.015*** (0.001)	0.016*** (0.001)	0.017*** (0.001)	0.016*** (0.002)	0.018*** (0.002)	0.020*** (0.002)	0.021*** (0.003)
oil_{-1}	0.006** (0.002)	0.004*** (0.002)	0.004*** (0.001)	0.002 (0.002)	0.002 (0.001)	0.001 (0.001)	-0.000 (0.002)	0.001 (0.002)	0.002 (0.004)
oil_{-2}	0.006*** (0.002)	0.003* (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)	0.003** (0.001)	0.004** (0.002)	0.004 (0.002)
oil_{-3}	0.005*** (0.002)	0.006*** (0.001)	0.006*** (0.001)	0.006*** (0.001)	0.006*** (0.001)	0.007*** (0.001)	0.007*** (0.001)	0.009*** (0.002)	0.010*** (0.002)
oil_{-4}	0.007*** (0.002)	0.005*** (0.002)	0.003*** (0.001)	0.003*** (0.001)	0.004*** (0.001)	0.003** (0.001)	0.003** (0.001)	0.003** (0.001)	0.000 (0.002)

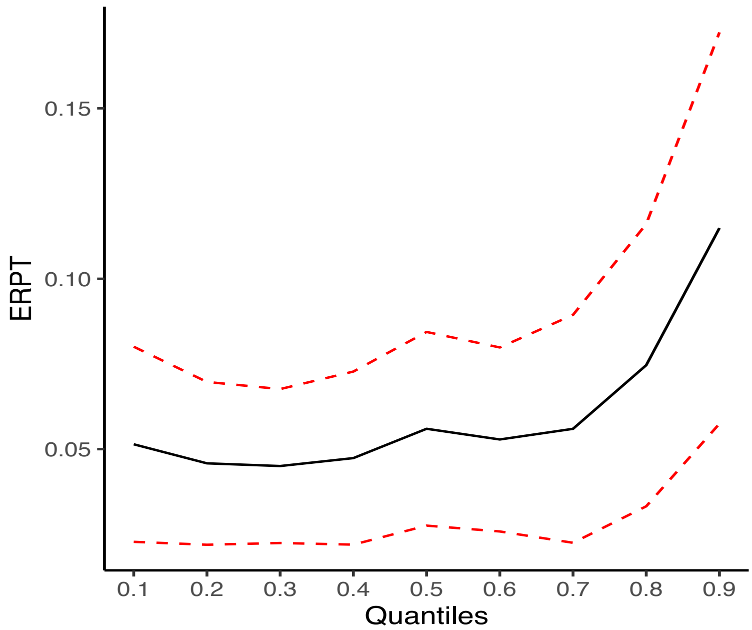


Figure 2. Estimated degrees of long-run ERPT
Notes: The black line shows the long-run ERPT coefficients from dynamic panel quantile estimation. The dashed lines represent 95% confidence interval.

1.5. CONCLUDING REMARKS

As most countries across the world have became more integrated and open along with the globalization waves, exchange rate fluctuations have come to play a pivotal role in transmitting external shocks to domestic economies. When the countries aiming to maintain price stability experienced difficulty because of high degrees of ERPT, policy makers started questioning the policy of the adaptation of floating exchange rate regime along with openness to international capital mobility. However, a novel study by Taylor (2000) raised an argument that the extent of ERPT mainly depends on the monetary stance of a domestic economy, predicting that the ERPT degree is higher in a high inflation environment where monetary shocks are likely to be perceived as permanent. Accordingly, there is no need for “fear of floating” with regard to the ERPT degree as long as monetary policy is credible in maintaining monetary stability and thus low inflation regime. The previous empirical studies provide supporting evidence for the

Taylor's hypothesis. The present study reexamines the issue by employing a panel quantile regression that serves as a suitable empirical strategy to directly test the Taylor's hypothesis. Using data from a panel of 37 countries we estimate various panel quantile regressions and find that ERPT degree is low at the low quantiles and getting larger along with the higher quantiles of inflation rates. These results clearly support the Taylor's hypothesis, reinforcing the previous findings. Instable monetary condition seems to be the major factor magnifying the extent of ERPT and resulting in an inflationary vicious circle. The policy implication of this finding is obvious. To stabilize prices, monetary policies must be geared towards achieving low inflation regime to mitigate the impact on domestic prices of exchange rate shocks. In so doing, policy makers should establish stronger institutional infrastructures to back up the credibility of monetary policy. This might in turn reduce the expected impact of exchange rate movements on future costs and domestic prices, leading to lower ERPT degree and lower inflation rate. Of course, the different pass-through coefficients might also be due to the nominal exchange rate regimes, the different currency of denomination, and also differences in product introductions, all of which might produce a correlation between the inflation rate and the pass-through above and beyond monetary stability.

CHAPTER 2

TIME-VARYING EXCHANGE RATE PASS-THROUGH USING DYNAMIC MODEL AVERAGING

2.1. INTRODUCTION

ERPT is a phenomenon known as the transmission of the changes in exchange rate to domestic prices, which has a crucial role from a macroeconomic perspective in conducting appropriate monetary and exchange rate policies. A low ERPT degree might allow monetary authorities to pursue a more flexible and independent monetary policy (Choudhri & Hakura, 2006). An influential study by Taylor (2000) suggests that the extent of ERPT depends mainly on monetary stance of an economy such that it becomes higher (lower) in high (low) inflationary environment. According to Taylor (2000)'s hypothesis, the changes in prices are associated with how changes are perceived in a staggered pricing model in which prices are determined several periods in advance under monopolistic competition environment. Thus, the persistence of the perceived price change will be less in low inflation environment, which will curtail the firm's pricing power. Therefore, exchange rate pass-through will be less in low inflation environment. Among others, this hypothesis provides a major reason why ERPT degree might be of time-varying nature. While a great deal of studies focuses on ERPT, there has been a growing body of empirical literature investigating time-varying structure of ERPT in the last decades[4]. The previous studies adopt both linear and non-linear approaches with conventional estimation techniques such as Kalman Filter, split sampling, rolling regressions, Markov Switching models, Smooth Transition Autoregressive (STAR) model, DCC-GARCH method, quantile regression, Markov Chain Monte Carlo (MCMC) Bayesian inference (Brun-Aguerre et al., 2012; Campa & Goldberg,2005; Choudri & Hakura,2006; Gagnon & Ihrig,2004; Gosh & Rajan, 2009a; b; Shintani et al., 2013;

[4]One can argue that it is also important to identify the sources of exchange rate shocks in analyzing exchange rate pass-through (ERPT). There are several studies investigating which exchange rate changes are more relevant for the ERPT channel (see for examples Shambaugh, 2008; Forbes et al., 2017 and Forbes et al., 2018).

Junttila & Korhonen, 2012; Jooste & Jhaveri, 2014; Baharumshah et al., 2017; Ozkan & Erden, 2015; Chou, 2019). While various empirical techniques are employed, one common feature of these studies is that they use fix model specifications in order to analyze the time-varying ERPT characteristics. However, internal and external factors driving inflation rate (measured by either import prices or domestic prices) and their relative significance might be changing over time, in which case the coefficients of the predictors determining the ERPT coefficient (slope of exchange rate) might be changing (Koop & Korobilis, 2012). Further, the number of the relevant factors along with their lags affecting inflation rate might be large such that the model geared towards obtaining the ERPT coefficient can change over time (model uncertainty). This means a model selection rule is required. Fortunately, a model averaging approach can serve as a convenient method to handle these issues.

Given these considerations, the aim of our study is to broaden current knowledge of the time-varying characteristics of ERPT with an application of Dynamic Model Averaging (DMA) method. DMA is firstly introduced by Raftery et al. (2010) and widely applied for forecasting macroeconomic variables (Baur et al., 2014; Beckmann & Schüssler, 2016; Bruyn et al., 2015; Catania & Nonejad, 2018; Drachal, 2020; Filippo, 2015; Hwang, 2019; Koop & Korobilis, 2011, 2012; Salisu & Isah, 2018). DMA provides a coherent mechanism that allows us to estimate time-varying coefficients together with posterior model probabilities for all possible model specifications over time. Allowing for both the predictors and coefficients to vary over time, DMA also allows to work with large number of predictors (Koop & Korobilis, 2012), addressing the model uncertainty in a dynamic way (Raftery et al.,2010). Using an ARDL specification of an open economy Phillips curve and applying DMA to quarterly time series of each of 39 countries, we estimated the short and long run ERPT degrees over time. The results show the presence of a change in the dynamics of ERPT degrees triggered by the global crisis in 2008-09. The degrees of ERPT are quite low in all advanced countries and even negative for most of the sample period while the degrees are also low in emerging economies but twice higher. Unlike developed countries, ERPT degrees present a U-shaped pattern over the sample period in emerging economies, pointing to a rising concern for price instability in recent years.

2.2. Empirical Literature on Time-varying ERPT

Almost all previous studies report a declining tendency of ERPT degrees for the last two decades (see, for example, Olivei, 2002; Otani et al., 2003; Gagnon & Ihrig, 2004; Campa & Goldberg, 2005; Ozkan & Erden, 2015; Marazzi et al., 2005; Ghosh, 2013; Sekine, 2006; Bouakez & Rebei, 2008; Takhtamanova, 2010) with a few exception (Brun-aguerre et al., 2012; Ghosh and Rajan, 2009b). Time-varying and non-linear aspects of ERPT and the ERPT behavior under an inflationary environment have been at the center of most of the previous works. (Otani et al., 2003, Campa &Goldberg, 2005; Sekine, 2006; Ghosh & Rajan 2009a; Takhtamanova, 2010; Frankel et al. 2012; Ghosh 2013; Ozkan & Erden, 2015; Kilic, 2016; Chou, 2019). These studies consistently document that the ERPT is low in low inflation states (Gagnon and Ihrig, 2004; Choudri & Hakura, 2006; Junttila & Korhonen 2012; Shintani et al.2013; Jooste & Jhaveri 2014; Jiménez-Rodríguez et al. 2016; Baharumshah et al. 2017). Some studies focus on the impact of the 2007-2008 global crisis on ERPT and find the substantial shift in ERPT degrees with the crisis (Hara et al., 2015 for Japan; Fleer et al., 2016 for Switzerland and Phuc and Duc, 2021 for New Zealand, Japan and South Korea).

Table 7 summarizes the empirical literature focusing on the nonlinear (time-varying) characteristics of ERPT. As seen, several estimation techniques are employed to examine the issue, which can broadly be grouped into three techniques: (i) time-varying parameter (TVP) models such as, split sampling (Campa and Goldberg, 2005, Takhtamanova, 2010, Gagnon and Ihrig, 2004, Choudri and Hakura, 2006), rolling window (Otani et al., 2003, Brun-aguerre et al., 2012, Fleer et al., 2016 and Phuc and Duc, 2021), recursive estimation (Ghosh& Rajan 2009b); Kalman Filter (Ghosh& Rajan 2009a, Ghosh, 2013), TVP-quantile regression (Chou, 2019),TVP (Jiménez-Rodríguez et al. 2016; Hara et al., 2015); TVP-VAR (Jooste and Jhaveri, 2014); (ii) regime switching models including Markov Switching (Baharumshah et al. 2017); TAR (Junttila and Korhonen, 2012), STAR (Shintani et. Al, 2013), logistic smooth transition (Kilic, 2016), and (iii) others such as DCC-GARCH (Ozkan and Erden, 2015); stochastic volatility model (Sekine, 2006) and trend interaction model (Frankel et al., 2012). These studies use fixed model specifications and try to analyze the change in parameters of these models through time.

Thus, the change in model specification (model uncertainty) through time is ignored in these techniques[5]. The complex structure of pricing behavior may need more powerful models that allow for both parameter values as well as model specification to change in time. DMA is such a model to address both time-varying parameters and model selection in empirical analysis. To fill this gap in the literature we take a rather distinct route and employ DMA to analyze time-varying ERPT under model uncertainty.

Table 7 Empirical Studies on Time-varying ERPT

Authors	Country & Period	Methodology	Major Findings
Otani et al.(2003)	Japan 1978-2002	Rolling regression	ERPT has declining trend especially in 1980s and mid-1990s.
Gagnon and Ihrig (2004)	20 Industrial countries 1971-2003	Split sample	Declining trend in ERPT 18 countries out of 20 countries.
Campa and Goldberg (2005)	23 OECD countries 1975-2003	Split sample	There is a decline in ERPT for OECD countries. Macroeconomic variables play important role in differences.
Choudri and Hakura (2006)	71 countries 1979-2000	Split sample	Low ERPT degrees are related to low inflation regimes.
Sekine (2006)	The United States, Italy, France,Japan, Germany,The United Kingdom 1974-2004	Stochastic Volatility (Time-varying parameter)	ERPT has declining trend for six major industrial countries.
Ghosh & Rajan (2009a)	Singapore 1980-2005	Kalman Filter	Declining ERPT for Singapore.
			Although Thailand has higher ERPT degree,

[5] Although Dedeoglu and Kaya (2015) discuss the uncertainty issue, they disregard the model uncertainty in ERPT estimations.

Ghosh & Rajan (2009b)	Korea and Thailand 1980-2006	Recursive estimation	there is no sufficient evidence to support declining ERPT for both countries. There is an upward trend during the currency crisis 1997-98.
Takhtamanova (2010)	14 OECD 1980-2007	Split Sample	Decline in ERPT especially during 1990s.
Brun-aguerre et al (2012)	18 Emerging Markets and 19 Developed Economies 1980-2009	Rolling regression	The results are not similar to those reported decreasing trend of ERPT. Increasing ERPT for emerging markets.
Junttila and Korhonen (2012)	9 OECD countries 1975-2009	Non-linear Threshold Estimation- TAR and STAR (exponential and logistic)	The decline in ERPT is related to low inflation environment.
Frankel et al. 2012	76 Countries 1990-2001	Trend interaction	A declining trend in ERPT, but developing countries have higher ERPT
Ghosh (2013)	9 Latin American Nation 1970-2010	Kalman Filter	Decreasing ERPT over time.
Shintani et al. (2013)	The United States 1975-2007	Non-linear Estimation	Low ERPT is associated with lower inflation environment.
Jooste and Jhaveri (2014)	South Africa 1981-2012	TVP-VAR	There is a declining pattern of ERPT associated with low inflation.
Hara et al. (2015)	Japan 1982-2014	TVP	Increasing ERPT especially after mid-2000s.
Ozkan and Erden (2015)	88 Countries 1990-2013	DCC-GARCH	Declining ERPT since mid-1990s.

Fleer et al. (2016)	Switzerland 1980-2016	Rolling regression	A sharp increase in ERPT between the period 2010-11.
Kilic (2016)	USA, Japan, Germany, UK, Canada, Australia 1975-2009	Non-linear Asymmetric Model	ERPT is higher under the high inflation regime, incomplete and low under the low inflation regime.
Jiménez-Rodríguez et al. (2016)	G-7 countries 1970-2014	TVP	ERPT has declined and remained stable for now. Taylor's hypothesis holds.
Baharumshah et al. (2017)	Six Asian Countries 1980-2014	Regime dependent	ERPT is low in stable inflation regimes.
Chou (2019)	16 OECD countries 1976-2016	Quantile Regression	The ERPT degrees are relatively lower before 1990s.
Phuc and Duc (2021)	Australia, New Zealand, Japan, Korea 1995-2012	Rolling regression	Increasing ERPT especially after global crisis for New Zealand, Japan and Korea whereas Australia has stable ERPT.

2.3. Methodology and Empirical Model

DMA is introduced by Raftery et al. (2010) for the engineering task of predicting the output thickness of cold rolling mill. This model draws inspiration from "Bayesian Model Averaging, BMA", "Hidden Markov Models", and "Kalman Filter". Their model is essentially a linear regression model with several variables where both the variables that enter the model and their coefficients change at each time point. While the time-varying coefficients are estimated with Kalman filtering, the estimated models are combined with the Markov chain for the best model. Hence model uncertainty is incorporated in a dynamic way. The computational burden is addressed with forgetting factors. In the DMA setting, time variation in coefficients and model mixtures are approximated with forgetting factors that help avoid simulations, which leads to less computational time and resources. Estimating and combining a large number of time-varying models makes DMA a very useful tool in economic applications in which model uncertainty is a concern. Koop and Korobilis (2011, 2012) can be seen as the first application of DMA in econometric applications (among others, some selected works include; Beckmann & Schüssler,2016; Catania & Nonejad, 2018). They suggested using DMA as one flexible and powerful technique to forecast inflation and output growth.

DMA consists of two parts; (i) time-varying parameter estimation of all possible model specifications and (ii) combining the models with the Markov chain. This approach allows for several valuable outputs for economic assessment, such as relative variable importance and the size of the model mixture at each time point. We can assess the explanatory variables supported by the observed data over time through this information. Thus, DMA is a beneficial method for investigating ERPT. In order to increase the clarity, we present a summary of the DMA approach taken mainly from the excellent papers of Koop and Korobilis (2012), Nima Nonejad (2021), Catania and Nonejad (2018), and Beckmann and Schüssler (2016). This section is divided into four parts, three of which explains DMA technique in detail and the last section presents the empirical model.

2.3.1.Time-varying Parameter Estimation

Following Koop and Korobilis (2011,2012), the observation and state equation of the k^{th} dynamic linear model can be modified as;

$$y_t = x_t^{(k)} \theta_t^{(k)} + \epsilon_t^{(k)} \qquad \epsilon_t^{(k)} \sim (0, V_t^{(k)}) \tag{5}$$

$$\theta_{t+1}^{(k)} = \theta_t^{(k)} + n_t^{(k)} \qquad n_t^{(k)} \sim (0, Q_t^{(k)}) \tag{6}$$

where k is the index for the k^{th} model among $2^n - 1$ possible models (n = number of variables – number of variables always kept in the models), $\theta_t^{(k)}$is the time-varying regression coefficients that follow random walk, $y_t$and x_t are observations, $V_t^{(k)}$ and $Q_t^{(k)}$

are unknown conditional variances. Kalman Filter can be used to filter time-varying coefficients conditional on $V_t^{(k)}$ and $Q_t^{(k)}$. Following Nonejad (2021), let

$\theta_{t|t-1}^{(k)} = \mathrm{E}\left[\theta_t^{(k)}|I_{t-1}\right]$ is the Kalman filter estimation of $\theta_t^{(k)}$ and the $\Sigma_{t|t-1}^{(k)} = E\left[\left(\theta_t^{(k)} - \theta_{t|t-1}^{(k)}\right)\left(\theta_t^{(k)} - \theta_{t|t-1}^{(k)}\right)^T |I_{t-1}\right]$ covariance of $\theta_t^{(k)}$ conditional on the information up to $t-1$ (I_{t-1}). At the beginning of time t, these estimates based on equations (5) and (6) are:

$$\theta_{t|t-1}^{(k)} = \theta_{t-1|t-1}^{(k)} \tag{7}$$

$$\Sigma_{t|t-1}^{(k)} = \Sigma_{t-1|t-1}^{(k)} + Q_t^{(k)} \tag{8}$$

$y_{t|t-1}^{(k)} = E\left[y_t|\theta_{t|t-1}^{(k)}, I_{t-1}\right]$ can now be predicted using equation (5). y_t is then observed at the end of time t. Hence the prediction error, $\eta_{t|t-1}$ and the prediction variance, $q_{t|t-1}$ can be calculated as,

$$\eta_{t|t-1}^{(k)} = y_t - y_{t|t-1} \tag{9}$$

$$q_{t|t-1}^{(k)} = x_{t-1}^{(k)} \Sigma_{t|t-1}^{(k)} \left(x_{t-1}^{(k)}\right)^T + V_t^{(k)} \tag{10}$$

And the model predictive likelihood, $f^{(k)}(y_t|I_{t-1}) \sim N\left(x_t^{(k)}\,\theta_{t|t-1}^{(k)}, q_{t|t-1}^{(k)}\right)$ as given in Kim and Nelson (1999) and Hamilton (1994). Given the observed y_t and the prediction error and variance the new estimates of time-varying coefficients and covariances are:

$$\theta_{t|t}^{(k)} = \theta_{t|t-1}^{(k)} + \Sigma_{t|t-1}^{(k)} \left(x_{t-1}^{(k)}\right)^T q_{t|t-1}^{-1(k)} \eta_{t|t-1}^{(k)} \tag{11}$$

$$\Sigma_{t|t}^{(k)} = \Sigma_{t|t-1}^{(k)} - \Sigma_{t|t-1}^{(k)} \left(x_{t-1}^{(k)}\right)^{T} q_{t|t-1}^{-1(k)} x_{t-1}^{(k)} \Sigma_{t|t-1}^{(k)} \tag{12}$$

Conditional on a set of initial values, $\theta_{0|0}^{(k)}$, $\Sigma_{0|0}^{(k)}$ (for example, noninformative prior) and $V_t^{(k)}$ and $Q_t^{(k)}$, it is possible to estimate the time-varying parameters and covariances using Kalman Filter through time zero to T.

Since $V_t^{(k)}$ and $Q_t^{(k)}$ are unknown, they should be estimated. Assume that $V_t^{(k)}$ is known for now, DMA sets $Q_t^{(k)} = (\lambda^{-1} - 1) \Sigma_{t-1|t-1}^{(k)}$ where $0 < \lambda \leq 1$ is the forgetting factor. Setting l=1 makes $Q_t^{(k)} = 0$ and $\theta_{t+1}^{(k)} = \theta_t^{(k)}$, or in other words, the equation becomes a constant-coefficients linear regression model. When λ is set to some value that is less than one, the time variation on the coefficients is introduced proportionally because $Q_t^{(k)}$ depends on the past covariances of the parameters. The observations taken $m - periods$ ago have weight λ^m on the time-varying parameters trajectory. The value of λ affects the model adaptation where low values, values close to zero, imply the model quickly adapts to the changes in data. Thus it is prone to overfit and closely follows the noise (see Nonejad (2021) for the effect of different values of λ). Hence, choosing λ is important and highlighted by Catania and Nonejad (2018). They pointed out the fact that it can be time-varying. Therefore, we used a grid of values $\{0.90, 0.91, 0.92, \ldots, 1.00\}$ for our DMA estimation.

In order to estimate $V_t^{(k)}$ Koop and Korobilis (2012) suggest "Exponentially Weighted Moving Average, EWMA", estimator. EWMA estimator of $V_t^{(k)}$can be written in recursive form,

$\hat{V}_t^{(k)} = \kappa \hat{V}_{t-1}^{(k)} + (1 - \kappa) \eta_{t|t-1}^{2(k)}$ where the smoothing factor κ has to be set to the values such that $0 < \kappa < 1$. Interpretation of κ is similar to the interpretation of λ. As the value of κ decreases, the effect of the past values of $V_{t-m}^{(k)}$ decreases exponentially with κ^m. Koop and Korobilis (2012) use $\kappa = 0.98$ for the quarterly data as they expect slower decay of volatility. On the other hand, Beckmann and Schüssler (2016) use a grid of values. Riskmetrics (1996) (via Koop & Korobilis (2012)) suggests values of 0.97 for monthly and 0.94 for daily data. We set this value to 0.96 to allow a bit faster decay (to give more weight to recent values) as the emerging market indicators change faster.

Since $\hat{V}_t^{(k)}$ and $Q_t^{(k)}$ are functions of λ and κ in this setting, re-estimate the whole model is unnecessary for the new observations, and hence this setting is not computationally expensive. Once the individual models are estimated, the next step is to combine them.

2.3.2 Combining Models

Combining individual models is performed using the Markovian transition matrix. Let set of models to be combined be $L_t \in \{1, \dots, K\}$ where $K = 2^n$, the elements of transition matrix, transition probabilities, $p_{ml} = Pr(l_t = m | l_{t-1} = l), m = 1, .., K$, there are $K \ x \ K$ elements need to be estimated. This task is quite time consuming and the estimated values may be imprecise given a large K value. Since predicting y_t with model k, $(y_{t|t-1})$, given information up to $t-1$, and $\theta_{t|t-1}^{(k)}$depends on $L_t = k$ (Raftery et al., 2010), the joint distribution of unobserved states, $\Theta = \{ \theta_{t|t}^{(1)}, \theta_{t|t}^{(2)}, \dots, \theta_{t|t}^{(K)}\}$ and L_t conditional on I_t are given as,

$$p(\Theta, L_t \, | I_t) = \sum_{k=1}^{K} p\left(\theta_t^{(k)} | L_t = k, I_t\right) Pr(L_t = k | I_t) \tag{13}$$

where $p\left(\theta_t^{(k)} | L_t = k, I_t\right) \sim N\left(\theta_{t|t}^{(k)}, \Sigma_{t|t}^{(k)}\right)$, $\theta_{t|t}^{(k)}$ and $\Sigma_{t|t}^{(k)}$ are available from equation (11) and (9) respectively. It is now necessary to predict and update the probability of model k conditional on I_t. Let the probability of model k is, $\pi_{t|t-1,k} = Pr(L_t = k | I_{t-1})$ before observing y_t. This can be calculated with the transition matrix. But, since the dimension of transition matrix is too large, Raftery et al. (2010) suggest using the following equation with another forgetting factor,

$0 < \alpha \leq 1$ to obtain $\pi_{t|t-1,k}$,

$$\pi_{t|t-1,k} = \frac{\pi^{\alpha}_{t-1|t-1,k}}{\sum_{l=1}^{K} \pi^{\alpha}_{t-1|t-1,l}} \tag{14}$$

The advantage of this simplification is clear. There is now no need to use MCMC algorithm to obtain transition matrix. Once predicted, the probability of model k is updated after observing y_t with,

$$\pi_{t|t,k} = \frac{\pi_{t|t-1,k} f^{(k)}(y_t|I_{t-1})}{\sum_{l=1}^{K} \pi_{t|t-1,l} f^{(l)}(y_t|I_{t-1})} \tag{15}$$

where $f^{(k)}(y_t|I_{t-1}) \sim N\left(x_t^{(k)}\, \theta_{t|t-1}^{(k)}, q_{t|t-1}^{(k)}\right)$ is the predictive density at time t given I_{t-1}.

Equation (15) and (14) help us interpreting α . We can obtain the proportionality of the probability $\pi_{t|t-1,k}$ as,

$$\pi_{t|t-1,k} \propto \left[\pi_{t-1|t-2,k} f^{(k)}(y_{t-1}|I_{t-2})\right]^{\alpha} = \prod_{j=1}^{t-1} \left[f^{(k)}(y_{t-j}|I_{t-i-1})\right]^{\alpha^j} \tag{16}$$

The prediction performance of model k affects its weight. The most recent likelihood has a higher weight than the recent past likelihoods that is controlled by the parameter α. Recall that the time variation of coefficients is controlled by λ, and now the probability of the model proportional to its past performances is controlled by α. If α and λ are set to one, the model reduces to recursive Bayesian Model Averaging (BMA). Following Catania and Nonejad (2018), Koop and Korobilis (2012), and Raftery et al. (2010), we set α=0.99.

The conditional prediction density and point forecast for $t+1$, $f^{(DMA)}(y_{t+1}|I_t)$ and $\hat{y}_{t+1}^{(DMA)}$, given information up to time t are weighted mixture distribution and point forecasts with weights $\pi_{t|t-1,k}$.as,

$f^{(DMA)}(y_{t+1}|I_t)=\sum_{k=1}^{K} f^{(k)}(y_{t+1}|I_t)\pi_{t+1|t,k}$ and,

$$\hat{y}_{t+1}^{(DMA)} = \sum_{k=1}^{K} \left(x_t^{(k)}\,\theta_{t+1|t}^{(k)}\right)\,\pi_{t+1|t,k}$$

2.3.3. Inclusion Probabilities, Expected Number of Predictors

It is possible to compute the inclusion probabilities (relative variable importance) with the DMA approach as the following,

$$Pr\left(x_t^i, |I_{t-1}\right) = \sum_{k=1}^{K} \pi_{t|t-1,k} 1\left(x_t^i\right)$$

where $1(.)$ is "the indicator function", which takes value 1 if i^{th} predictor x_t^i is included in the model at time t. This quantity indicates whether data support the predictor inclusion. It lets researchers ex-post assess the predictors of interest and the model evolution through time. Another information that we can get from the DMA approach is the expected number of predictors at each time point. It is the weighted average of the size of the models. Let S_t^k is the number of predictors in model k, then the expected number of predictors given information I_{t-1} is,

$$E[S_t|\, I_{t-1}] = \sum_{k=1}^{K} S_t^k\,\pi_{t|t-1,k}$$

2.4. Time-varying ERPT with DMA

In order to investigate time-varying ERPT, we specify our empirical model in equation (5) based on the open economy Phillips curve (see for details Takhtamanova, 2010). Accordingly, y_t represents the inflation rate and the predictor matrix x_t includes demand and supply shocks represented by changes in oil prices and output gap along with the exchange rate changes. Considering the dynamics and persistency in the inflation rate, we define the open economy Phillips equation as an ARDL model as the following;

$$y_{it} = \theta_{0,it} + \sum_{j=1}^{4} \theta_{j,it} y_{t-i} + \beta_{1,it} \Delta EXCHANGE\ RATE_{\ it} + \sum_{l=1}^{4} \beta_{l,it} \Delta EXCHANGE\ RATE_{it-l} + \sum_{l=0}^{4} \gamma_{l,it} \Delta OIL_{it-l} + \sum_{l=0}^{4} \alpha_{l,it} \Delta GAP_{it-l} + \varepsilon_{it} \quad (17)$$

where, y_{it} is the i^{th} country's inflation rate measured as the log difference of consumer price index (CPI). Δ is the (logarithmic) first difference operator. OIL is the oil price representing supply shocks, the GAP is the output gap obtained as the percent deviation of real GDP from its HP trend (Hodrick & Prescott, 1997), and ε_{it} is the disturbance term. $\beta_{1,it}$ is a measure of the time-varying short run ERPT degree for the i^{th} country. The sum of the coefficients of lagged exchange rates, $\sum_{l=1}^{4} \beta_{l,it}$, shows the time-varying long run ERPT degree. Autoregressive lags of inflation rate will also control for seasonal pattern in inflation which is the only variable in the model that contains seasonality[6].

[6] We apply the same modelling approach with seasonally adjusted inflation series. To do so, we use the X13-ARIMA-SEATS method (Following, Sax & Eddelbuettel,2018). Then we perform the same steps to obtain the new figure 1 that is shown in Appendix C. The mean coefficients of the fourth lag of inflation for both developed and emerging economies become insignificant as expected. Mean coefficients of other variables are quite similar.

2.5. Data and Empirical results

The data for 39 developed and emerging countries over the period 1996:1 to 2021:3[7] are used. The number of countries is limited to 10 emerging and 29 developed countries[8] due to data availability. The quarterly percentage change in Consumer Price Index (inflation rate) and the exchange rate as per US dollar are taken from the "International Financial Statistics, IFS" of IMF. Real seasonality adjusted GDP is taken from OECD statistics. The output gap is obtained from HP trend of GDP (Hodrick & Prescott, 1997). WTI crude oil prices are taken from the "Federal Reserve Bank of St. Louis". The seasonality is not detected in the exchange rate and Oil prices.

We apply DMA to quarterly data over 1996:1 to 2021:3 for each country to estimate the ARDL specification of open economy Phillips curve (equation (17)). Since the study focuses on the ERPT degrees, we impose the inclusion of contemporaneous exchange rate and the intercept to the model such that the relative importance of this variable only is set to maximum value. The inclusion probabilities of all other variables and their lagged values are calculated endogenously with DMA approach. More specifically, the equation contains 20 right-hand side regressors, two of which are always kept in all model specification. Hence, there are $K = 2^{18}$ models to be considered in each time point. Given 2^{18} =262144 model combinations[9] with a grid of $\lambda = \{0.90, 0.91, 0.92, \dots, 1.00\}$, the total combination is $2^{18} x\ 11 = 2{,}883{,}584$ for each country in the sample. As there are 39 countries in the data set, 19x39 time-varying coefficients and 18x39 time-varying inclusion probabilities are obtained. DMA provides time-varying coefficients and the inclusion probabilities of all variables and their lags.

[7] The adaptation of the model given prior takes at least 30 observations for time series (Catania and Nonejad 2018). All the estimations before adaptation (during burn in period) are discarded. We set burn-in period as 30 since we use quarterly time series data. Consequently, the time-varying coefficients and posterior inclusion probabilities starting from 2005:1 are obtained.

[8] The list of countries and descriptive statistics for variables are represented in Appendix section.

[9] Although we have 19 potential predictors, we impose the inclusion of exchange rate in each time point in the model and thus our combination is 2^{18}.

2.5.1. Results regarding model selection and sparsity

Applying DMA to quarterly data between 1996:1 and 2021:3, we first analyze the time-varying relevance of the regressors along with their lags by means of the inclusion probabilities to see if their inclusions are supported by the data. The result is presented in Figure 3, which shows the inclusion of the variables used in equation (17) through time for both developed countries, Panel (A) and emerging countries Panel (B). The sizes of the points are proportional to the mean values of the coefficients. The coefficients with the inclusion probabilities less than the threshold of 25% for all countries at a given time point are left as blank in the figure.[10]

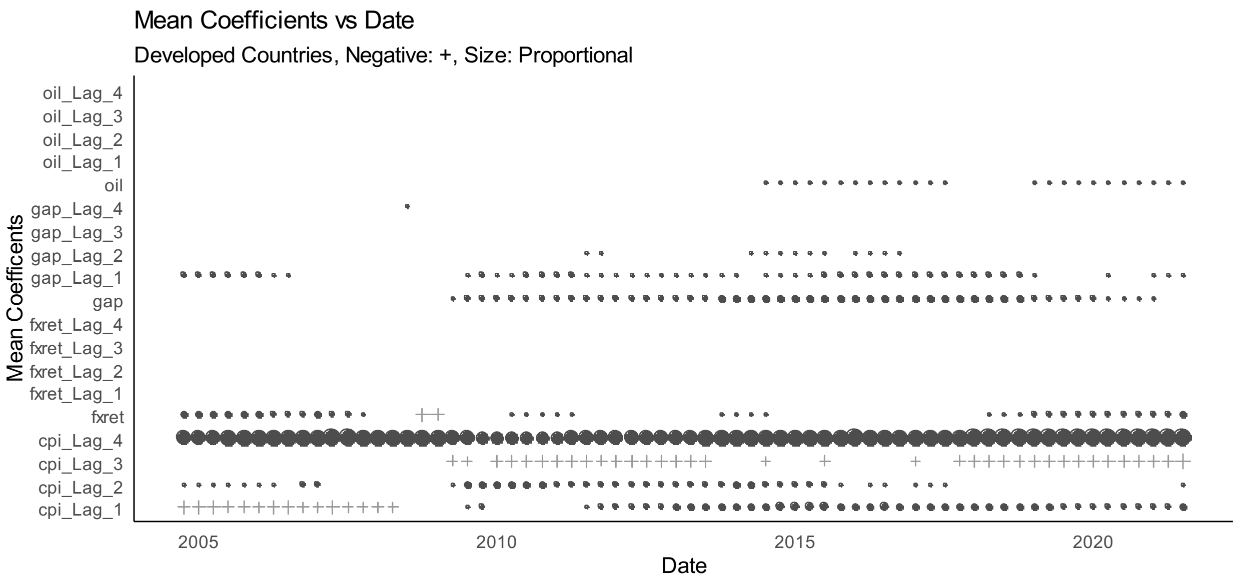
Sparsity seems to be evident[11]. The previous lag enters the model at all-time points for both group of countries, suggesting that there is high inertia. In addition, the fourth lag of inflation is significant at all-time points, indicating seasonal pattern in inflation as expected. While oil prices have downward pressure on the inflation in developed countries starting with 2014 when oil prices dramatically declined and remained relatively low in recent years, oil prices and its lags do not enter the model at all for developing countries. One explanation for this could be it is mainly the exchange rate shocks that dominate inflation rate rather than oil shocks in developing countries during the same time period when FED stopped purchasing bonds (the QE tapering) and started to increase interest rate, leading to sharp rises in the value of US dollar against the currencies of emerging economies. Interestingly while output gap enters the model at all-time periods in emerging markets, it only becomes significant right after the global crisis in 2008-09 in developed countries. It seems that inflation in developed countries is driven by demand pressures with the QE policies implemented after the crisis.

---

[10] The coefficients for the countries are filtered with the inclusion probabilities are greater than 0.25 at each point in time. The mean is then calculated by summing all coefficients with an inclusion probability more than 0.25 and means are illustrated in Figure 1. Since the ERPT coefficient is set to be included in all models the dots only give the idea about the magnitude of its effect. ERPT coefficient is left blank if the coefficient is very small (less than 0.01 in absolute value).

[11] Although noninformative prior distribution of models may affect expected model size such that it is centered around half of the number of predictors (18/2), it is found that 75% of expected model sizes are less than 5 predictors. The histogram of expected model sizes is presented in Appendix B. This result is also confirms the study by Koop and Korobolis (2012), finding that the expected size is not larger than that including three predictors despite their model has 14 predictors.

As for the major purposes of this study, the contemporaneous impact of exchange rate (short run ERPT) seems important at all-time points in emerging economies while it is rather sparse over time in developed economies. The short run ERPT is mostly significant before 2008, turns into negative only during the global crisis and becomes relevant in early 2010s and the recent years. Whereas the exchange rate has no long run impact for developed countries, the first and second lags of exchange rate enter the model before the global crisis and very recent years for developing countries. This means that most of the exchange rate shocks is realized contemporaneously and such impact is more dominant on developing than developed economies though it seems rising up in very recent years for developed economies. Also, the pass-through coefficients are larger in emerging countries than developed countries, a result consistent with the previous studies (Ozkan & Erden, 2015; Calvo & Reinhart,2000; Goldfajn &Werlang, 2000). More specifically, the range of mean ERPT over the sample period is narrow in developed countries (-0.02 to 0.03) while it is wider for developing countries (-0.09 to 0.11). Further, the mean ERPT is rather low in developed countries, approximately around 0.015 while it is twice as large in emerging countries. However, the ERPT degree rises up in recent years for developed countries as well. Especially, a noticeable increase in ERPT can be observed with the onset of the pandemic for developed countries in contrast to previous evidence pointing out declining tendency in ERPT degrees.



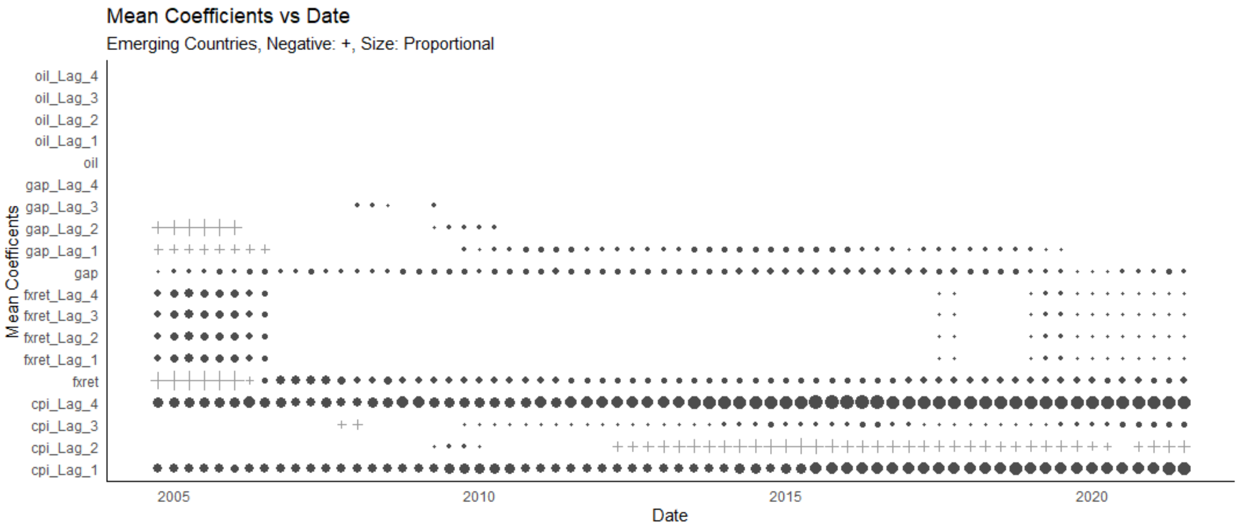


Figure 3: The inclusion of regressors into model. Size of points are proportional to mean values of the coefficients.

Overall, these results show the impacts of the regressors and their lags change over time. As a model selection tool, DMA captures the relevance of these variables at each time point to correctly estimate ERPT coefficients for the long and short run. In what follows, we scrutinize the degree of ERPT in a time-varying fashion for each country.

2.5.2. Results regarding Time-varying ERPT for Each Country

First, we show the sample's developed and emerging nations' respective time-varying short run ERPT coefficients in Figures 4(A) and (B). Overall, the findings indicate that the global financial crisis of 2008–09 caused a shift in the dynamics of ERPT degrees.

As seen from Figure 4 (A), the degrees of ERPT are quite low in all advanced countries and even negative for the majority of the time points in Austria, Australia, Czech Rep., Netherlands, New Zealand, Portugal and Sweden. However, for Israel and Iceland, the levels of ERPT seem to be relatively higher (around 0.05), a result that is consistent with Forbes et al. (2017) for Iceland and Eckstein & Soffer (2008) for Israel. There is a similar pattern in ERPT degrees especially for Euro adopters (Austria, Belgium, Germany, Greece, France, Italy, Denmark, Finland, Ireland, Portugal). The ERPT degree in these countries falls dramatically just around the global crisis in 2008, but returns back to its pre-crisis level quickly and remains low throughout 2010s. It takes a little longer to get back to its pre-crisis level only for Spain. Interestingly, while the extent of ERPT is lower in pre-2008, there seems to be an upward drift in post 2008 in Canada and Japan. On the contrary, it is a little higher in pre-2008, and shifts toward the lower state in post-2008 periods in Czech Rep., Netherlands, New Zealand, Norway, S. Korea, Switzerland, Sweden and UK. Lastly, the ERPT degrees seem to be tailing up in the last two years for all developed countries except Finland, Iceland, Israel, Japan, Latvia and Slovenia.

As for the extent of ERPT in emerging countries depicted in Figure 4 (B), the degrees are also low but higher than those of advanced economies. Similar to the developed economies, we can observe the presence of a change in the dynamics of ERPT degrees triggered by the global crisis. It is especially interesting to note a U-shaped pattern in ERPT degrees over the sample period in most emerging countries such as Brazil, Hungary, Poland, Turkey, Russia. The ERPT coefficients start declining before 2008, go on to fall a little further in 2008 and the following a few years, remain rather low until 2014 when the FED reverses its Quantitative Easing (QE) policy, but begins to rising up around 2015. However, ERPT degrees are not significant at all-time points for Bulgaria and while the extent of ERPT is a little high in pre-2008 in Romania, it goes down during the crisis periods, and remains near zero level over the years 2010s. Similar to the degrees for developed economies, it seems to be tailing up in the last two years for Brazil, Chile, Colombia and Poland.

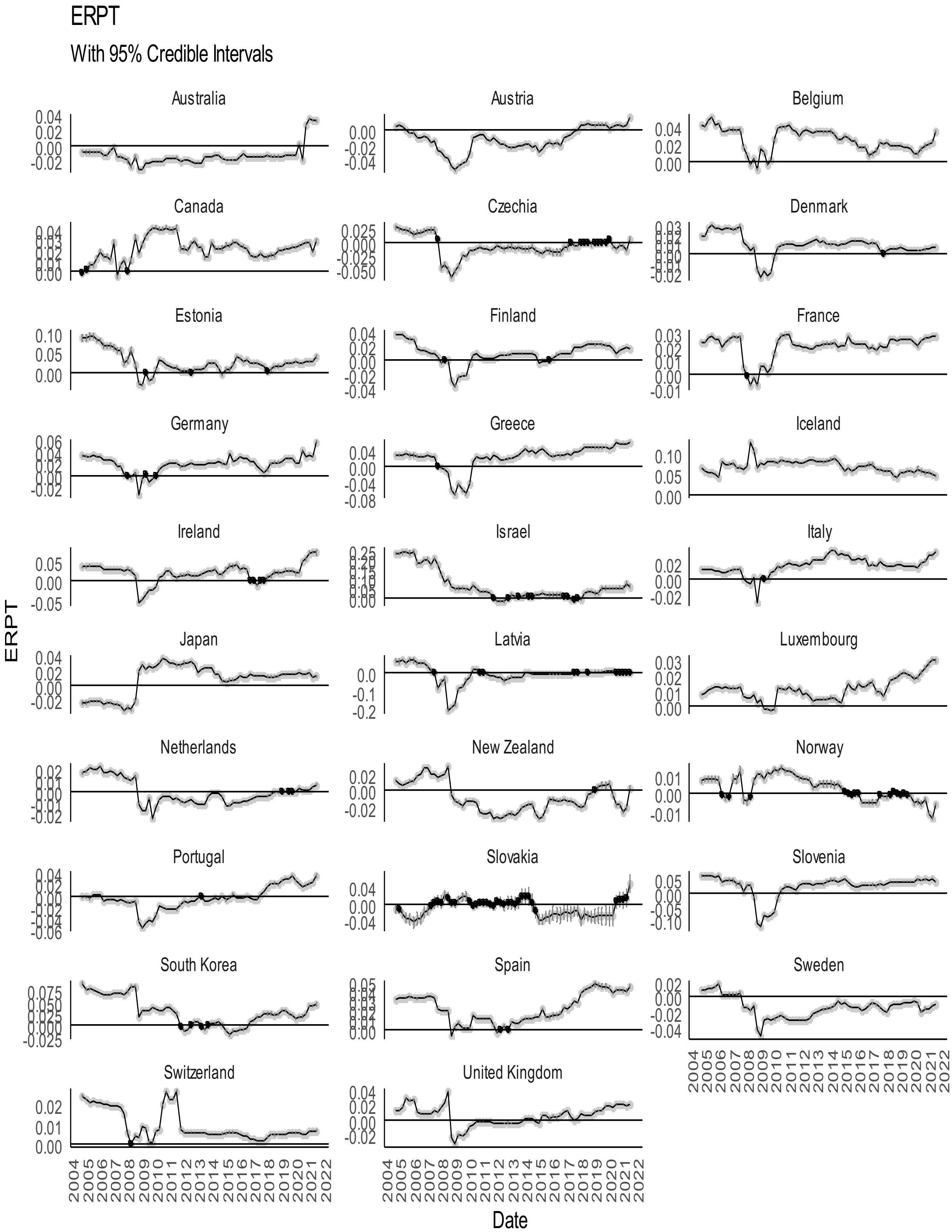


Figure 4 panel (A): Quarterly time-varying ERPT coefficients of Developed Countries

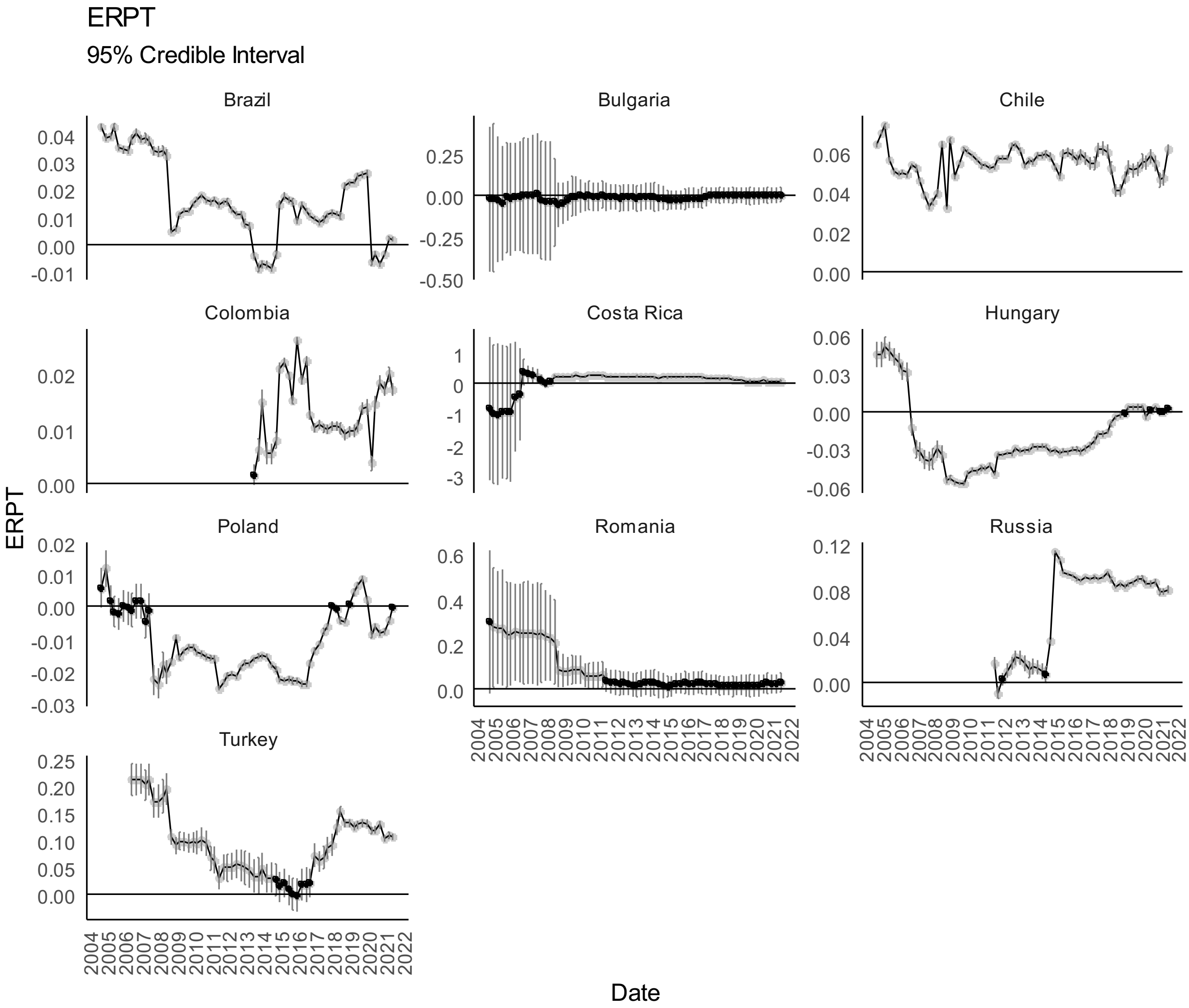


Figure 4 panel (B): Quarterly time-varying ERPT coefficients of Emerging Countries

Next, we focus on “the long-run ERPT” degrees, which are obtained by adding all four periods lagged coefficients of the exchange rate. As mentioned previously, we allow DMA method to endogenously select the predictors such as the lagged exchange rate. However, we observe that the posterior inclusion probabilities for the first and second lagged exchange rate never reach above 0.5 except for Brazil, Turkey, Israel, Iceland and New Zealand while the posterior inclusion probabilities of the third and fourth lags of exchange rate are never above 0.2 for all countries. Thus, we depict the inclusion probabilities for these five countries in Figure 5. As seen for New Zealand, the inclusion probability of the second lagged exchange rate jumps during 2008 global crisis and gets back to quite lower values for the rest of the sample period. One can spot a comparable pattern for Israel, where the inclusion probabilities of the first lagged exchange rate settle toward 0.1 after the crisis. Iceland, as an advanced country, presents an interesting picture. As mentioned earlier, along with the high contemporaneous pass through, Iceland appears to be experiencing high delayed pass through as evidenced by rising inclusion probabilities of the first lagged exchange rate. As for Brazil and Turkey, the delayed responses to exchange rate fluctuations appear to be significant and increasing after the global crisis.

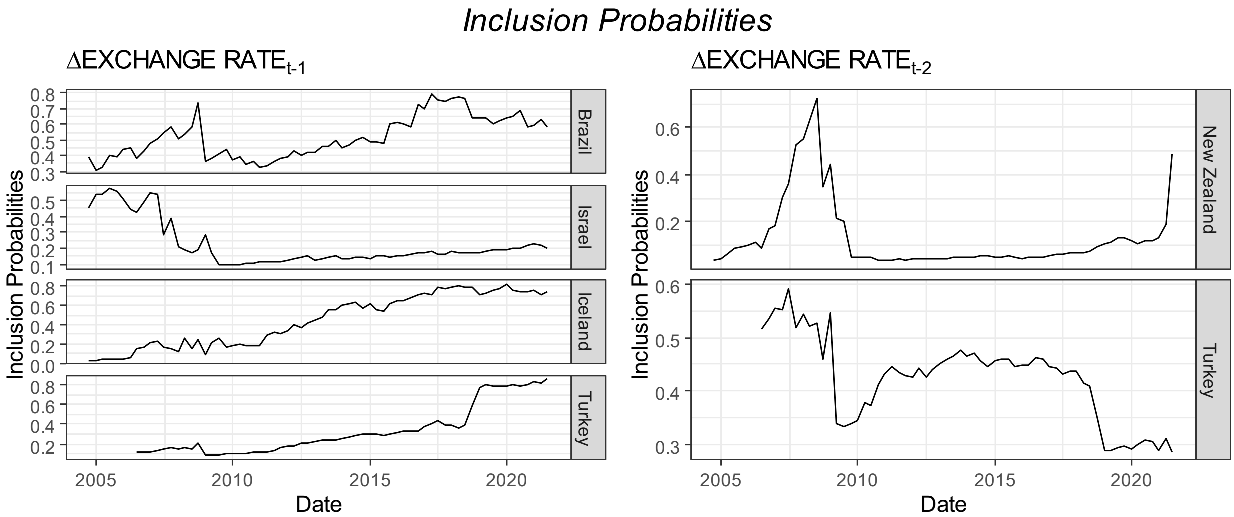


Figure 5: Posterior inclusion probabilities for lagged exchange rate. Left panel represents inclusion probabilities of first lag of exchange rate while right panel represents those of the second lag of exchange rate.

2.5.3. Results Regarding Major Macroeconomic Factors that affect the ERPT

There are several factors discussed in the literature that might influence the extent of ERPT. However, the three of them seem to be the most prominent ones, i.e. overall inflationary environment, exchange rate volatility and openness. While the empirical literature consistently documents that ERPT degree is higher (lower) in high (low) inflationary states in the context of Taylor (2000)'s hypothesis (see, Gagnon & Ihrig, 2004; Shintani et al.,2013; Choudri & Hakura, 2006; Maria-Dolares, 2009; Junttila &Korhonen,2012; Ozkan & Erden, 2015; Jiménez-Rodríguez & Morales-Zumaquero,2016), the evidence on the linkage between ERPT degree and exchange rate volatility seems to be rather mixed (Brun-Aguerre et al.,2012). Further, related empirical literature also documents mixed results on the relationship between ERPT and openness. While María-Dolores (2009) and Choudhri & Hakura(2006) could not find any clear linkage, Barhoumi (2006), Ca'Zorzi, Hahn & Sánchez (2007) and Soto & Selaive (2003) find a positive and Goldfajn & Werlang(2000), Ozkan and Erden (2015) find a negative relationship.

To investigate the relationship between the mean ERPT and the exchange rate volatility, we first calculate the volatility by using moving average standard deviations as

$$\sigma_E = [\tfrac{1}{m}\sum_{i=1}^{m}(E_{t+i-1} - E_{t+i-2})^2]^{\frac{1}{2}} \tag{18}$$

where E is the first difference of exchange rate and m is the order of moving average.[12] Then we compute the means of ERPT degrees and exchange rate volatility for each quarter across countries. Figure 6 depicts the scatter plots for developed and emerging countries.

[12] m is chosen as 7, following Arize et al. (2000).

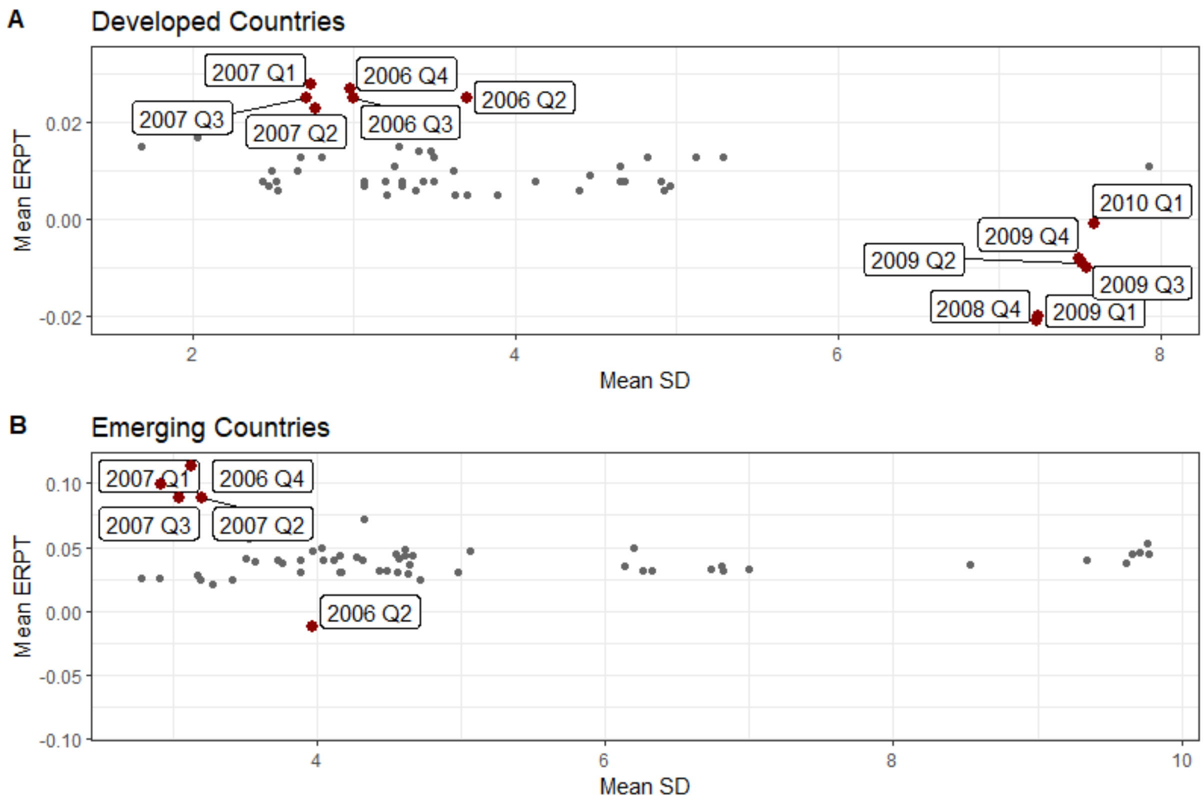


Figure 6: ERPT degrees vs. exchange rate volatility

As seen, while there appears no clear linkage between exchange rate volatility and ERPT degrees for emerging economies, there seems to be a downward relationship between the two for developed countries. Interestingly, the ERPT is higher at the lower volatility of exchange rates just before the global crisis in 2008 and vice versa just afterwards. These two extreme clusters seem to reflect the effect of a major crisis rather than to provide a clear picture so as to conclude that there is a link between exchange rate volatility and ERPT degrees. Similarly, in their study for Singapore and for nine Latin American economies, Ghosh and Rajan (2009a) and Gosh (2013) report no significant link. On the contrary, while Brun-Aguerre et al. (2012), Ghosh and Rajan (2009b), and Phuc and Duc (2021) find a positive link, Campa and Goldberg (2005), Ozkan and Erden (2015), Chou (2019), Jiménez-Rodríguez and Morales-Zumaquero (2016) report a negative link between them. Froot and Klemperer (1989) explain the existence of high volatility of exchange rate and low ERPT through mark-up fluctuations caused by exporters willing to hold their market shares with the perception of changes as temporary. In contrast, Devereux and Engel (2001) argue that low ERPT and low exchange rate volatility occur because exporters set prices in LCP or PCP in accordance with the monetary stabilization policies conducted in the country of interest. As can be noticed from these findings, there is no clear picture between ERPT and exchange rate volatility.

Second, in order to investigate whether there exists a relationship between the mean ERPT and inflationary environment, we compute the means of ERPT degrees and average inflation rate for each country at a point in time. The aim is to see the co-existence of higher ERPT with high average inflation rates. Figure 7 depicts the scatter plots for developed and emerging countries. As expected, the average inflation is so low in developed countries that there is no clear linkage between the two. However, ERPT degrees get larger with high average inflation in emerging economies, a result that supports Taylor (2000)'s hypothesis. In fact, virtually all previous studies provide supporting evidence for Taylor's hypothesis (Gagnon and Ihrig, 2004; Goldfajn and Werlang, 2000; Choudri and Hakura, 2006; Sekine, 2006). Especially, our results are quite in parallel with the study by Ozkan and Erden (2015), documenting insignificant association between ERPT and average inflation for developed countries while a positive relationship for developing and less-developed countries.

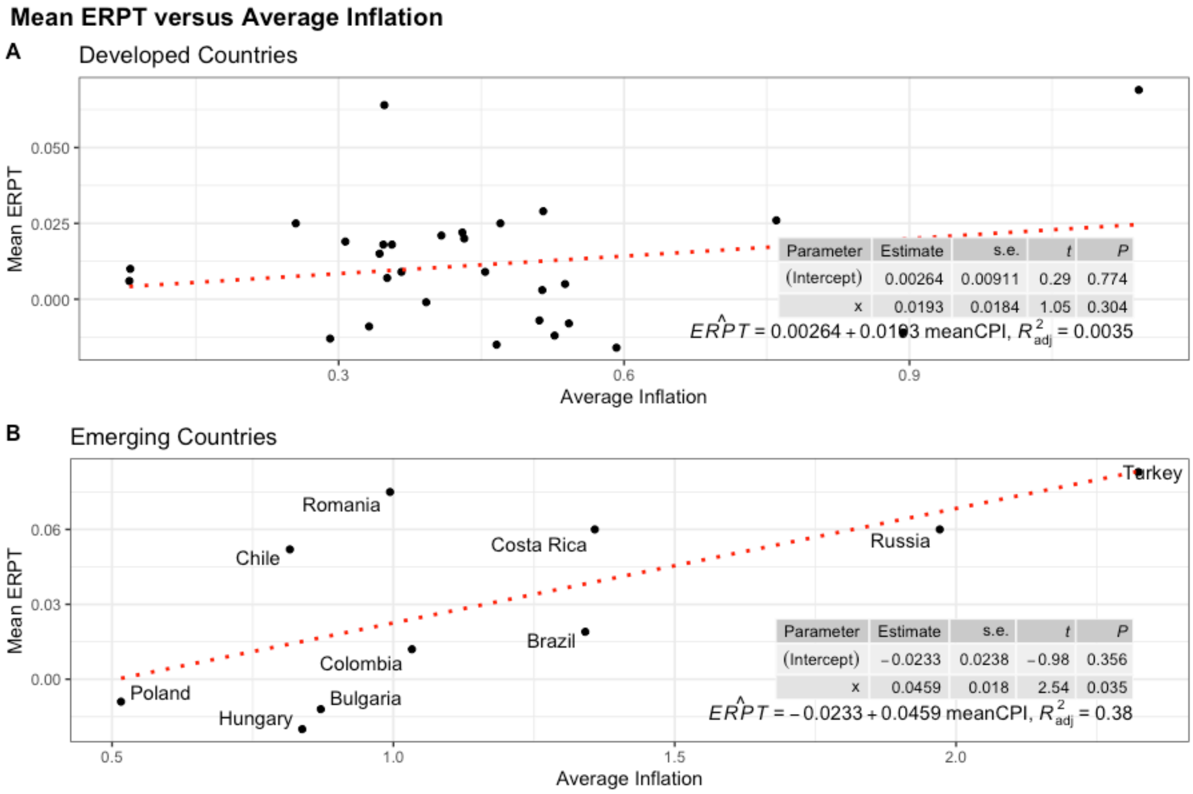


Figure 7: ERPT degrees vs. average inflation rates.

Lastly, to examine the association between ERPT and openness, we calculated the mean of openness measure for developed and emerging countries at each point in time[13]. Figure 8 depicts the scatterplots of mean ERPT and mean openness measure. As seen, there is no clear linkage for developed countries while there seems positive but weak relationship between the two for emerging economies. More specifically, the linkage appears to be positive for the mean value of openness less than 0.8 and turns into flat after that.

[13] The measure for openness is calculated as trade openness by exports plus imports over GDPs obtained from OECD database.

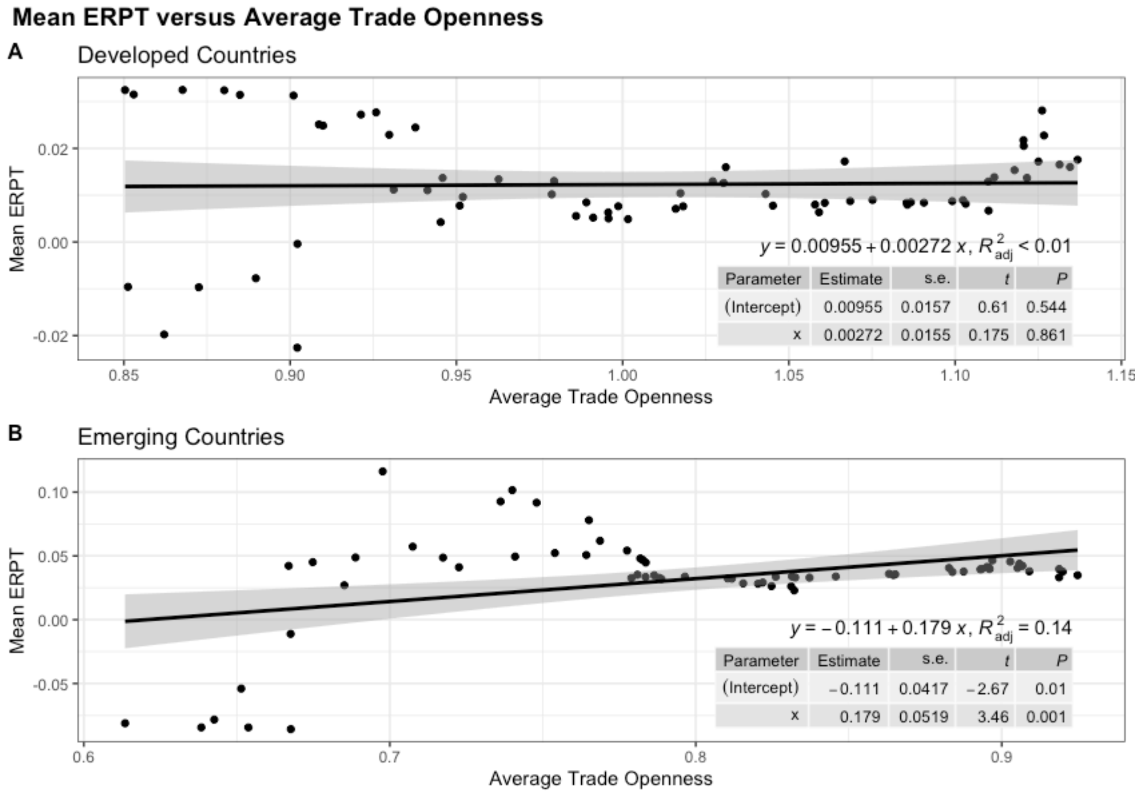


Figure 8: ERPT degrees vs. mean openness measure

2.6. CONCLUSION

Given a high ERPT degree might disturb price stability, monetary policy's effectiveness and credibility depend on the exchange rate pass-through. A high ERPT might require the implementation of major changes in monetary policies to buffer the adverse effects of price fluctuations. Global shocks transmitted through exchange rate fluctuations may result in a high ERPT, disrupting the inflation expectations and thus limiting the effectiveness of especially monetary policies. Therefore, a careful empirical investigation of ERPT is quite crucial. This paper studies the time-varying pattern of the association between exchange rate fluctuations and inflation by considering both model uncertainty and parameter uncertainty. To this end, we use "Dynamic Model Averaging, DMA" approach to compute ERPT coefficients.

DMA approach takes into account the parameter uncertainty and model uncertainty providing time-varying coefficients as well as posterior inclusion probabilities of regressors. Our study covers 39 countries, of which 29 are developed and 10 are emerging, over the periods of 1996:1-2021:3. We find that the ERPT degrees are time-varying, reinforcing the results of previous studies. Furthermore, ERPT degrees are lower for developed countries except for Israel and Iceland compared to those for emerging countries. More specifically, ERPT in emerging countries is twice as large as developed countries. Unlike developed countries, ERPT degrees present U-shaped pattern over the sample period in emerging economies, pointing to a rising concern for price instability in recent years. Moreover, the results show a change in the dynamics of ERPT degrees triggered by the global crisis in 2008-09. Although ERPT decreased substantially during the global crisis in many developed countries, it is short-lived and reversed after FED's tapering started in 2014. It is also worth mentioning that a noticeable increase in the ERPT degrees can be observed in recent years for developed countries as well, in contrast to previous evidence pointing out a declining tendency in ERPT degrees. Moreover, there appears to be no evidence of a significant long run ERPT for all countries except for Brazil and Turkey.

Since the ERPT exhibits time varying dynamics, we scrutinize the effects of average inflation, exchange rate volatility, and openness, as three major macroeconomic factors, on ERPT degrees. Openness seems affecting ERPT degrees positively for those countries with lower openness degree, but such linkage disappears for those countries reaching to a mean degree of openness greater than 0.8. While it appears that ERPT in emerging countries is unaffected by exchange rate volatility, two distinct patterns are detected in developed countries during just before the 2008 global crisis and afterwards. Before the global crisis the mean ERPT was high while exchange rate volatility was low, and vice versa in the post crisis period. The relationship between average inflation and the mean ERPT degrees is found to be positive in emerging countries, similar to most previous studies. This implies the importance of inflation for monetary stability goals, which should be taken into account by policymakers to avoid the adverse effects of ERPT. Due to the impact of the pandemic for the last two years, we observe a dramatic rise in global inflation rate, which also raises concerns over the increasing ERPT degrees not only for emerging markets but also for developed economies. Furthermore, there is an ongoing discussion about the extent of ERPT depending on invoicing currency (local currency or producer currency pricing or US dollar currency as a ‘dominant currency paradigm’. See for instances, Boz et al., 2017, Gopinath et al., 2020, Gopinath, 2015;). While the present study considers US dollar currency based on dominant currency paradigm, it might also be interesting to investigate if ERPT may vary systematically with the weights of trading partners in effective exchange rates. We leave this for future work within DMA framework.

CONCLUDING REMARKS

The ERPT phenomenon is a popular topic in macroeconomics due to increasing globalization, making countries more vulnerable to external shocks. After implementing floating exchange rate regimes, monetary authorities closely monitor the pass-through to domestic prices. Low ERPT degree gives the flexibility to implement efficient monetary policies. Thus, the empirical examination of ERPT is quite pivotal for the monetary authorities. Taylor (2000) suggests that the low (high) ERPT degree is related to low (high) inflation environment where monetary shocks are presumably perceived as temporary (permanent). Although several studies previously investigated Taylor's hypothesis, the first chapter of this study utilizes "the panel quantile regression, PQR" technique to directly re-examine Taylor's hypothesis in a single step. The quarterly time series data spanning 1996-2018 for 37 countries are used to estimate panel quantile regression coefficients. The results support Taylor's hypothesis. The degree of ERPT is smaller at lower quantiles of the inflation rate but increases along with the higher quantiles. This result highlights the importance of keeping a low inflation environment so that the prices may be less affected by external shocks. In other words, establishing a credible monetary policy might lead to lower ERPT by reducing the effect of exchange rate movements in a low-inflation environment.

The second chapter of this study investigates time-varying behavior of ERPT degree. For this pupose, DMA approach is employed, which addresses both the model and parameter uncertainty over time. The empirical strategies of the exisiting studies focusing on time varying ERPT fail to take into account of these uncertainties which might influence the extent of ERPT. The study contains 39 countries, among them 29 are developed, and 10 are emerging. The quarterly data cover the periods of 1996:1-2021:3. The posterior inclusion probabilities, as well as time-varying coefficients for all countries, are obtained. Posterior probabilities provide information related to model sparsity. Sparsity is evident in the model. Lags of oil prices are not supported to include the model for all countries. The inertia, together with the seasonal pattern in inflation, is significant. The results show the ERPT degree is lower for developed countries except for Israel and Iceland compared to those for emerging countries. The other fact is that emerging countries have the Ushape ERPT over time, which raises concern for the stability of prices in recent years. The results demonstrated that the dynamics of ERPT changed by 2008-09 crisis. Also, FED's tapering in 2014 appears to reverse the decreasing tendency of ERPT for both developed and emerging countries, unlike the previous studies reported. Furthermore, results do not support the existence of long-run ERPT except for Brazil and Turkey.

Three prominent macroeconomic factors that might affect ERPT degree, namely openness, average inflation, and exchange rate volatility, are investigated. Firstly, ERPT and volatility of exchange rate have no clear linkage between them for emerging countries. In comparison, the model reveals two clusters of linkage behavior for developed countries. These clusters appeared around 2008. The mean ERPT is low, and the exchange rate volatility is high right after the global financial crisis. The phenomenon is reversed right before the crisis. Secondly, the average inflation and the mean ERPT show no clear relationship for developed countries, while there is a positive relationship for emerging countries. Developed countries had lower inflation until the global pandemic. Since inflation started to increase after the pandemic, developed countries exhibited increasing ERPT. Lastly, the linkage between the degree of openness and the ERPT degree is ambiguous. However, there is a weak but positive relationship between openness and ERPT degree for emerging countries.

In open economies, the exchange rate can affect monetary policy in two ways since it acts as a transmission channel. First, monetary policy must respond to nominal exchange rate shocks to ensure price stability, as these shocks contribute to inflation fluctuations. Therefore, implementing monetary policy in open economies requires an understanding of the magnitude of exchange rate shocks transmitted to inflation. Second, by controlling the exchange rate, monetary authorities may control inflation, so investigating ERPT is crucial for them. Therefore, our findings have clear policy implications.

As a first one, results support previous findings of Taylor's hypothesis. The scale of ERPT appears to be significantly increased in an inflationary environment. A monetary policy designed to achieve a low inflation regime should consider reducing the impact of exchange rate shocks on domestic prices. The exchange rate fluctuations caused by global shocks may affect inflation expectations under high ERPT degrees, limiting monetary policy efficacy. In order to increase monetary credibility, stronger institutional infrastructure should be established, which in turn helps reduce the effect of exchange rate movements on future cost expectations. As a result, a low inflation environment and low ERPT may be achieved.

As a second one, the time-varying behavior of ERPT is reinforced by our findings. The 2008-09 global crisis seems to be triggering the change in the dynamics of the time-varying ERPT degrees. Estimated ERPT degrees are quite low for emerging countries during the crisis. Low ERPT may help authorities to establish more flexible monetary policies to overcome the effects of the crisis. Also, we have seen a sharp increase in worldwide inflation rates due to the pandemic's effects over the past two years, which raises concerns about the rising ERPT degrees for both developed and emerging economies. This result indicates that the authorities should consider implementing policies to prevent the adverse effects of ERPT for monetary stability objectives.

Despite the fact that this dissertation has both strengthened and enhanced the related empirical literature, it can be extended in several directions. For instances, there is a continuous debate regarding the invoicing currency (LCP, PCP, or the dominant currency paradigm) and ERPT. In this work, the US Dollar currency is used, and hence, the dominant currency paradigm is followed. While, according to the dominant currency paradigm, the US dollar significantly influences the exchange rates used in international trade, it could also be interesting to look into ERPT considering effective exchange rate which depends on the weights of the currencies of trading partners. Further, additional control variables can also be used to limit the possible bias in ERPT estimations. These discussions are left for future work.

APPENDİX

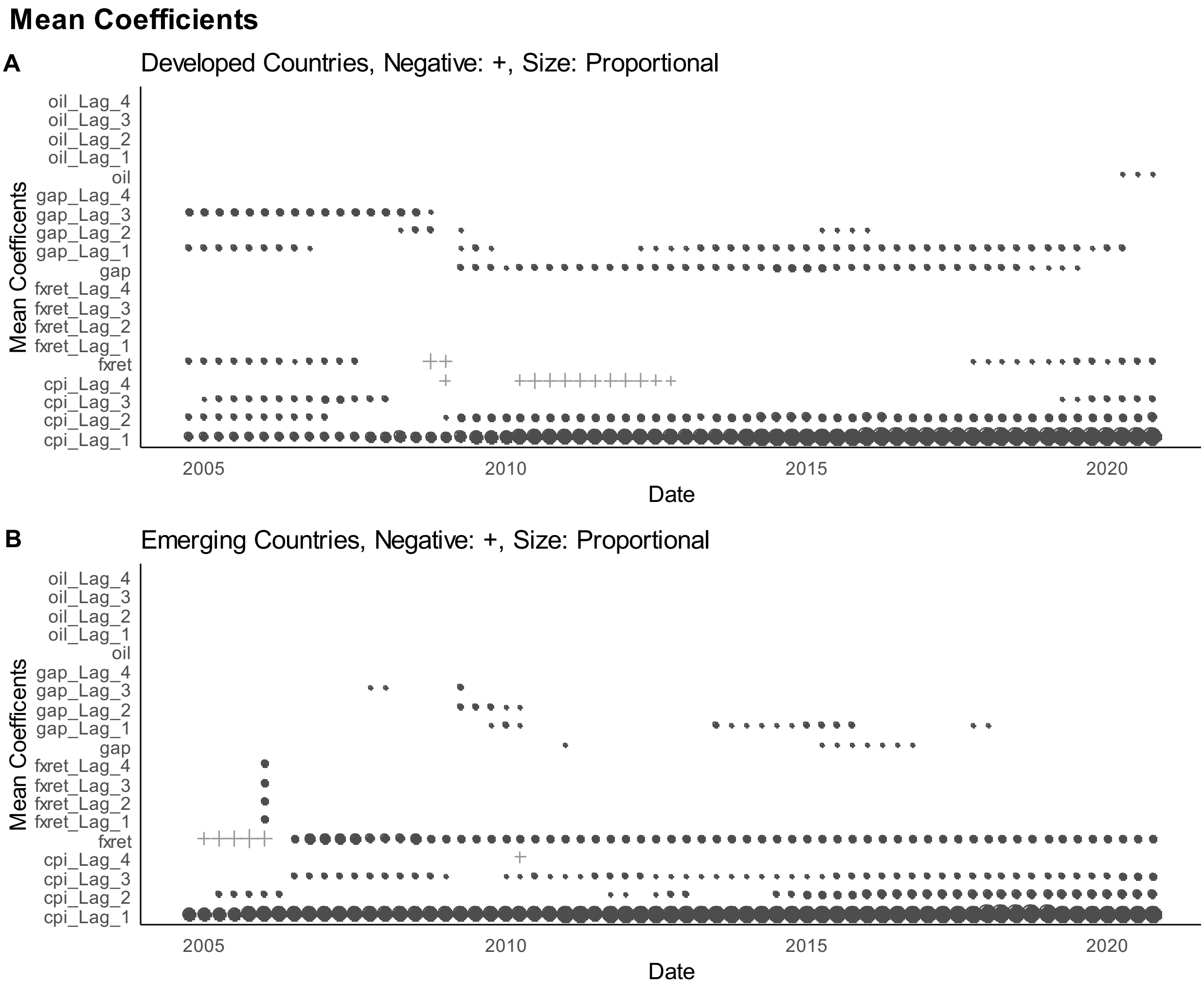
A. Mean and Standard Deviation of Variables

	Exchange Rate (%)		CPI (%)		GAP (%)	
Developed Contr.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Australia	0.028	5.144	0.581	0.573	-0.001	0.953
Austria	0.120	3.992	0.459	0.448	-0.004	1.849
Belgium	0.123	3.991	0.465	0.467	-0.002	1.609
Canada	-0.080	3.367	0.473	0.552	-0.005	1.581
Czechia	-0.221	5.041	0.767	1.023	-0.026	2.103
Denmark	0.103	3.985	0.424	0.449	-0.007	1.476
Estonia	0.120	3.987	1.017	1.287	-0.054	3.970
Finland	0.105	3.994	0.358	0.446	-0.011	1.914
France	0.098	3.974	0.334	0.409	-0.003	1.992
Germany	0.120	3.991	0.372	0.468	-0.004	1.832
Greece	0.176	4.062	0.541	1.471	-0.073	2.890
Iceland	0.636	6.153	1.043	0.982	-0.041	3.328
Ireland	0.053	3.928	0.444	0.815	-0.069	3.453
Israel	0.037	3.273	0.570	1.085	-0.005	1.880
Italy	0.042	3.943	0.426	0.377	-0.007	2.143
Japan	0.039	4.230	0.041	0.527	-0.006	1.585
Latvia	0.433	4.709	0.984	1.360	-0.088	4.341
Luxembourg	0.123	3.991	0.458	0.498	-0.008	2.111
Netherlands	0.126	3.991	0.476	0.524	-0.009	1.597
New Zealand	-0.041	5.158	0.512	0.520	-0.006	1.512
Norway	0.305	4.667	0.533	0.623	-0.003	1.232
Portugal	0.108	3.980	0.468	0.797	-0.015	2.237
Slovakia	-0.157	4.250	0.977	1.302	-0.021	2.408
Slovenia	0.426	4.065	0.893	1.161	-0.023	2.352
South Korea	0.384	5.994	0.655	0.729	-0.002	1.957
Spain	0.129	3.985	0.514	0.973	-0.023	2.478
Sweden	0.239	4.596	0.287	0.553	-0.005	1.714
Switzerland	-0.255	3.764	0.115	0.546	-0.003	1.329
United Kingdom	0.104	3.690	0.497	0.441	-0.011	2.337
Emerging Contr.						
Brazil	1.641	7.958	1.539	0.951	-0.013	1.886
Bulgaria	3.036	18.119	6.679	38.942	-0.060	2.777
Chile	0.620	4.645	0.859	0.747	-0.007	2.361
Colombia	1.294	5.414	1.600	1.519	-0.008	2.521
Costa Rica	1.119	1.886	1.754	1.325	-0.005	1.738
Hungary	0.719	5.190	1.437	1.538	-0.021	2.077

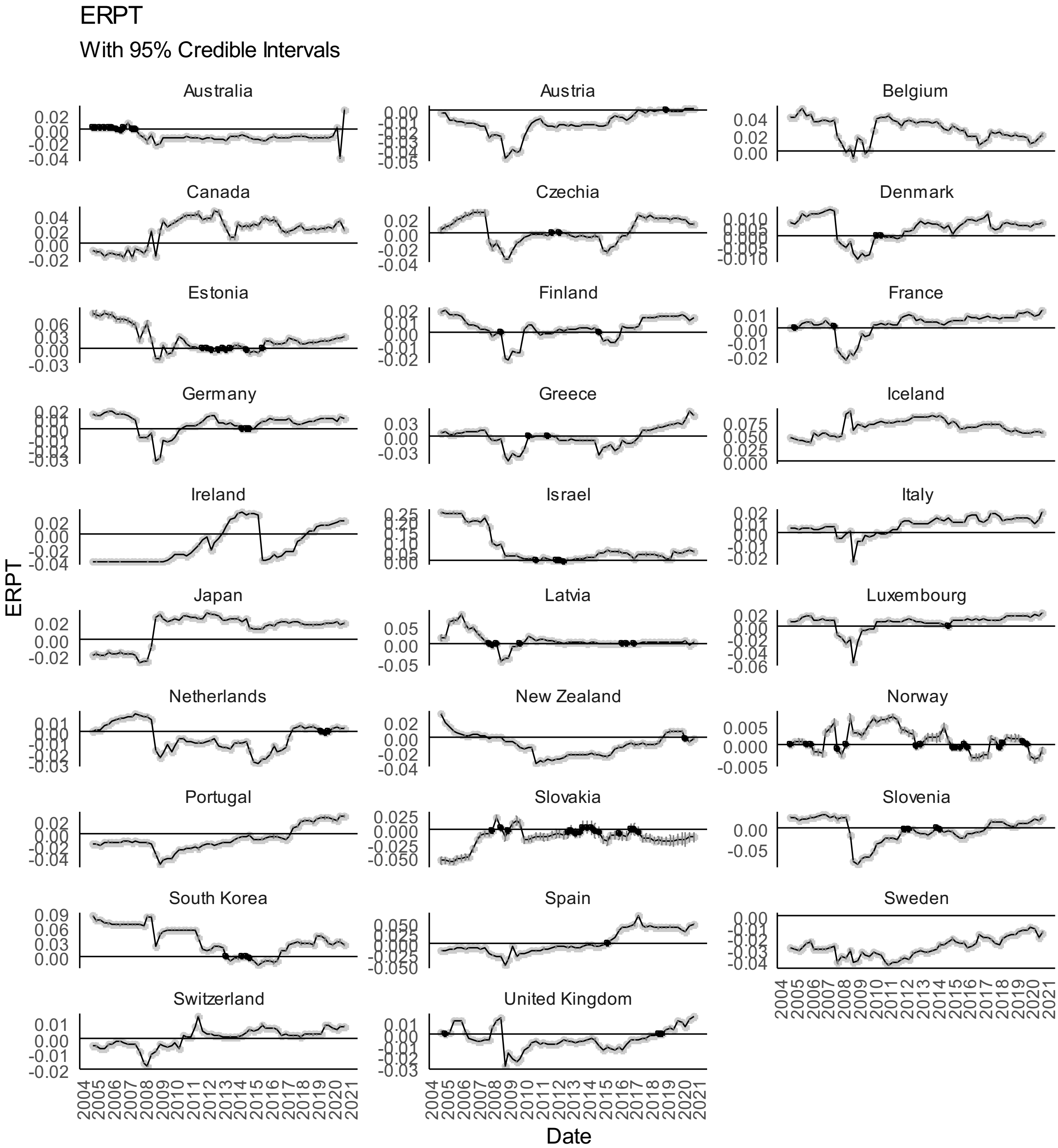
Poland	0.412	5.487	1.007	1.332	-0.006	1.650
Romania	2.667	8.052	3.983	7.193	-0.052	2.668
Russia	2.683	9.842	3.284	4.761	-0.019	2.421
Turkey	4.791	8.399	5.407	5.570	-0.030	3.554
Oil	Mean: 1.248	St. Dev: 16.407				

B. The histogram of expected size of models

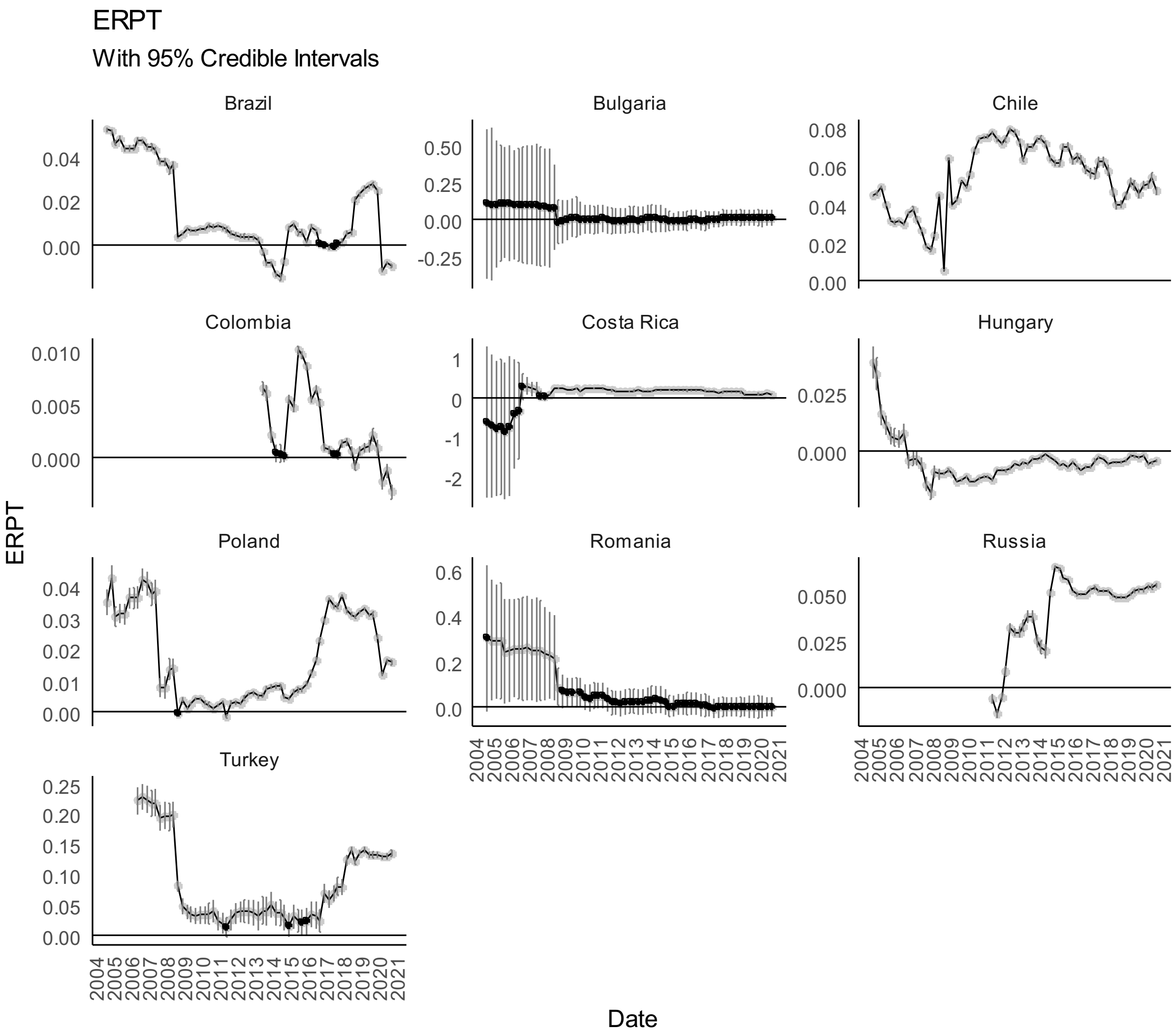
C. The inclusion of regressors into model



D. Quarterly time-varying ERPT coefficients of Developed Countries



E. Quarterly time-varying ERPT coefficients of Emerging Countries



BIBLIOGRAPHY

Al-Abri, A. S., & Goodwin, B. K. (2009). Re-examining the exchange rate pass-through into import prices using non-linear estimation techniques: Threshold cointegration. *International Review of Economics & Finance*, *18*(1), 142-161.

Arize, A. C., Osang, T., & Slottje, D. J. (2000). Exchange-rate volatility and foreign trade: evidence from thirteen LDC's. *Journal of Business & Economic Statistics*, *18*(1), 10-17.

Baharumshah, A. Z., Soon, S. V., & Wohar, M. E. (2017). Markov-switching analysis of exchange rate pass-through: Perspective from Asian countries. *International Review of Economics & Finance*, *51*, 245-257.

Barhoumi, K. (2006). Differences in long run exchange rate pass-through into import prices in developing countries: An empirical investigation. *Economic Modelling*, *23*(6), 926-951.

Baur, D. G., Beckmann, J., & Czudaj, R. (2014). Gold Price Forecasts in a Dynamic Model Averaging Framework–Have the Determinants Changed Over Time?. *Ruhr Economic Paper*, (506).

Beckmann, J., & Schüssler, R. (2016). Forecasting exchange rates under parameter and model uncertainty. *Journal of International Money and Finance*, *60*, 267-288.

Betts, C., & Devereux, M. B. (1996). The exchange rate in a model of pricing-to-market. *European Economic Review*, *40*(3-5), 1007-1021.

Betts, C., & Devereux, M. B. (2000). Exchange rate dynamics in a model of pricing-to-market. *Journal of international Economics*, *50*(1), 215-244.

Bouakez, H., & Rebei, N. (2008). Has exchange rate pass-through really declined? Evidence from Canada. *Journal of International Economics*, *75*(2), 249-267.

Boz, E., Gopinath, G., & Plagborg-Møller, M. (2017). *Global trade and the dollar* (No. w23988). National Bureau of Economic Research.

Brun-Aguerre, R., Fuertes, A. M., & Phylaktis, K. (2012). Exchange rate pass-through into import prices revisited: what drives it?. *Journal of international Money and Finance*, *31*(4), 818-844.

Bruyn, R.D., Gupta, R., & Van Eyden, R. (2015). Can We Beat the Random-Walk Model for the South African Rand–US Dollar and South African Rand–UK Pound Exchange Rates? Evidence from Dynamic Model Averaging. *Emerging Markets Finance and Trade*, *51*(3), 502-524.

Ca'Zorzi, M., Hahn, E., & Sánchez, M. (2007). Exchange rate pass-through in emerging markets. *EBC Working paper 739/March 2007.*

Calvo, G. A., & Reinhart, C. M. (2000). Fixing for your life (No. w8006). *National Bureau of Economic Research.*

Campa, J. M., & Goldberg, L. S. (2005). Exchange rate pass-through into import prices. *Review of Economics and Statistics*, *87*(4), 679-690.

Catania, L., & Nonejad, N. (2018). Dynamic model averaging for practitioners in economics and finance: The eDMA package. *Journal of Statistical Software 84,1-39*

Chou, K. W. (2019). Re-examining the time-varying nature and determinants of exchange rate pass-through into import prices. *The North American Journal of Economics and Finance*, *49*, 331-351.

Choudhri, E. U., & Hakura, D. S. (2006). Exchange rate pass-through to domestic prices: does the inflationary environment matter?. *Journal of international Money and Finance*, *25*(4), 614-639.

Choudhri, E. U., & Hakura, D. S. (2015). The exchange rate pass-through to import and export prices: The role of nominal rigidities and currency choice. *Journal of International Money and Finance*, *51*, 1-25.

Coricelli, F., Jazbec, B., & Masten, I. (2006). Exchange rate pass-through in EMU acceding countries: Empirical analysis and policy implications. *Journal of Banking & Finance*, *30*(5), 1375-1391.

Correa, A. D. S., & Minella, A. (2010). Nonlinear mechanisms of the exchange rate pass-through: A Phillips curve model with threshold for Brazil. *Revista Brasileira de Economia*, *64*, 231-243.

Corsetti, G., Dedola, L., & Leduc, S. (2008). High exchange-rate volatility and low pass-through. *Journal of Monetary Economics*, *55*(6), 1113-1128.

Davino, C., Furno, M., & Vistocco, D. (2013). *Quantile regression: theory and applications* (Vol. 988). John Wiley & Sons.

Dedeoglu, D., & Kaya, H. (2015). Model Belirsizligi Altinda Döviz Kurunun Enflasyona Etkisi. *Central Bank Review*, *15*(2), 79.

Delatte, A. L., & López-Villavicencio, A. (2012). Asymmetric exchange rate pass-through: Evidence from major countries. *Journal of Macroeconomics*, *34*(3), 833-844.

Devereux, M. B., & Engel, C. (2001). Endogenous currency of price setting in a dynamic open economy model. *NBER working paper no.* 8559 (2001)

Devereux, M. B., & Yetman, J. (2010). Price adjustment and exchange rate pass-through. *Journal of International Money and Finance*, *29*(1), 181-200.

Dornbusch, R. (1987), "Exchange Rates and Prices", American Economic Review, 77(1), March 1987, pp. 93-106.

Drachal, K. (2020). Forecasting the Inflation Rate in Poland and US Using Dynamic Model Averaging (DMA) and Google Queries. *Romanian Journal of Economic Forecasting*, *23*(2), 18.

Eckstein, Z., & Soffer, Y. (2008, January). Exchange rate pass-through implications for monetary policy: the Israeli case. *BIS Papers, no 35, Bank for International Settlements*.

Filippo, G. D.(2015). Dynamic model averaging and CPI inflation forecasts: A comparison between the Euro area and the United States. *Journal of Forecasting*, *34*(8), 619-648.

Fleer, R., Rudolf, B., & Zurlinden, M. (2016). Price change dispersion and time-varying pass-through to consumer prices (No. 2016-17). *Swiss National Bank.*

Forbes, K. J., Hjortsoe, I., & Nenova, T. (2017). Shocks versus structure: explaining differences in exchange rate pass-through across countries and time. *External MPC Unit of the Bank of England,Discussion paper n.50.*

Forbes, K., Hjortsoe, I., & Nenova, T. (2018). The shocks matter: improving our estimates of exchange rate pass-through. *Journal of international economics*, *114*, 255-275.

Frankel, J., Parsley, D., & Wei, S. J. (2012). Slow pass-through around the world: a new import for developing countries?. *Open Economies Review*, *23*(2), 213-251

Froot, K. A., & Klemperer, P. D. (1989). Exchange rate pass-through when market share matters. *The American Economic Review* , Sep., 1989, Vol. 79, No. 4 (Sep., 1989), pp. 637- 654

Gagnon, J. E., & Ihrig, J. (2004). Monetary policy and exchange rate pass-through. *International Journal of Finance & Economics*, *9*(4), 315-338.

Galvao, A. F., and Montes-Rojas, G. V. (2010). Penalized quantile regression for dynamic panel data. *Journal of Statistical Planning and Inference*, *140*(11), 3476–3497.

Ghosh, A. (2013). Exchange rate pass through, macro fundamentals and regime choice in Latin America. *Journal of Macroeconomics*, *35*, 163-171.

Ghosh, A., & Rajan, R. S. (2007). A Selective Survey of Exchange Rate Pass-Through in Asia: What Does the Literature Tell Us?. *Asian Pasific Economic Literature, 21(2),* 1-37.

Ghosh, A., & Rajan, R. S. (2009a). What is the extent of exchange rate pass-through in Singapore? Has it changed over time?. *Journal of the Asia Pacific Economy*, *14*(1), 61-72.

Ghosh, A., & Rajan, R. S. (2009b). Exchange rate pass-through in Korea and Thailand: Trends and determinants. *Japan and the World Economy*, *21*(1), 55-70.

Goldberg, P. K., & Knetter, M. M. (1997). Goods prices and exchange rates: what have we learned?*.Journal of Economic Literature, 35(3),* 1243-1272.

Goldfajn, I., & Werlang, S. R. D. C. (2000). The Pass-Through from Depreciation to Inflation: A Panel Study *(July 2000). Banco Central de Brasil Working Paper*, (5).

Gopinath, G. (2015). The international price system *(No. w21646). National Bureau of Economic Research.*

Gopinath, G., Boz, E., Casas, C., Díez, F. J., Gourinchas, P. O., & Plagborg-Møller, M. (2020). Dominant currency paradigm. *American Economic Review*, *110*(3), 677-719.

Gust, C., Leduc, S., & Vigfusson, R. (2010). Trade integration, competition, and the decline in exchange-rate pass-through. *Journal of Monetary Economics*, *57*(3), 309-324.

Hamilton, J.D. (1994). State-Space Models. *Handbooks of Econometrics,* vol 4 (Chapter 50, pp 3014-3077).

Hara, N., Hiraki, K., & Ichise, Y. (2015). Changing exchange rate pass-through in Japan: does it indicate changing pricing behavior? (No. 15-E-4). *Tokyo, Japan: Bank of Japan.*

Herzberg, V., Kapetanios, G., & Price, S. (2003). Import prices and exchange rate pass-through: theory and evidence from the United Kingdom. *Bank of England working paper no.182.*

Hodrick, R. J., & Prescott, E. C. (1997). Postwar US business cycles: an empirical investigation. *Journal of Money, credit, and Banking*, 1-16.

Holmes, M. J. (2009). The response of exchange rate pass-through to the macroeconomic environment. *The Open Business Journal*, *2*(1).

Hwang, Y. (2019). Forecasting recessions with time-varying models. *Journal of Macroeconomics*, *62*, 103153.

Ito, T., & Sato, K. (2007). Exchange rate pass-through and domestic inflation: A comparison between East Asia and Latin American countries. *Research institute of Economy, Trade and Industry, RIETI Discussion Papers*, *7040*.

Jasova, M., Moessner, R., & Takáts, E. (2019). Exchange rate pass-through: What has changed since the crisis?. *Internatonal Central Banking.* Vol15 (3). 27-58, September.

Jiang, J., & Kim, D. (2013). Exchange rate pass-through to inflation in China. *Economic Modelling*, *33*, 900-912.

Jimborean, R. (2013). The exchange rate pass-through in the new EU member states. *Economic Systems*, *37*(2), 302-329

Jiménez-Rodríguez, R., & Morales-Zumaquero, A. (2016). A new look at exchange rate pass-through in the G-7 countries. *Journal of Policy Modeling*, *38*(5), 985-1000.

Jooste, C., & Jhaveri, Y. (2014). The Determinants of Time-Varying Exchange Rate Pass-Through in South Africa. *South African Journal of Economics*, *82*(4), 603-615.

Judson, R. A., & Owen, A. L. (1999). Estimating dynamic panel data models: a guide for macroeconomists. *Economics letters*, *65*(1), 9-15.

Junttila, J., & Korhonen, M. (2012). The role of inflation regime in the exchange rate pass-through to import prices. *International Review of Economics & Finance*, *24*, 88-96.

Kassi, D. F., Sun, G., Ding, N., Rathnayake, D. N., & Assamoi, G. R. (2019). Asymmetry in exchange rate pass-through to consumer prices: Evidence from emerging and developing Asian countries. *Economic Analysis and Policy*, *62*, 357-372.

Kilic, R. (2016). Regime-dependent exchange-rate pass-through to import prices. *International Review of Economics & Finance*, *41*, 295-308.

Kim, C.J. and Nelson C.R (1999) State Space models with regime switching classical and Gibbs sampling approaches with applications. *Cambridge, MA: MIT.*

Knetter, M. (1993), "International Comparisons of Pricing-to-Market Behaviour", American Economic Review, 83(3), pp. 473-486.

Koenker, R. (2004). Quantile regression for longitudinal data. *Journal of Multivariate Analysis*, *91*(1), 74-89.

Koenker, R., & Bassett Jr, G. (1978). Regression quantiles. *Econometrica: journal of the Econometric Society*, 33-50.

Koop, G., & Korobilis, D. (2011). UK macroeconomic forecasting with many predictors: Which models forecast best and when do they do so?. *Economic Modelling*, *28*(5), 2307-2318.

Koop, G., & Korobilis, D. (2012). Forecasting inflation using dynamic model averaging. *International Economic Review*, *53*(3), 867-886.

Krugman, P. R. (1987). Pricing to market when the exchange rate changes. Arndt, Sven W. and J. David Richardson (eds.) *Real-financial linkages among open economies*. Cambridge, MA and London: MIT Press, 49-70.

Lane, P. R. (2001). The new open economy macroeconomics: a survey. *Journal of international economics*, *54*(2), 235-266.

Mann, C. L. (1986). Prices, profit margins, and exchange rates. *Fed. Res. Bull.*, *72*, 366.

Marazzi, M., Sheets, N., Vigfusson, R. J., Faust, J., Gagnon, J. E., Marquez, J., ... & Rogers, J. H. (2005). Exchange rate pass-through to US import prices: some new evidence. *International Discussion Paper No.833,2005*

María-Dolores, R. (2009). Exchange Rate Pass-Through in Central and East European Countries: Do Inflation and Openness Matter?. *Eastern European Economics*, *47*(4), 42-61.

McCarthy, J. (2007). Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies. *Eastern Economic Journal*, *33*(4), 511-537.

Nogueira Junior, R.P., León-Ledesma, M.A & Pinheiro, F. J. (2010). Is low inflation really causing the decline in exchange rate pass-through?. *University of Kent School of Economics Discussion Paper*. KDPE 1002.

Nogueira Junior, R. P., & León-Ledesma, M. A. (2011). Does exchange rate pass-through respond to measures of macroeconomic instability?. *Journal of Applied Economics*, *14*(1), 167-180.

Nonejad, N. (2021). An overview of Dynamic Model Averaging techniques in time-series econometrics. *Journal of Economic Surveys*, *35*(2), 566-614.

Obstfeld, M., Rogoff, K. (1996). *Journal of Political Economy*, Vol. 103, No. 3 (Jun., 1995), pp. 624-660.

Olivei, G. P. (2002). Exchange rates and the prices of manufacturing products imported into the United States. *New England Economic Review*, 3-18.

Otani, A., Shiratsuka, S., & Shirota, T. (2003). The decline in the exchange rate pass-through: evidence from Japanese import prices. *Institute for Monetary and Economic Studies, Bank of Japan*, 21(3),53-81.

Ozkan, I., & Erden, L. (2015). Time-varying nature and macroeconomic determinants of exchange rate pass-through. *International Review of Economics & Finance*, *38*, 56-66.

Phuc, N. V., & Duc, V. H. (2021). Macroeconomics determinants of exchange rate pass-through: new evidence from the Asia-Pacific region. *Emerging Markets Finance and Trade*, *57*(1), 5-20.

Raftery, A. E., Kárný, M., & Ettler, P. (2010). Online prediction under model uncertainty via dynamic model averaging: Application to a cold rolling mill. *Technometrics*, *52*(1), 52-66.

Riskmetrics (1996). Technical Document- Fourth Edition. Available at: https://www.msci.com/documents/10199/5915b101-4206-4ba0-aee2-3449d5c7e95a . Accessed 22 May 2022.

Salisu, A. A., & Isah, K. O. (2018). Predicting US inflation: Evidence from a new approach. *Economic Modelling*, *71*, 134-158.

Sax, C., & Eddelbuettel, D. (2018). Seasonal adjustment by x-13arima-seats in r. *Journal of Statistical Software*, *87*, 1-17.

Sekine, T. (2006). Time-varying exchange rate pass-through: experiences of some industrial countries. *BIS Working Paper 202. Basel, Switzerland: Bank for International Settlements, March*

Shambaugh, J. (2008). A new look at pass-through. *Journal of International Money and Finance*, *27*(4), 560-591.

Shintani, M., Terada-Hagiwara, A., & Yabu, T. (2013). Exchange rate pass-through and inflation: A nonlinear time series analysis. *Journal of international Money and Finance*, *32*, 512-527.

Soto, C., & Selaive, J. (2003). Openness and imperfect pass-through: implications for the monetary policy. *Documentos de Trabajo (Banco Central de Chile)*, (216), 1-40.

Stulz, J. (2007). Exchange rate pass-through in Switzerland: Evidence from vector autoregressions. *Swiss National Bank Economic Studies*, (4).

Takhtamanova, Y. F. (2010). Understanding changes in exchange rate pass-through. *Journal of Macroeconomics*, *32*(4), 1118-1130.

Taylor, J. B. (2000). Low inflation, pass-through, and the pricing power of firms. *European economic review*, *44*(7), 1389-1408.

Vo, A.T., & Ho, C. M., & Vo, D. H. (2020). Understanding the exchange rate pass-through to consumer prices in Vietnam: the SVAR approach. *International Journal of Emerging Markets*, *15*(5), 971-989.

Yanamandra, V. (2015). Exchange rate changes and inflation in India: What is the extent of exchange rate pass-through to imports?. *Economic Analysis and policy*, *47*, 57-68.

Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression. *Economic Modelling*, *58*, 237-248.

ETHICS COMMISSION FORM FOR THESIS

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS

Date: 04/01/2023

Thesis Title: Essays on Exchange Rate Pass-Through

My thesis work related to the title above:

1. Does not perform experimentation on animals or people.
2. Does not necessitate the use of biological material (blood, urine, biological fluids and samples, etc.).
3. Does not involve any interference of the body's integrity.
4. Is not based on observational and descriptive research (survey, interview, measures/scales, data scanning, system-model development).

I declare, I have carefully read Hacettepe University's Ethics Regulations and the Commission's Guidelines, and in order to proceed with my thesis according to these regulations I do not have to get permission from the Ethics Board/Commission for anything; in any infringement of the regulations I accept all legal responsibility and I declare that all the information I have provided is true.

I respectfully submit this for approval.

04/01/2023

Name Surname:	Yasemin Çolak
Student No:	N17247264
Department:	Economics
Program:	Economics (English)
Status:	☐ MA ☒ Ph.D. ☐ Combined MA/ Ph.D.

ADVISER COMMENTS AND APPROVAL

Prof. Dr. Lütfi Erden

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
Ph.D. DISSERTATION ORIGINALITY REPORT

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS

Date: 04/01/2023

Thesis Title : Essays on Exchange Rate Pass-Through

According to the originality report obtained by myself/my thesis advisor by using the Turnitin plagiarism detection software and by applying the filtering options checked below on 04/01/2022 for the total of 72 pages including the a) Title Page, b) Introduction, c) Main Chapters, and d) Conclusion sections of my thesis entitled as above, the similarity index of my thesis is 9 %.

Filtering options applied:

1. ☒ Approval and Decleration sections excluded
2. ☒ Bibliography/Works Cited excluded
3. ☒ Quotes excluded
4. ☐ Quotes included
5. ☒ Match size up to 5 words excluded

I declare that I have carefully read Hacettepe University Graduate School of Social Sciences Guidelines for Obtaining and Using Thesis Originality Reports; that according to the maximum similarity index values specified in the Guidelines, my thesis does not include any form of plagiarism; that in any future detection of possible infringement of the regulations I accept all legal responsibility; and that all the information I have provided is correct to the best of my knowledge.

I respectfully submit this for approval.

04/01/2023

Name Surname:	Yasemin Çolak
Student No:	N17247264
Department:	Economics
Program:	Economics (English)
Status:	☒ Ph.D. ☐ Combined MA/ Ph.D.

ADVISOR APPROVAL

APPROVED.

Prof. Dr. Lütfi Erden