Assessing the Impact of Exchange Rate Pass-Through on the U.S. Dollar

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1 Introduction

Since the late 1990's, the increasing current account deficit has been regarded as cause for concern. Whether the cause is the increased use of the dollar as an international reserve currency or the perceived safety of U.S. assets, the increasingly negative current account is inevitably related to the accumulation of liabilities to the rest of the world. If we accept the logic that this accumulation of liabilities to the rest of the world is a problem, it is sensible to find a solution to the issue of a growing current account. One channel through which a reduction in the current account deficit may reasonably be achieved is through a real deprecation of the dollar. Howard (1989) claims that a switch in world expenditures can reasonably be engendered through a real deprecation of the dollar wherein there is a bias toward U.S. products and a subsequent increase in import prices. Mechanically, one might assume that a real depreciation of the dollar against a basket of weighted foreign currencies would lead to an increase in U.S. import prices, driving down the volume of U.S. imports and ultimately increasing the current account.

There is a significant caveat that must be addressed regarding the efficacy of this channel for achieving the desired effect on the current account—to what extent is a real depreciation (appreciation) of the U.S. dollar "passed through" to import prices? The mechanics above assume a pass-through coefficient of 1: a real depreciation of the U.S. dollar brings about a corresponding increase in import prices of equal magnitude to the change in the dollar value. If the pass-through coefficient is not equal to 1, an empirically sound assumption, then how large of an exchange rate change is needed to bring about the desired reduction in import prices and, by extension, the desired reduction in the current account deficit? Further, if the pass-through coefficient is not equal to 1, what value does it take when estimated, and how has it evolved over time? This analysis seeks to address these questions.

Hooper and Mann (1989) suggest that "movements in the exchange rate of the dollar widely perceived to have less impact on U.S. import prices than they had at the beginning of this decade... a depreciation of the dollar may be less effective in bringing about adjustment in the real external balance" (p. 297). There are many narratives one can postulate to explain why pass-through may be declining. While a detailed discussion of these narratives is beyond the scope of this analysis, they broadly center around the role of exchange rates in the intermediary stages of pricing imports. Regardless of the narrative one accepts to explain a possible decline, I seek to evaluate, empirically, the extent to which this supposition of Hooper and Mann is valid.

The work of Gruber, McCallum, and Vigfusson (2016) provides an effective starting point for this analysis to the extent this issue has been addressed in existing literature. In "The Dollar in the U.S. International Transactions (USIT) Model," and its accompanying dataset, the authors construct sound measures of key variables for exploring the magnitude of and decline of exchange-rate pass through related to the U.S. dollar. Notably, they provide a reasonable qualification of a weighted real dollar exchange rate which encapsulates a broad measure of foreign currencies, which addresses issues that may arise when evaluating the relationship solely with bilateral exchange rates. Using a log-linear specification for modeling the relationship between U.S. non-oil import prices and the real exchange rate of the weighted foreign currencies to the U.S. dollar (discussed in greater detail below), the authors find that a 10% appreciation of the dollar corresponds to a 3% decline in the level of import prices. If we accept the results of this analysis, the rationale of Hooper and Mann (1989) seems reasonable, and the pass-through coefficient for the U.S. real exchange rate is far from 1.

In this analysis, I will utilize counterpart data from the Gruber, McCallum, and Vigfusson (2016) to assess the magnitude of exchange-rate pass-through with respect to the U.S. dollar. I attempt to replicate the results of their analysis, and subsequently expand the analysis to better parse out the behavior of the pass-through coefficient over time to determine to what extent the coefficient has declined in line with the work of Ihrig et al. (2006) and Hooper and Mann (1989). Further, recognizing key limitations of the log-linear specification in these analyses for measuring the evolution of the pass-through coefficient over time, I adopt a flexible linear specification which allows for changes to the pass-through coefficient over time by design. Consequently, this constructs a series of import price elasticities (with respect to the exchange rate) for the data sample. Taken together, I hope to empirically evaluate the decline of pass-through in the U.S.

2 Data & Methodology

To assess whether exchange rate pass-through has declined in the United States, I invoke two different specifications: the first, a log-linear specification based on the work of Ihrig et al. (2006) and Gruber, McCallum and Vigfusson (2016), and the second, a linear model. The use of both specifications allows us to explore this relationship to the extent it has been addressed in the literature with the log-linear model, and correct for weaknesses in the existing literature surrounding this specification by utilizing the more flexible linear model. The first log-linear regression model is postulated as follows

$$\Delta lnP^{\$}_{M,t} = \alpha + \pi \cdot \Delta lnE_{\frac{fx}{\$}t} + \delta \cdot \Delta lnP^{fx}_{t} + \mu \cdot \Delta lnP^{com}_{t} + \lambda \cdot P^{\$}_{M,t-1}$$

While the subsequent linear regression model is postulated as such

$$\Delta P^{\$}_{M,t} = \alpha' + \pi' \cdot \Delta E_{\frac{fx}{\$}t} + \delta' \cdot \Delta P^{fx}_{t} + \mu' \cdot \Delta P^{com}_{t} + \lambda' \cdot P^{\$}_{M,t-1}$$

Where, in both specifications, $P^{\$}_{M,t}$ is a composite measure of the U.S. non-oil import price index at a time, t; $E_{\frac{fx}{\$}t}$ is a broad measure value of the dollar weighted by "source country shares of U.S. non-oil imports," (Gruber, McCallum and Vigfusson 2016) at a time, t; P^{fx}_{t} is a composite index of foreign prices measured in CPI, at a time, t, to serve as a proxy for foreign marginal costs; P^{com}_{t} is a composite measure of the U.S. non-oil price index at a time, t; and $P^{\$}_{M,t-1}$ is simply a lag of the composite measure of the U.S. non-oil price index at a time, t. The coefficients of interest in the equations specified above are π and π', which are indicative of the sensitivity of import prices to fluctuations in the broad measure of the FX/USD exchange rate index. As indicated in the previous section, the work of Gruber, MacCallum and Vigfusson (2016) offers a benchmark for the estimation of the pass-through coefficient, and provides a concise dataset which encompasses the variables specified above from the first quarter of 1988 through the second quarter of 2016.

For the purposes of estimation, and recognizing that all data are already indexed, the data are renormalized to 100 the beginning of the sample (1988Q1) for ease of understanding and clarity. Prior to estimation, per the specifications above, the data are either first-differenced or log-first-differenced. In doing so, the entry for 1988Q1 is lost, so I qualify the "full sample" estimation as 1989Q1 through 2016Q2, to capture a full year of observations at the onset of the data set. This seems a cleaner approach that what could be an arbitrary choice of quarter and year based on the manipulation of the data.

In estimating the pass-through coefficients, I begin by re-estimating the exact specification and sample of Gruber, MacCallum and Vigfusson (2016), seeking to determine if their results can be replicated as a benchmark for the rest of the analysis. I will then apply the log-linear specification detailed above in accordance with the existing literature. Since the log-linear specification uses a constant pass-through coefficient by construction, I will determine the degree to which the pass-through coefficient has declined by estimating the above equation for three sample periods: 1989-2016, 1989-2004, and 2005-2016. I am chiefly interested in the change between the coefficients corresponding to the subdivided samples. I calculate both short-run and long-run pass-through coefficients in this manner. The "short-run" models are partial adjustment models, wherein changes in the values of the regressors will, in theory, repeatedly impact the value of the dependent variable since a lag is included in the specification. The "long-run" estimated coefficient allows us to break this cycle and assess coefficient at a long-run, "steady-state," value.

Table 1: Regression Replication Coefficients

Dependent Variable: Log of U.S. Non-Oil Import Price Index

VARIABLES - All in Log Form	Gruber, McCallum and Vigfusson 1990Q1 - 2013Q4	Replication 1990Q1-2013Q4
Constant	2.97	3.601***
Foreign Price Index - First lag	0.49	0.309***
U.S. Exchange Rate (FX/USD)	-0.095	-0.024
U.S. Exchange Rate (FX/USD) - First lag	-0.14	-0.184***
Non-oil Commodity Price Index	0.041	-0.012
Non-oil Commodity Price Index - First lag	0.02	0.091**
Non-oil Commodity Price Index - Second lag	0.014	-0.029
Non-oil Commodity Price Index - Third lag	0.008	0.064***

*** p<0.01, ** p<0.05, * p<0.1

As indicated, the log-linear model above is ubiquitous in the existing literature surrounding exchange-rate pass-through, but by construction incorporates a constant pass-through coefficient and then finds the pass-through is not constant. The tension that arises from this violation of assumptions leads me to the linear specification which, by design, features a changing pass-through coefficient that corresponds to the elasticity of the import price regarding changes in the exchange rate when multiplied by the ratio of the exchange-rate to the non-oil import price index. This exercise is conducted with the estimated coefficient for all observations of the exchange rate index and non-oil import price index in the sample to plot the evolution of the pass-through coefficient over time. Again, this exercise is repeated for short- and long-run horizons and is conducted for the full sample. Taken together, these specifications allow us to observe the behavior of exchange-rate pass-through over time while taking into consideration the existing literature on the subject.

3 Results

As indicated, the specification utilized by Gruber, McCallum, and Vigfusson (2016) serves as a benchmark for this analysis and deserves attention here. The specification of Gruber, McCallum, and Vigfusson (2016) differs from that which will be used in the subsequent analysis, utilizing different lagged values of the coefficients. [1]

The results in Table 1 clearly imply this is not an adequate replication of the results of Gruber, McCallum, and Vigfusson (2016). Particularly, if we are to assume the coefficient on the "U.S. Exchange Rate (FX/USD)" term is the pass-through coefficient, I find it to be -0.024 with this specification, versus the -0.095 from the original results, suggesting that my replication reports a pass-through that is less pronounced than the authors found. There are two primary considerations for why this is the case: 1) the dataset utilized in this analysis is not exactly the dataset used by the authors—through "sanitization" some of the observations in the data used in this analysis differ from the original, likely due to confidentiality issues; and 2) the authors define the error term to behave as an autoregressive process with an autoregressive coefficient of 0.99 (a highly persistent

[1] The original specification with coefficients from Gruber, McCallum, and Vigfusson (2016) is: $p_t = 2.97 + 0.49p^*_{t-1} - 0.095s_t - 0.14s_{t-1} + 0.041cp_t + 0.02cp_{t-1} + 0.014cp_{t-2} + 0.008cp_{t-3} + \nu_t$, and $\nu_t = 0.99\nu_{t-1} + \mu_t$ where μ_t is white noise. Variables here are natural counterparts of those postulated in the methodology section above. Here, p_t is a composite measure of the U.S. non-oil import price index at a time, t; s_t is a broad measure value of the dollar weighted by "source country shares of U.S. non-oil imports," (Gruber, McCallum and Vigfusson 2016) at a time, t; is p^*_{t-1} a composite index of foreign prices measured in CPI, at a time, t, to serve as a proxy for foreign marginal costs, lagged one period; and cp_t is a composite of non-oil U.S. prices. Subsequent variables are simply lags. All variables are in log form.

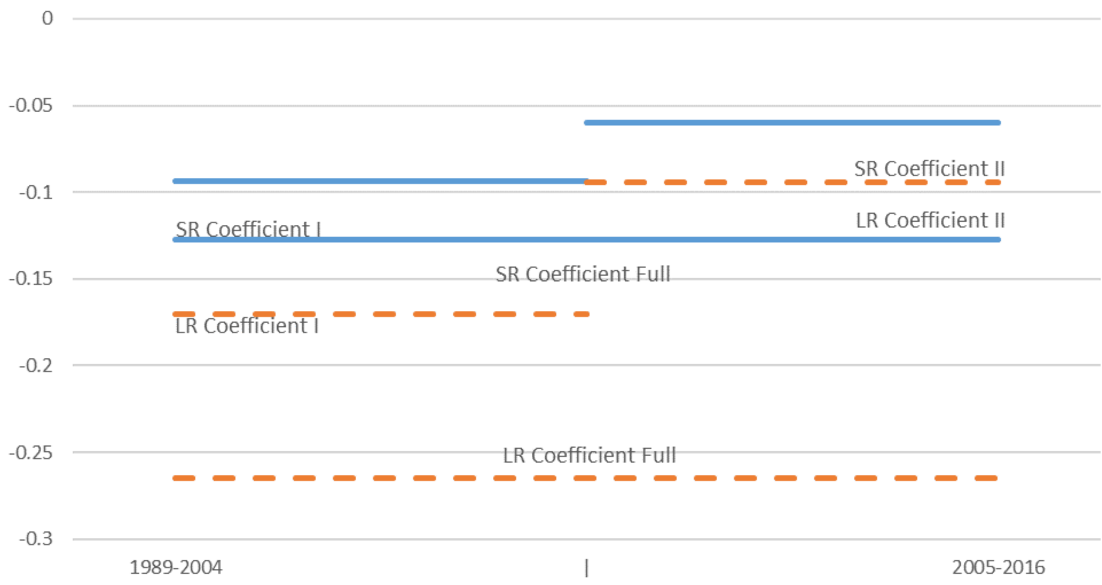

Figure 1: Short-Run & Long-Run Pass-Through Coefficients: Log-Linear Model

series). Since this unique treatment of the error term is outside the scope of this analysis, and is therefore not applied to the replication estimation, it is reasonable to assume the resulting coefficients would differ. I will note, that the authors also contend, "Taking these direct and indirect effects together, the overall exchange-rate elasticity of core import prices is estimated to be about 0.3, such that only about a third of movements in the dollar is passed through to import prices" (Gruber, McCallum, and Vigfusson, 2016). While the authors provide few details about how this 0.3 is determined, the finding is valuable as a broader benchmark for overall exchange-rate pass-through. I will attend to this more directly below.

One can clearly observe the apparent "jump" in the pass-through coefficient between both sample periods in both the long-run and short-run estimations in Figure 1. Numerically, in the short-run, the full-sample pass-through coefficient is -0.127, the first pass-through coefficient is -0.093, and the second pass-through coefficient is -0.06. In the long-run, the full-sample pass-through coefficient is -0.265, the first pass-through coefficient is -0.170, and the second pass-through coefficient is -0.094 (See Appendix, Table A.2 for log-linear regression table with all values and standard errors).

Of note, here, is the consistent decline in pass-through between both the 1989-2004 and 2005-2016 samples in both the long and short-run. In the short-run, the difference is -0.034 while in the long-run, the difference is -0.076. Both subperiods in both samples are also markedly higher than the full-sample estimated coefficients. Since the broad measure exchange rate index is measured in foreign currency per USD, the intuition is as follows—as the coefficient on the exchange rate measure "decreases" (becomes closer to zero), this suggests that an appreciation of the USD against the broader foreign currency in the index corresponds to *less* of an impact on U.S. non-oil import prices. This is clear evidence of a decline in the U.S. pass-through coefficient over time, and the values estimated imply that, when compared to the pass-through in the 1989-2004 sample, a 1% appreciation of the USD against the broader foreign currency measure corresponds 0.034 and 0.076 percentage points less change in import prices. Note further, that the pass-through coefficients estimated for the 2005-2016 sample, in the long- and short-run, are not statistically significantly different from zero, suggesting the decline in the pass-through may be *more* dramatic than indicated with the estimated values (see Appendix, Figures B.4 and B.5 for graphical representation of coefficients with standard error bands).

Before attending to the linear model for exchange-rate pass-through, note the long-run estimated pass-through coefficient for the full sample is -0.265. I contend that this serves as an allegory for the broader exchange-rate pass-through coefficient indicated in Gruber, MacCallum, and Vigfusson (2016) of 0.3. The authors find that the predicted effect of a 10% real dollar appreciation on the level of core import prices after one, two, and three years is -3.0%, as compared to the -2.65% estimated in this analysis with the log-linear specification detailed above. This suggests

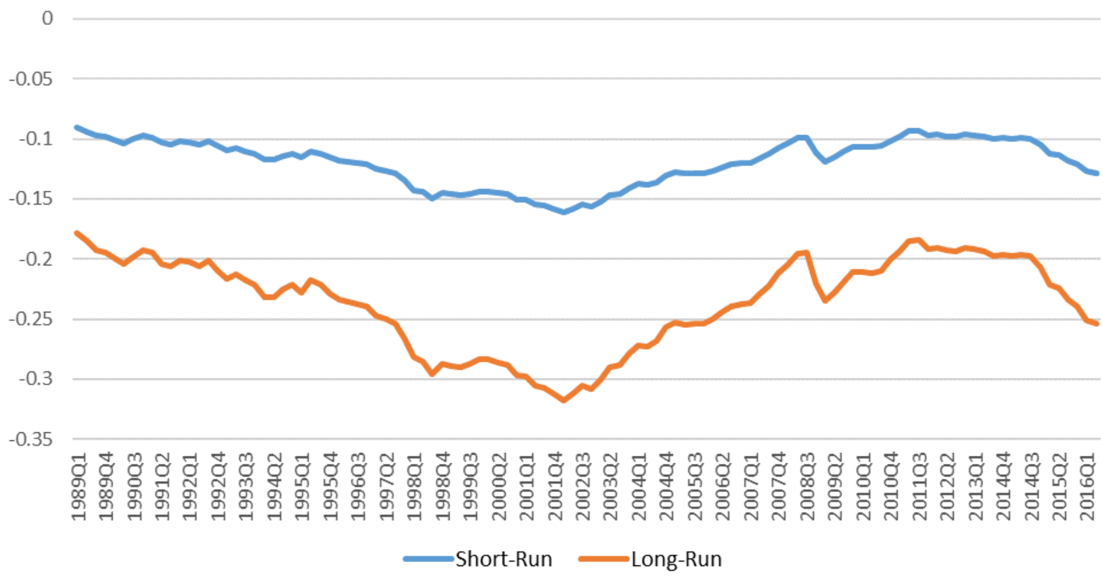

Figure 2: Pass-Through Coefficients: SR & LR Linear Model

that, while I was unable to replicate the original coefficients from the author's model as specified, the overall long-run results of this analysis and Gruber, MacCallum, and Vigfusson (2016) regarding the pass-through coefficient are reasonably similar. Both results imply a similar long-run effect of an exchange-rate appreciation on import prices, differing by 0.35%.

As indicated in the methodology section, the observations of the exchange-rate pass-through in the linear model are price elasticities with respect to the ratio of the exchange rate index and non-oil import price index in each quarter (see Figure 2). The initial coefficients estimated for the construction of this illustration are -0.090 and -0.177 in the short-run and long-run, respectively (see Appendix, Table A.3 for linear regression table with values and standard errors). Following the same logic as detailed above, there appears to have been an increase in the exchange-rate pass-through from the beginning of the sample through mid-2001. Subsequently, since 2001 there has been a steady (except for the 2008 financial crisis) decline in exchange rate-pass through until the end of 2014. Since 2014, it appears pass-through may be increasing again. An analysis of this anomaly is appropriate in further research as more data become available. Overall, the linear model which allows us to plot a changing pass-through coefficient over time further substantiates the results of the log-linear model which suggest that between the 1989-2004 and 2005-2016 sample periods exchange-rate pass-through has declined. The linear model provides a more dynamic glimpse at this evolution, clearly illustrating the steady decline in the degree to which changes in exchange rates are "passed through" to import prices in the past 16 years.

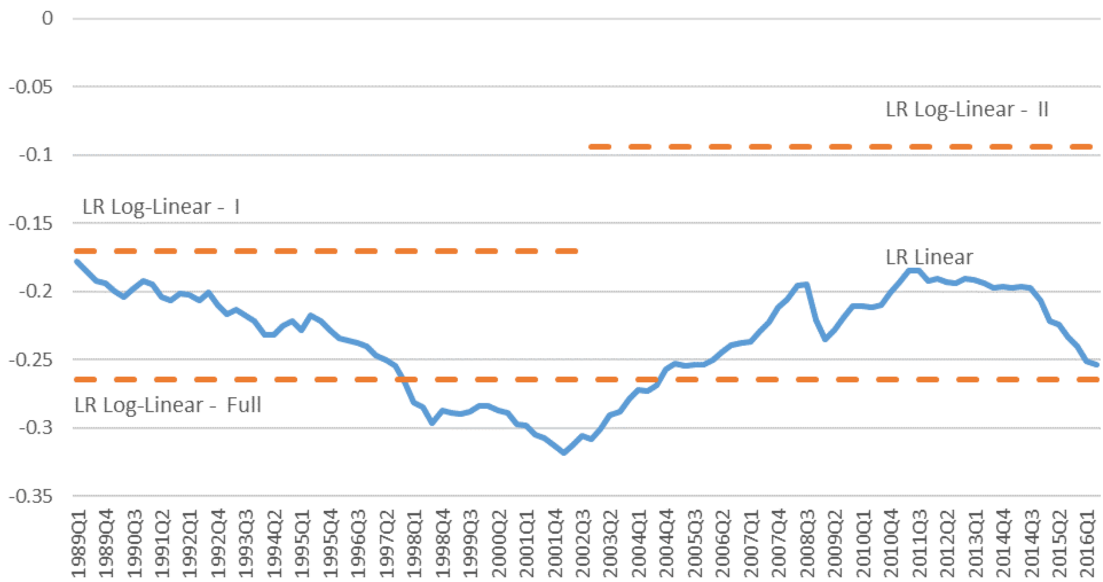

Figure 3: Long-Run Pass-Through Coefficients: Sensitivity to Model Specification

Further, taken together, one can observe the sensitivity of the pass-through coefficients to model specification, represented in Figure 3. The results of this illustration are intuitively sound. The value of the log-linear pass-through coefficient corresponds roughly with the average of the linear model, and the relative decline in the pass-through coefficients estimated in the split-sample log-linear regressions match the behavior of the linear model during these periods. While the pattern is consistent across samples, it is possible the log-linear model is overstating the decline in pass-through with respect to the linear model, and developing an accurate way to compare the two is deserving of further research. Further, more research will be needed to address the apparent increase in pass through that is observed post-2014 in the linear model, a nuance that is absent from the log-linear specification.

4 Conclusion

Approaching the question of exchange-rate pass-through through the lens of existing research and with the application of a new specification, the results of this analysis suggest that exchange-rate pass-through has declined in the United States. Invoking the log-linear model that is frequently employed in existing literature, I find that, between two distinct sampling periods (1989-2004 and 2005-2016), there is a marked decline in the pass-through coefficient in the short- and long-run. Reconciling my results and approach with existing literature, I am unable to replicate the results of Gruber, MacCallum and Vigfusson using their original specification. As indicated, the data I utilize in this analysis is not the exact same data as that of the authors, having been "sanitized" to some extent, excluding confidential observations. This, coupled with a slightly different approach to estimation (the authors recognize the error terms of their regression equation to have time-series properties that are addressed in the actual regression), implies that the results should not be exact. However, the author's finding a 10% increase in the value of the dollar corresponds to a 3% reduction in import prices is more closely in line with the results of my long-run log-linear estimates of pass-through (at 2.65%), differing by only 0.35%.

Further, I recognize key limitations in the use of the log-linear specification that render the pass-through coefficient constant, creating tension in interpreting results of a more granular nature. To ensure the results of the log-linear model are more robust to these criticisms, I utilize an alternative specification—a linear model that, when coupled with observations of exchange rate indices and import price indices, offers a continuum of price elasticities across the sample. This provides the opportunity to observe the behavior of the pass-through across the sample in each quarter, and can be easily illustrated graphically. The results of the linear model jibe nicely with those of the log-linear model. In either specification, we observe that the pass-through of exchange rate changes to import prices has declined over the course of the last 30 or so years, most prominently in the past two decades. The decline in the pass-through coefficient implies that the efficacy of fluctuations in the value of the dollar to bring about changes in the current account via expenditure-switching is suspect—substantially larger changes in real dollar value are needed to bring about concurrent impacts on imports and exports, suggesting that the use of this as a policy tool is less practical than theory suggests. The results of the analysis are firmly in line with the intuitive findings of Hooper and Mann (1989), whereby a real depreciation (appreciation) of the dollar is less effective at engendering adjustments in the real account balance than a theoretical 1:1 relationship.

As time passes, further research will be warranted to assess the robustness of this relationship with additional observations of the exchange rate index and import price index. This is especially important considering the marked increase in pass-through exhibited in the linear-model from 2014 to present. While the effects of this are largely ignored in the log-linear model, I suspect that the behavior of the pass-through coefficient is likely to change in the coming years given the trend observed in the data at present. The degree to which this can be captured in the log-linear model is important if it is to be applied moving forward, and the economic ramifications of increased pass-through must be addressed if it is to deviate from the historical evolution observed in the past 15 or so years. In the data, during the post-2014 pass-through increase, we observe relatively large increases in the broad exchange rate measure (a strengthening dollar) with respect to counterpart decreases in the price of non-oil U.S. imports.

Note that, prior to this period, import prices remained relatively constant for some time as the U.S. dollar fluctuated about the same relative average. Since, however, the dollar has continually strengthened whilst import prices have declined. This might suggest that the dollar has become so strong relative to the weighted-basket of currencies it has begun to manifest a more pronounced pass-through to import prices than has been seen in recent years. As stated, more research will be crucial for assessing both the duration of and consequences of this phenomenon going forward. Further, future research on this subject might be appropriate in determining a more direct way to compare the results of the log-linear and linear models. While the full sample log-linear coefficient corresponds nicely with what appears to be the average the linear model observations, the sub-period observations exhibit substantially higher (closer to zero) pass-through coefficients than the linear model. Reconciling this will be helpful in future research on the subject.

A Tables

Table A.2: Pass-Through Coefficients (Log-Linear Model)

Dependent Variable: Log of U.S. Non-Oil Import Price Index (First-Difference)						
	Short-Run Coefficients			Long-Run Coefficients		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	1989Q1-2016Q2	1989Q1-2004Q4	2005Q1-2016Q2	1989Q1-2016Q2	1989Q1-2004Q4	2005Q1-2016Q2
Broad U.S. Exchange Rate (FX/USD)	-0.127***	-0.094***	-0.06	-0.265***	-0.170**	-0.094
	[0.0301]	[0.0228]	[0.0626]	(-0.0695)	(-0.0657)	(-0.1172)
Lag Non-oil Commodity Price Index	0.519***	0.451***	0.363***			
	[0.0639]	[0.0837]	[0.0628]			
Foreign Price Index	0.174***	0.125**	1.666***	0.362**	0.227*	2.616***
	[0.0561]	[0.0578]	[0.5466]	(-0.1408)	(-0.1288)	(-0.5948)
Non-oil Commodity Price Index	0.056***	0.051***	0.044***	0.117***	0.093**	0.069*
	[0.0108]	[0.0134]	[0.0133]	(-0.0293)	(-0.0334)	(-0.0356)
Constant	0.000	0.000	-0.008**	0.000	0.000	-0.013***
	[0.0008]	[0.0009]	[0.0034]	(-0.0019)	(-0.0021)	(-0.004)
Observations	110	64	46	110	64	46
R-squared	0.641	0.489	0.771			

Note: HAC Standard Errors are indicated above in brackets, while standard errors are indicated in parentheses. These standard errors are used to tabulate error bars in subsequent graphical representations. I defer to the HAC standard errors in the short-run coefficients since they correct for possible violations of proper calculation of standard errors and are readily available in the output. Note that, given the long-run coefficients are calculated as a ratio between two normal variables, the distribution of the resulting coefficient is non-normal. The statistical software used to calculate the resulting standard errors performs a Taylor expansion and only generates ordinary standard errors in output. Thus, the standard errors from static long-run equation estimation are used here. Significance levels are as follows: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.3: Pass-Through Coefficients (Linear Model)

Dependent Variable: Log of U.S. Non-Oil Import Price Index (First-Difference)		
	Short-Run Coefficients	Long-Run Coefficients
	(1)	(2)
VARIABLES	1989Q1 - 2016Q2	1989Q1-201Q2
Broad U.S. Exchange Rate	-0.090***	-0.177***
	[0.0240]	(0.048)
Lag Non-oil Commodity Price Index	0.494***	
	[0.0509]	
Foreign Price Index	0.233***	0.460***
	[0.0827]	(0.1299)
Non-oil Commodity Price Index	0.053***	0.106***
	[0.0105]	(0.0275)
Constant	-0.312*	-0.616**
	[0.1861]	(0.3243)
Observations	110	110
R-squared	0.667	

Note: HAC Standard Errors are indicated above in brackets, while standard errors are indicated in parentheses. These standard errors are used to tabulate error bars in subsequent graphical representations. I defer to the HAC standard errors in the short-run coefficients since they correct for possible violations of proper calculation of standard errors and are readily available in the output. Note that, given the long-run coefficients are calculated as a ratio between two normal variables, the distribution of the resulting coefficient is non-normal. The statistical software used to calculate the resulting standard errors performs a Taylor expansion and only generates ordinary standard errors in output. Thus, the standard errors from static long-run equation estimation are used here. Significance levels are as follows: *** p<0.01, ** p<0.05, * p<0.1

B Figures

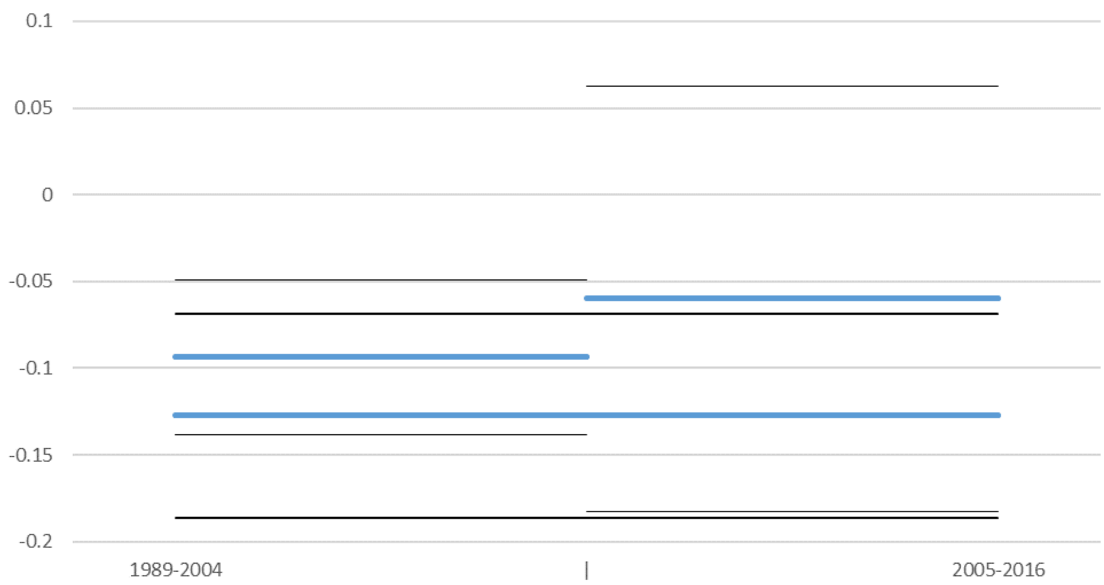

Figure B.4: Short-Run Pass-Through Coefficients with HAC Error Bands: Log-Linear Model

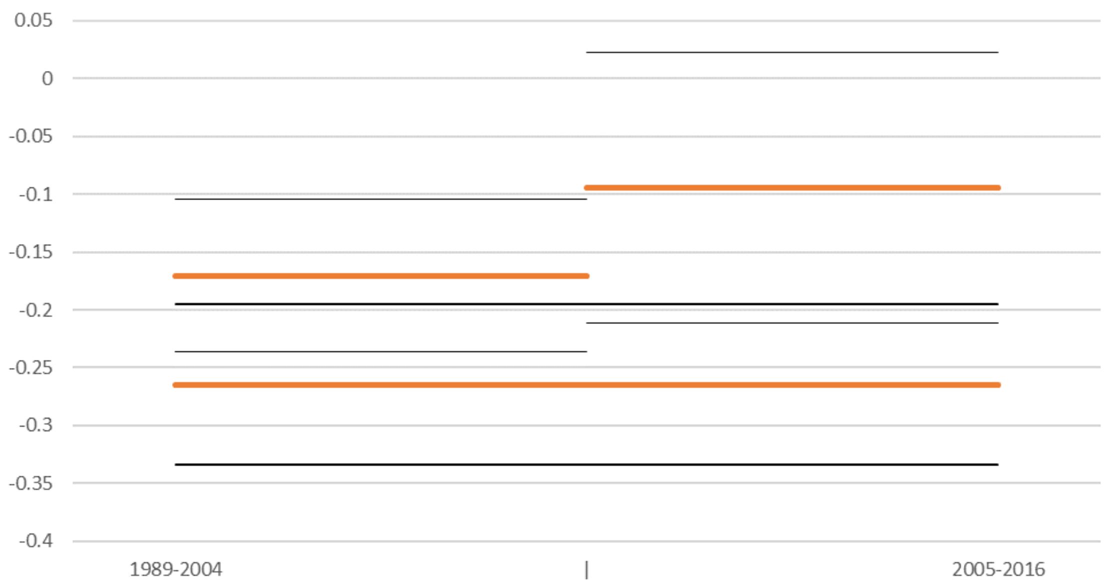

Figure B.5: Long-Run Pass-Through Coefficients with HAC Error Bands: Log-Linear Model

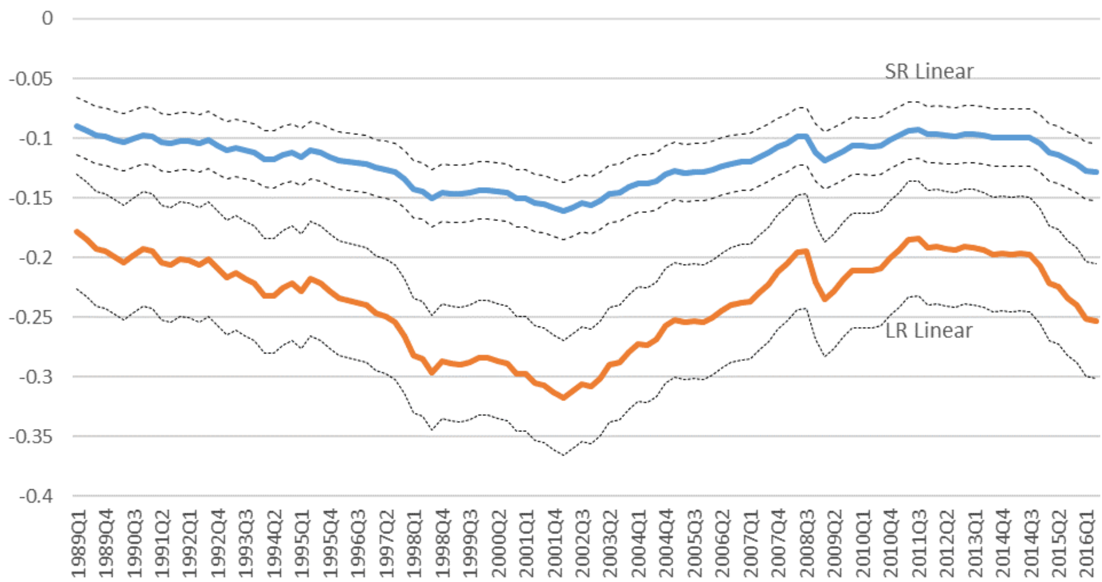

Figure B.6: Pass-Through Coefficients with Error Bands: SR & LR Linear Model

References

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