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Dollar not so dominant: Dollar invoicing has only a small effect on trade prices

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ABSTRACT

This paper estimates and tests three models of the effects of exchange rate changes on export prices. It supports the Goldberg and Knetter (1997) canonical result that exporters adjust their prices by about half of any movement in exchange rates. A new twist is that exchange rate movements against importing countries account for only two-thirds of this price adjustment, while exchange rate movements against a dominant currency account for the other third. The dominant currency is the euro in Europe and Africa and the US dollar in Asia and the Western Hemisphere. The recent claim that the dollar is the most important driver of export prices (Gopinath et al. 2020) is shown to be valid only for the smallest transactions. For the bulk of international trade, the extra effects of the dollar (or the euro) beyond their effects as exporter or importer currencies are relatively modest.

1. Introduction

Many exporters around the world quote prices and accept payment in dollars or euros, even when neither the exporting country nor the importing country uses the dollar or the euro for domestic transactions. For exporters that maintain prices fixed in dollars or euros, a broad appreciation of the dollar or the euro would raise export prices when converted into the currencies of both exporters and importers, potentially reducing international trade and dragging down global growth. Indeed, a recent study argues that “the US dollar plays an outsized role in driving international trade prices and quantities” (Gopinath et al. 2020, 695).

This paper shows that most of any outsized role for the dollar in trade pricing is limited to the smallest transactions; for the bulk of international trade, the effect of dollar invoicing diminishes after a few months. Instead, this paper supports the older conventional wisdom that export prices tend to move halfway between domestic prices and foreign prices when exchange rates move. The new twist is that only about two-thirds of the foreign price impact comes from prices in importing countries, whereas one-third is tied to either the dollar or the euro depending on the geographic location of the exporter.

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2. Previous research

For many years, economic textbooks employed the simple assumption that the prices of a country's exports are identical to the prices of similar goods in its domestic markets. This model of export pricing is known as producer currency pricing (PCP). Although it was widely accepted that exporters in a large country such as the United States would follow domestic prices, it was less clear that exporters in smaller countries would do so. However, Sven Grassman (1973) reported that Swedish exporters typically invoice prices and accept payment in Swedish krona, whereas Swedish importers typically pay for imports in foreign currencies. These findings are consistent with the PCP model, although it should be noted that invoicing in exporter currency does not preclude export prices from moving independently of domestic prices.[2] When inflation rates are low and stable at home and abroad, PCP implies that a currency appreciation will cause a country's exports to become more expensive in terms of the currencies of its foreign buyers, while a depreciation will make its exports cheaper.

Peter Hooper and Catherine Mann (1989) observed that the pronounced appreciation of most foreign currencies against the US dollar in the late 1980s did not lead to a comparable increase in the prices of US imports, contrary to the predictions of the PCP model. Subsequently, an outpouring of research found that export prices sometimes follow prices in the importing markets and that this behavior can lead to different prices being charged for the same product in different destinations. This phenomenon is called local currency pricing (LCP).

Pinelopi Goldberg and Michael Knetter (1997) surveyed studies on different countries and products at varying levels of aggregation and found a canonical result for manufactured exports[3] that prices tend to split the difference between the predictions of the PCP and LCP models. In other words, an exchange rate appreciation of, say, 10 percent would raise prices in importer currency by 5 percent and lower prices in exporter currency by 5 percent.[4]

Gita Gopinath and colleagues (2020) proposed a new model of export pricing that they label the dominant currency paradigm (DCP). The DCP is motivated by the fact that many exports of smaller countries are invoiced in US dollars or euros, even when neither the exporter nor the importer uses the dollar or the euro as its domestic currency. Gopinath et al. run regressions that nest the PCP, LCP, and DCP models. They regress bilateral import prices on exporter producer price indexes (PPIs), the bilateral exporter-importer exchange rate, and the bilateral importer–United States exchange rate (all variables are expressed as rates of change).[5] They do not report coefficients on exporter PPI, but they do show that the DCP effect (US exchange rate coefficient) is notably larger than the effect of the exporter exchange rate, which they implicitly interpret as a measure of the PCP effect. They do not report an estimate of the LCP effect, but their results imply that it is very small.

This paper explores the PCP, LCP, and DCP models using both bilateral and multilateral export prices. These models are not mutually exclusive; it is rather a question of gauging the relative importance of each.

3. Export prices and the dollar appreciation of 2014–15

The sharp and sustained dollar appreciation of late 2014 and early 2015 provides a natural test of the DCP model, which predicts a large and sustained rise in export prices when expressed in exporter currency. Fig. 1 displays annual export, domestic, importer, and US prices, all expressed in terms of exporter currency, for the period from 2013 to 2016. The sample includes 33 countries that do not use the US dollar or the euro as their main currency and do not have a lot of primary commodity exports. Further details on the sample selection are provided in the next section.

During this period the US dollar appreciated against almost all currencies by an average of around 20 percent owing to developments unique to the United States which are plausibly viewed as exogenous to the non-commodity exporters examined here.[6] Such an almost uniform and considerable strengthening of the US dollar makes this time frame a natural experiment to test whether the dollar has any effect on export prices over and above its role as the currency of a major importer. All price indexes are normalized at 100 in 2013, the year before the dollar appreciation.

The most common outcome in these episodes is that US prices rise distinctly higher than the other prices, which remain relatively stable.[7] This outcome is consistent with either the PCP or LCP model but not with the DCP model. It occurs in Albania, Bosnia and Herzegovina, Denmark, Hungary, India, Japan, Korea, Morocco, Poland, Romania, Serbia, and Tanzania. The second most common

[2] A producer who wishes to keep her export prices close to the prices of her domestic sales would find it more convenient to invoice in domestic currency because prices invoiced in foreign currency would need to be adjusted frequently as exchange rates move. On the other hand, a producer who wishes to keep her export prices close to the prices in the importing market would find it convenient to invoice in the importer's currency. Accordingly, researchers typically assume that export prices are sticky in the currency in which they are invoiced. Goldberg and Tille (2006) find that export prices tend to be relatively more stable in the currency of invoice but that there is still considerable adjustment of invoice prices to exchange rates over time.

[3] Prices of primary commodities are roughly equal across exporters and are determined by global supply and demand conditions.

[4] Other studies have found somewhat lower pass-through of exchange rates to import prices in the United States than in other countries.

[5] They do not include US and importer PPIs in their main regressions. This omission may bias their results against the LCP model, especially if some importers have high inflation, as discussed later in this paper.

[6] The dollar appreciation is widely attributed to relatively strong US growth which raised expectations for monetary tightening. A contributing factor may have been the rise in US petroleum production from oil shale, which reduced oil imports and the supply of dollars to pay for them.

[7] The figure is essentially unchanged if the US PPI in exporter currency is replaced by the US dollar exchange rate against the exporter currency because US PPI (in dollars) was relatively stable over this period.

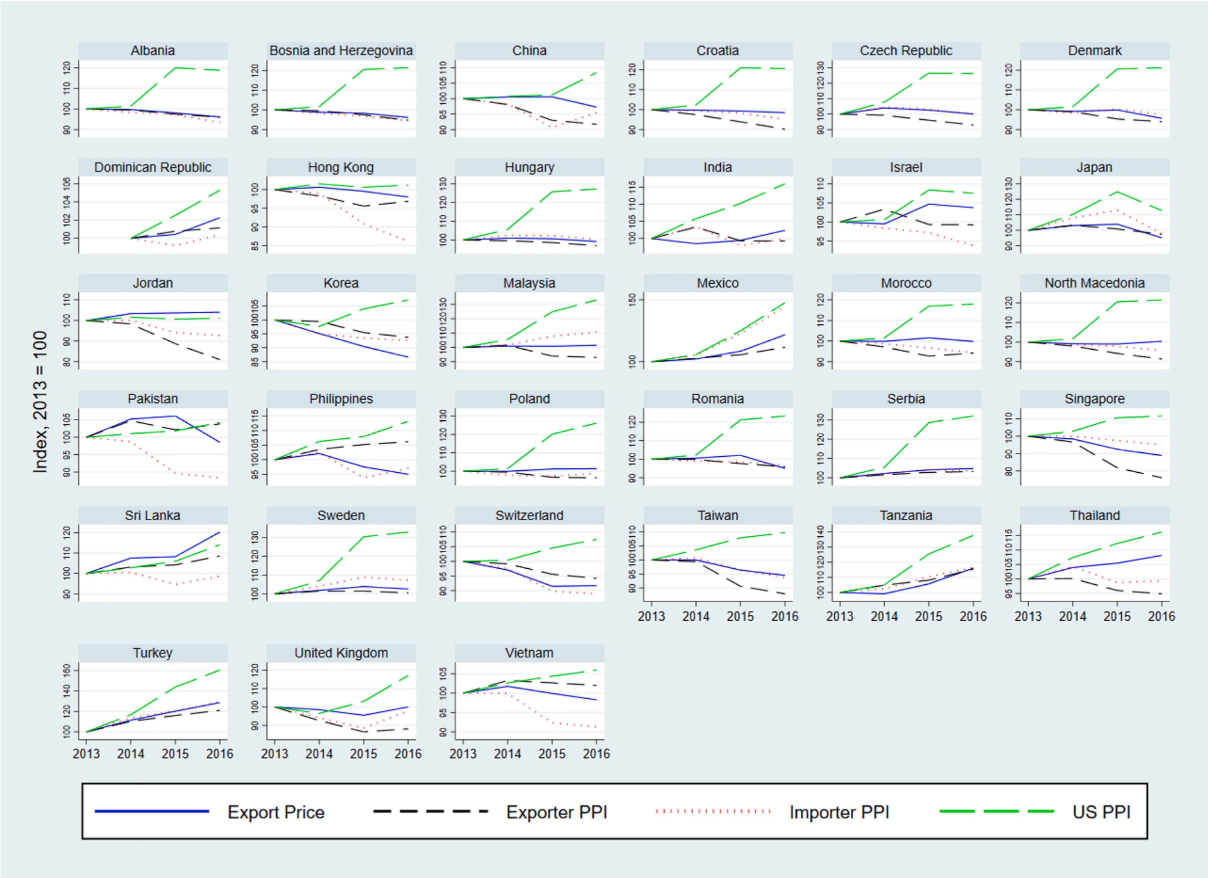

Fig. 1. Export price responses to US dollar appreciation, 2013–16 Note: All prices are expressed in exporter currency. Source: Authors' calculations based on data described in Appendix A.

outcome is for export prices to move closely with importer prices (LCP), as is the case in China, Croatia, Czech Republic, North Macedonia, the Philippines, Taiwan, Turkey, and the United Kingdom. (We focus on the cumulative effects of the dollar as of 2016, by which time lagged adjustments should have been completed.) The third most common outcome is for export prices to move between domestic prices (PCP) and importer prices (LCP): Malaysia, Mexico, Pakistan, Singapore, Switzerland, and Vietnam. There are two cases of each of the following outcomes: export prices follow domestic prices most closely (PCP) in Hong Kong and Sweden; export prices follow US prices most closely (DCP) in Jordan and Sri Lanka; and export prices move between domestic prices (PCP) and US prices (DCP) in the Dominican Republic and Israel. Finally, in Thailand, export prices move between importer prices (LCP) and US prices (DCP).

It should be noted that neither US PPI nor importer PPI seems to have an outsized effect on Mexico's export prices, despite the country's close trade links with the United States. Mexico's export prices rise slightly above domestic PPI, but still lag substantially behind US and importer PPI.

Altogether then, in this episode of a large and sustained dollar appreciation, export prices tend to follow domestic prices (PCP), importer prices (LCP), or some path between domestic and importer prices. Only in five of the 33 countries do export prices follow US prices (DCP) to any notable extent.

4. A broader historical analysis

The dollar appreciation of 2014–15 is arguably unrepresentative of the overall history of exchange rates and trade prices, even though it seems tailor-made to test the assertion of the DCP literature that dollar movements have large and sustained impacts on trade prices around the world. The sample constructed for the rest of this paper thus covers the period from 1983 to 2019, annually. It includes all countries with available data and 2019 nominal GDP greater than $10 billion, except the following: the United States, countries that use the US dollar as their main currency, euro area countries, and economies with primary commodity exports higher than one third of their merchandise exports. The latter economies are excluded because primary commodity prices are determined in global markets and do not differ significantly across exporters. Concerns about data quality led us to drop data from formerly socialist economies (except China and Hungary) before 1999; the first rates of change for these countries are in 2000. There are 33 countries in our dataset. Appendix A provides details on country coverage, data sources, and the construction of the variables.

4.1. Vector Autoregressions (VARs)

We begin with VARs of the data:

$$\Delta \mathrm{PX}_{it}\ \Delta \mathrm{PCP}_{it}\ \Delta \mathrm{LCP}_{it}\ \Delta \mathrm{DCP}_{it}$$

where PX is the price of goods and services exports from the national income accounts and subscripts *i* and *t* denote countries and years, respectively. Δ denotes the year-over-year logarithmic percent change in a variable. PCP is the exporter's PPI. LCP is the average PPI of all importing countries converted into exporter currency and weighted by the share of exports to each country.[8] DCP is the PPI of either the United States or the euro area converted into exporter currency.[9]

In our dataset, DCP is calculated using US PPI for Asian and Western Hemisphere countries (including Israel and Jordan) and euro area PPI for African and European countries (including Turkey). As discussed below, the estimated role of DCP is smaller and less statistically significant if it is based on the US dollar for all exporters.

VARs enable us to trace out the impact of innovations in each variable on its own value over time and on the other variables in the system. The resulting impulse response functions (IRFs) depend critically on the assumed ordering of the transmission of contemporaneous innovations. We assume that PX responds to contemporaneous shocks of all the other variables and is thus ordered last. We tried all possible orderings of the other variables. Fig. 2 displays IRFs for export prices (in cumulative percent changes) for three representative orderings. The VARs include the contemporaneous value and one lag of each variable plus a full set of country fixed effects. Results are not noticeably affected when two lags are included. The DCP impacts decline slightly when time effects are included. The 95 percent confidence bands are based on 200 random draws of the regression sample (the default in Stata).

The first column in Fig. 2 displays IRFs when DCP is placed first in the ordering and thus does not respond contemporaneously to any other variable. Innovations in DCP have a large and growing effect on PX, as shown in the first panel. Nevertheless, innovations in LCP and PCP have positive and statistically significant effects, as shown in the second and third panels. Innovations to PX have very small and only marginally significant effects, as shown in the last panel.

The second column displays IRFs when LCP is placed first in the ordering. In this case, LCP has a large and growing impact similar to that shown for DCP in the first column. Now DCP has only a very small and not statistically significant impact on PX. PCP, however, continues to have a moderate and significant impact.

The third column displays IRFs when PCP is placed first in the ordering. In this case, PCP has a very large and growing impact similar to those shown for DCP in the first column and LCP in the second. Unlike the results of the second column, under this ordering DCP has a moderate and statistically significant impact on PX. LCP has a small and marginally significant impact.

These results suggest that there is a common shock that affects all variables in roughly equal proportions. The IRFs for DCP, LCP, and PCP (not shown) have the property that all variables grow over time by about the same amount in response to the innovation in whichever variable is placed first in the ordering. This may be considered an inflationary shock that causes all prices (expressed in exporter currency) to rise in proportion.

Regardless of which variable is placed first, the innovations in the other variables typically have statistically significant impacts on PX. The exception is that innovations in DCP lose any significant impact when LCP is placed earlier in the ordering. These results also hold for the other possible orderings not shown in Fig. 2.

4.2. A structural model

The VAR results show that the largest fluctuations in the data reflect inflationary shocks that raise all prices and exchange rates together. All of the export pricing models are consistent with these effects of common inflationary shocks. To learn more about the roles of the export pricing models in the face of shocks that do not affect all prices and exchange rates equally, we consider a simple structural model of export prices that nests the PCP, LCP, and DCP models. This model is a straightforward expansion of earlier work that modeled export prices as following a linear combination of the PCP and LCP models under the assumptions that marginal cost moves closely with the exporter's PPI, markets are segmented, and foreign and domestic PPIs are exogenous to PX (Feenstra, Gagnon, and Knetter 1996).[10]

$$\Delta \mathrm{PX}_{it} = \beta \Delta \mathrm{PCP}_{it} + \gamma \Delta \mathrm{LCP}_{it} + \mu \Delta \mathrm{DCP}_{it}$$

The effects of exchange rates on export prices show up in the coefficients on LCP and DCP because these variables are foreign prices converted into exporter currency using the relevant exchange rates.

The final regression equation allows for lagged adjustment and fixed effects. The coefficients α_i and τ_t represent full sets of country

8 LCP is calculated based on data for the 33 exporting countries in the sample plus the United States and the euro area.

9 The euro was not created until 1999, but the German mark may have played the role of a dominant currency—the currencies of the initial members of the euro area were linked increasingly tightly to the mark from 1979 through 1998.

10 The VARs show only tiny and insignificant effects of PX innovations on the other variables. The theory implies that the coefficients sum to 1, a restriction that is not imposed here but is usually not rejected.

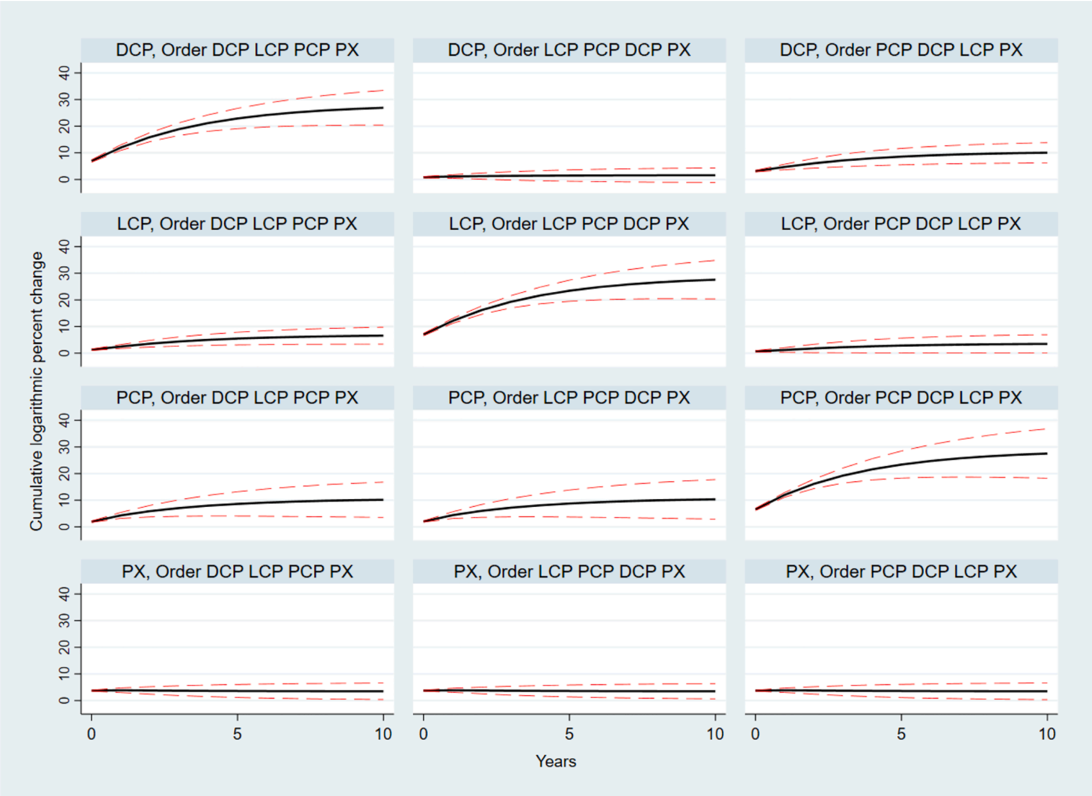

Fig. 2. Impulse response functions (IRFs) for PX in vector autoregressions (VARs), 1983–2019 Note: Rows display the impact of each variable on PX. Columns display different orderings of the residual covariance matrix. Dashed lines denote 95 percent confidence bands. The Stata pVAR package is from Abrigo and Love (2016). Source: Authors' calculations using data described in Appendix A.

and year fixed effects.

$$\Delta PX_{it} = \beta_1 \Delta PCP_{it} + \beta_2 \Delta PCP_{it-1} + \gamma_1 \Delta LCP_{it} + \gamma_2 \Delta LCP_{it-1}$$

$$+ \mu_1 \Delta DCP_{it} + \mu_2 \Delta DCP_{it-1} + \rho \Delta\Delta LCP\_PPI_{it} + \theta \Delta\Delta DCP\_PPI_{it} + \alpha_i + \tau_t$$

The double-difference terms (ΔΔLCP_PPI and ΔΔDCP_PPI) are the changes in the rates of change of the PPIs used in the construction of LCP and DCP, respectively. These terms allow for the short-run effects of PPI changes to differ from those of exchange rates while enforcing the restriction that these effects are identical in the long run, which is embedded in the definitions of LCP and DCP as exchange-rate adjusted PPIs. The coefficients ρ and θ are jointly significant at the 5 percent level. Allowing the PPIs to have different long-run effects from their associated exchange rates (by replacing each double-differenced variable with a current and a lagged PPI inflation rate) is not statistically significant and has little effect on the other coefficients.

Column 1 of Table 1 displays the baseline results. The reported effects are the sums of the estimated coefficients on the current and lagged values of the independent variables.[11] Thus, the table reports the cumulative effects of the independent variables after a year has gone by. Standard errors are clustered by country. Standard errors on the sums of coefficients are based on the estimated covariance matrix of the coefficients. Neither a lagged dependent variable nor additional lags of the independent variables are statistically significant.

Export prices are most strongly influenced by domestic prices (PCP coefficient of 0.52) but importer prices also have an important effect (LCP coefficient of 0.32). The effect of a dominant currency (over and above its role as an element of importer prices) is moderate (DCP coefficient of 0.16) and statistically significant. These coefficients imply that a 1 percentage point increase in exporter PPI raises export prices 0.52 percent, the same increase in exchange-rate-adjusted importer PPIs raises these prices 0.32 percent, and in the exchange-rate-adjusted US or euro area PPI raises export prices 0.16 percent. Adding the LCP and DCP coefficients together to get an estimate of the overall effect of exchange rates on export prices of 0.48 leads to a conclusion remarkably close to the canonical finding

[11] The double-difference coefficients are not reported. They are negative for DCP, indicating a smaller response to the US or euro-area PPI in the short run, and positive for LCP, indicating a larger response to importer PPI in the short run. Dropping these terms has only a small and statistically insignificant effect on the coefficients shown in Table 1.

Table 1
Export pricing models.

Variable	Baseline	No outliers	No time effects	US PPI	Advanced economies	Developing economies	2000–2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔPCP	0.52**	0.52**	0.50**	0.54**	0.54**	0.45**	0.37**
	(0.05)	(0.07)	(0.05)	(0.05)	(0.05)	(0.07)	(0.05)
ΔLCP	0.32**	0.26**	0.29**	0.48**	0.38*	0.37*	0.37**
	(0.09)	(0.08)	(0.09)	(0.10)	(0.12)	(0.17)	(0.09)
ΔDCP	0.16*	0.17*	0.21**		0.07	0.18	0.12
	(0.08)	(0.07)	(0.07)		(0.10)	(0.15)	(0.07)
ΔDCPUS				−0.02			
				(0.10)			
Observations	891	855	891	891	358	533	588
Within R^2	0.906	0.638	0.891	0.903	0.969	0.866	0.669

* $p < 0.05$, ** $p < 0.01$.
Note: Estimates are the sums of coefficients on the current value and one lag of the independent variables. Standard errors (in parentheses) are clustered by country and for coefficient sums are computed from the estimated coefficient covariance matrix. Within R^2s refer to the percent of variation explained after removing country effects.
Source: Authors' calculations using data described in appendix A.

of Goldberg and Knetter (1997) that half of an exchange rate change is passed through to importers, with exporters absorbing the other half.

Column 2 displays a regression that excludes high-inflation outliers, defined as observations in which any one of the four price variables increases or decreases by more than 40 percent. Relative to baseline, this reduces the coefficient on LCP by a small amount with little effect on the other coefficients.[12] Column 3 shows that the results are robust to dropping the time effects, with only a small and not statistically significant increase in the coefficient on DCP.[13]

Column 4 shows that defining the DCP variable entirely in terms of dollars and US PPI leads to a statistically insignificant DCP coefficient close to zero. The R^2 declines by a tiny amount. Defining DCP entirely in terms of euros also leads to a lower R^2 and yields a negative coefficient on DCP (not shown).

Column 5 shows that the coefficients for the advanced economies are broadly similar to those for the full sample, with a larger LCP coefficient and a smaller DCP coefficient. For developing economies (column 6) the coefficients are again roughly similar to the full sample results, with a smaller PCP effect and a bit more LCP effect.

Finally, column 7 displays the baseline model estimated on the second half of the sample period. Compared to the full sample results (column 1) the PCP and DCP effects decline and the LCP effect rises. However, the sum of the coefficients is smaller, 0.87 versus 1.00 in the full sample, and the t-statistic on this difference is statistically significant.[14]

The coefficient estimates in Table 1 broadly support the Goldberg-Knetter result of a 50–50 split in the effect of exchange rates on trade prices, with just a bit more weight on domestic prices and a bit less weight on foreign prices in the advanced economies and vice versa in the developing economies and in the second half of the sample.

5. Comparison with findings of Gopinath et al.

Gopinath et al. (2020, Table 3) report considerably larger DCP coefficients than those presented here. This section shows that the differences in estimated DCP coefficients derive from differences in the model specification, from the influence of trade prices associated with the smallest trade flows, and from a shift in focus between short-run and long-run responses. The Gopinath et al. dataset yields long-run DCP coefficients similar to those presented in Table 1 of this paper when observations are weighted by the value of trade and invalid restrictions on the model are relaxed.

Differences between the data and specification of Table 1 in this paper and those of Table 3 in Gopinath et al. include.

[12] We also tried excluding even more outliers, by dropping any observation with a price change of more than +/− 20 percent. The resulting coefficient for LCP is little changed from that shown in column 2, but the coefficient on PCP declines by about one standard deviation and that on DCP declines by about half a standard deviation.

[13] A difference in coefficient values is considered to be statistically significant if it exceeds twice the standard error of the baseline coefficient value.

[14] In principle, one would expect these coefficients to sum to one, so that a generalized increase in domestic and exchange-rate-adjusted foreign prices raises export prices proportionally. The smaller PCP coefficient in the second half of the sample may reflect the smaller variation in PCP after 2000, which leads to a downward-biased and less precise estimate of the PCP coefficient. Exchange rates, on the other hand, are measured very precisely and have a great deal of variation, leading to less biased and more precise estimates of the LCP and DCP coefficients. Imposing the restriction of summing to one (not shown) moderately increases the PCP coefficient, slightly increases the DCP coefficient, and has little effect on the LCP coefficient.

- Gopinath et al. use bilateral import prices covering over 2600 country pairs. This study uses aggregate export prices covering 33 countries. Gopinath et al. run both unweighted and trade-weighted regressions. The aggregate data in this study are more comparable to trade-weighted data.
- Gopinath et al. use annual data from 1992 through 2015. This study uses annual data from 1983 through 2019.
- Gopinath et al. construct aggregate import prices using unit value data for goods at the Harmonized Schedule 6-digit level, excluding primary commodities. This study uses national income accounts goods and services export deflators for countries with low levels of commodity exports.
- Gopinath et al. assume the US dollar is the dominant currency for all exporters in the regressions reported in their Table 3, though they consider the possibility of the euro as a dominant currency elsewhere in their paper. This study allows the dominant currency to vary by exporter location.
- Gopinath et al. derive the DCP model abstracting from inflation, which leads to an estimating equation that ignores PPI inflation in the dominant currency country and in importing countries. To the extent that exporters anticipate ongoing inflation in prices denominated in the invoicing currency, they should be increasing prices in that currency at the anticipated inflation rate, which supports the inclusion of dominant currency and importer PPIs as in Table 1.[15]
- Gopinath et al. include two lags of all variables in addition to their contemporaneous values. This study includes one lag of all variables in addition to their contemporaneous values.
- Gopinath et al. report only the contemporaneous coefficients, which represent the impact effect of exchange rates. This study reports the sums of the contemporaneous and lag coefficients, which represent the effects of exchange rates after one year.

Appendix B lays out a general model of export pricing within which the model of this paper and that of Gopinath et al. may be derived as special cases.[16] The general model enables us to translate the coefficients of Gopinath et al. into estimates of the PCP, LCP, and DCP effects reported here.

The first column of Table 2 reports the baseline coefficients of this paper. Column 2 reports the coefficients obtained when the DCP variable is defined solely in terms of US prices and exchange rates, as is done in Gopinath et al. Column 3 reports estimates from Gopinath et al. in which all observations are given equal weight.[17] The DCPUS coefficient is very large at 0.78, with only a small PCP effect and almost no LCP effect. Unlike the approach presented in this paper, column 3 reports only the contemporaneous coefficients, a choice that can have important implications, as discussed below. Column 4 reports estimates from Gopinath et al. in which observations are weighted by bilateral import values. It is apparent that the DCPUS effect is notably smaller and the PCP effect notably larger in relationships that account for the bulk of international trade. Nevertheless, the DCPUS coefficient, at 0.58, remains larger than the PCP and LCP coefficients.

Column 5 displays the sums of the contemporaneous and lagged coefficients from the regression shown in column 4. Whereas column 4 displays the impact effect of exchange rate changes, column 5 displays the cumulative effect after two years. The DCPUS effect declines and the PCP effect rises, so that the two are almost equal at around 0.45. The LCP effect remains small. The shift in PCP and DCPUS effects from column 4 to column 5 likely reflects a temporary effect of dollar invoicing. When the dollar rises late in the year, import prices invoiced in dollars rise in terms of importer currency, but some of this increase is removed the following year as import contracts are renegotiated.

The results in columns 3, 4 and 5 are consistent with those displayed in figure 4 in Gopinath et al. The DCPUS coefficient in column 3 equals the response to the USD in year 0 shown in the top right (unweighted) panel of figure 4. The DCPUS coefficient in column 4 equals the response to the USD in year 0 shown in the bottom right (trade-weighted) panel of figure 4. Finally, the DCPUS coefficient (actually the sum of current and lagged coefficients) in column 5 equals the response to the USD in year 2 shown in the bottom right panel of figure 4 in Gopinath et al.

Column 6 displays the cumulative effects when importer and US PPI are added to the regression with unrestricted coefficients.[18] The LCP and DCPUS effects are taken from the exchange rate coefficients only, as is done in Gopinath et al. However, including importer PPIs in the regression has an important effect on the other coefficients, substantially raising the LCP effect and reducing the DCPUS effect to a value below that of both the PCP and LCP effects. The contemporaneous importer PPI is statistically significant,

[15] In the very short run, export prices are fixed in the invoicing currency and thus respond to surprises in that currency but not to surprises in the associated PPI. This motivates the estimation of independent short-run effects of exchange rates and PPIs while maintaining the long-run restriction of equal effects in the regressions of Table 1.

[16] Gopinath et al. also display regressions that include interactions of exchange rate changes and the share of a country's imports invoiced in dollars. These regressions show that import prices are more responsive to the dollar when a larger fraction of imports is invoiced in dollars. However, the regressions are less useful for measuring the effects of different exchange rates on average import prices.

[17] We use the underlying data and regression code from Gopinath et al. to replicate their results. The DCPUS coefficient is identical to that shown in column 2 of Table 3 in Gopinath et al. (2020). The PCP (exporter PPI) coefficient is not reported by Gopinath et al. but is available in the underlying regression. The LCP coefficient is a translation of the coefficients reported by Gopinath et al. based on the model of appendix B.

[18] The regressions in columns 1 and 2 impose restrictions of long-run equality between exchange rates and PPIs, but those restrictions are not imposed in columns 6 and 7.

Table 2
Comparison with Gopinath et al. (2020).

Variable	This paper		Gopinath et al. (2020) dataset				
	Baseline (1)	US PPI (2)	Unweighted regression	Trade-weighted regression			
			As reported (3)	As reported (4)	Sum of coefficients (5)	Unrestricted sum of coefficients (6)	Unrestricted sum without second lag (7)
ΔPCP	0.52**	0.54**	0.14**	0.31**	0.45**	0.40**	0.42**
	(0.05)	(0.05)	(0.02)	(0.04)	(0.06)	(0.06)	(0.06)
ΔLCP	0.32**	0.48**	0.05**	0.07**	0.08**	0.41**	0.59**
	(0.09)	(0.10)	(0.01)	(0.03)	(0.02)	(0.06)	(0.19)
ΔDCP	0.16*						
	(0.08)						
ΔDCPUS		−0.02	0.78**	0.58**	0.44**	0.16	−0.03
		(0.10)	(0.01)	(0.04)	(0.07)	(0.10)	(0.23)
Observations	891	891	46,820	46,820	46,820	42,303	44,131
Within R^2	0.906	0.903	0.398	0.371	0.371	0.381	0.420

* $p < 0.05$, ** $p < 0.01$.
Note: Estimates in columns 1, 2, and 7 are the sums of coefficients on the current value and one lag of theindependent variables, while estimates in columns 5 and 6 additionally incorporate the second lag of the independent variables. Columns 3 and 4 report only contemporaneous coefficients. Standard errors (in parentheses) are clustered by country. For coefficient sums, standard errors are computed from the estimated coefficient covariance matrix. Within R^2s refer to the percent of variation explained after removing country effects.
Sources: Authors' calculations using data described in appendix A and data provided by Gopinath et al. (2020).

rejecting the Gopinath et al. assumption of zero coefficients.[19]

Exclusion of importer PPI biases the LCP coefficient downward because some importers have high domestic inflation (rising PPI) coupled with a depreciating exchange rate. In such a circumstance, an exporter following the LCP model would raise prices (in importer currency) in proportion to the rising importer PPI. When importer PPI is excluded from the regression, the coefficient on the importer-exporter exchange rate (or the importer-US exchange rate, both of which rise with a depreciation) will be biased upward to fill in the gap left by the missing PPI. As shown in Appendix B, the LCP effect is a negative function of the coefficients on these exchange rates in the Gopinath et al. regressions, reflecting the translation from exporter currency to importer currency. The upshot is that excluding importer PPI biases the LCP effect downward. By excluding importer inflation from their model, Gopinath et al. missed an important factor that influences export prices.[20]

None of the second lags in the regression of column 6 is statistically significant. Column 7 reports cumulative effects from a regression with only one lag.[21] The DCPUS coefficient is near 0 and almost equal to that of this paper, shown in column 2. The PCP coefficient is a bit smaller than that of column 2 and the LCP coefficient a bit larger.[22] This shift from PCP to LCP behavior likely reflects the greater proportion of developing economies and post-2000 data in the Gopinath et al. sample compared to the sample of this paper. As is shown in Table 1 of this paper, developing economies tend to be associated with somewhat larger LCP effects and smaller PCP effects, as are years after 2000.

Altogether then, different results on the export pricing models arise from different weights attached to very small trade flows, whether the focus is on short-run or long-run effects, whether the regression includes importer PPIs or second year lags, and whether the DCP variable is defined in US-only or US and euro-area terms. The DCP model appears to be relevant mainly for the smallest trade flows. When observations are weighted by the value of trade, the DCPUS coefficient declines from 0.78 to 0.58. The DCPUS effect declines further to 0.44 when expressed in terms of the long-run effect instead of the short-run effect. When US and importer PPIs are added as control variables, the cumulative effect declines further to 0.16. Finally, when insignificant second lags are dropped, the DCPUS effect declines to near 0, as is found in this paper.

[19] Gopinath et al. report results in an online appendix that relaxes the restriction of no importer PPIs but still omits US PPIs. (The regressions in columns 6 and 7 include US PPIs.) In their table 19, column 5 of the appendix, the contemporaneous DCPUS coefficient declines to 0.46 in the trade-weighted regression when importer PPI and importer GDP growth are included. The appendix does not report the sum of the DCPUS coefficients, which declines to 0.18.

[20] Exclusion of US PPI has much less impact because US inflation has been relatively stable over the sample period.

[21] Further restrictions that the long-run PPI effects equal the long-run exchange rate effects (as in the baseline model of Table 1) are rejected for the LCP term but the difference in long-run effects is only 0.03. These restrictions have essentially no effect on the sums of the coefficients or on the R^2 reported in column 7.

[22] When the regression of column 7 is run without trade weights, the coefficients are 0.22 on PCP, 0.27 on LCP, and 0.50 on DCPUS. This reflects a considerable decline in the DCPUS coefficient from that in column 3 but a much larger coefficient than that in column 7, suggesting that the smallest exporting firms are more inclined toward stabilizing prices in US dollars.

6. Conclusion

This paper examines the behavior of aggregate export prices in a sample of 33 advanced and developing economies from 1983 through 2019. It finds strong support for the Goldberg and Knetter (1997) canonical result that exporters adjust their prices by about half of any movement in exchange rates. The new twist is that exchange rate movements against importing countries account for only two-thirds of this price adjustment, while exchange rate movements against a dominant currency account for the other third. The dominant currency is generally the euro in Europe and Africa and the US dollar in Asia and the Western Hemisphere.

This paper does not support the claim that the dollar is the most important driver of export prices (Gopinath et al. 2020). The large coefficient (0.78) on the US dollar in Gopinath et al. declines to zero as (1) larger trade flows are given more weight in the regression, (2) results are reported in terms of cumulative rather than impact effect, (3) importer PPIs are included as control variables, and (4) insignificant second-year lags are excluded from the regression.

By finding only a small role for the DCP model and a larger role for the PCP model, this paper supports the traditional textbook view that exchange rate changes can have important effects on a country's export competitiveness and trade balance.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A: Description of data and list of countries in the Paper's sample

The primary sources of data are the International Monetary Fund's (IMF) Direction of Trade Statistics (DOTS), International Financial Statistics (IFS), and World Economic Outlook (WEO) databases; the World Bank's World Development Indicators (WDI) database; and several other sources accessed either via Macrobond or directly. All data are annual and were downloaded in June–August 2021, except as noted below.

The sample includes all countries with available data and 2019 nominal GDP greater than $10 billion, except the following: the United States, countries that use the US dollar as their main currency, euro area member countries, and economies with primary commodity exports higher than one third of their merchandise exports. The countries are listed in Table A1.

Commodity exports are the sum of exports of agricultural raw materials, food, fuel, and ores and metals (all expressed as a percentage of merchandise exports) in 2019 or, in the case of missing data, the most recent year with available data in 2015–18. GDP and commodity exports data used in determining the country sample were downloaded in February 2021 from the WEO and WDI databases, respectively. Transition economies (with IMF country codes above 900), except China and Hungary, are excluded from the regression sample before 2000. Otherwise, our baseline regression covers the period from 1983 to 2019.

Change in export prices (ΔPX) is the logarithmic percent annual increase in export prices of an exporting country. Export prices are goods and services export deflators, calculated by dividing nominal exports by real exports in exporter currency. Both series come from

Table A1
List of countries included in regression sample.

Countries for which ΔDCP takes values of ΔDCPUS		Countries for which ΔDCP takes values of ΔDCPEA	
1	China	18	Albania
2	Dominican Republic	19	Bosnia and Herzegovina
3	Hong Kong[A]	20	Croatia
4	India	21	Czech Republic
5	Israel[A]	22	Denmark[A]
6	Japan[A]	23	Hungary
7	Jordan	24	Morocco
8	Korea[A]	25	North Macedonia
9	Malaysia	26	Poland
10	Mexico	27	Romania
11	Pakistan	28	Serbia
12	Philippines	29	Sweden[A]
13	Singapore[A]	30	Switzerland[A]
14	Sri Lanka	31	Tanzania
15	Taiwan[A]	32	Turkey
16	Thailand	33	United Kingdom[A]
17	Vietnam		

"A" denotes advanced economy. DCP = dominant currency paradigm.
Note: Transition economies (with IMF country codes above 900), except China and Hungary, are excluded from the regression sample before 2000. Data for the United States and the euro area are used to construct some variables.

WDI. For China, export deflator data are obtained from the Organization for Economic Cooperation and Development's (OECD) Economic Outlook database via Macrobond. For Taiwan, nominal and real export series are accessed via Macrobond from the Taiwan Directorate General of Budget, Accounting and Statistics.

Change in exporter's producer price index (denoted ΔPCP since it is used to test the importance of the producer currency pricing hypothesis) is the logarithmic percent annual increase in the producer price index (PPI) of an exporting country. A wholesale price index (WPI) is used for the following countries, where either PPI data are not available or have fewer observations than the WPI series: India, Israel, Pakistan, the Philippines, Singapore, Sri Lanka, and Taiwan. The principal source for both PPI and WPI series is the IFS database. However, for a few countries with missing information data are obtained from national sources via Macrobond. In particular, the PPI statistics for China come from the China National Bureau of Statistics; data for Tanzania are from the Tanzania National Bureau of Statistics; and WPI data for Taiwan are from the country's Directorate General of Budget, Accounting and Statistics. For the Dominican Republic, manufacturing PPI (from the National Statistics Office) is used as industrywide PPI or WPI data are not available.

Missing PPI observations for some years are filled in based on country data from the Bank of Japan, Jordan's and Malaysia's Department of Statistics, the Mexican National Institute of Statistics and Geography, and the Vietnamese General Statistics Office. Central bank data are used to fill in missing WPI observations for Sri Lanka. These data are accessed via Macrobond.

For Israel, the WPI series provided in the IFS database appears to have been rebased in 1985 as the index suddenly drops after 1984. Thus, 1985 producer price inflation from the World Bank's Global Database of Inflation (June 2021 version; Ha et al., 2021) is used to readjust Israel's WPI series from 1985 onward.

Change in importer producer price index (denoted ΔLCP since it is used to test the importance of the local currency pricing hypothesis) is the trade-weighted logarithmic percent annual increase in PPIs in importing countries converted to exporter currency and calculated as follows:

$$\Delta \mathrm{LCP}_{it} = \left(\sum_{j \neq i} \left(\log(\mathrm{PPI}_{jt} {*} \mathrm{ER}_{jit}) - \log(\mathrm{PPI}_{jt-1} {*} \mathrm{ER}_{jit-1}) \right) \mathrm{w}_{ijt} \right) {*} 100,$$

where PPI_{jt} is the producer price index of an importing country, ER_{jit} is the bilateral exchange rate between the exporter (i) and importer (j) country (expressed as exporter currency per unit of importer currency), w_{ijt} is the weight representing the share of exporting country i's total exports flowing to importer j. In addition to all 33 exporting countries in our sample, calculations include the United States and the euro area as importers.

For the euro area, various PPI series are merged to construct a single index since no series is long enough to cover the entire period analyzed in this paper. Thus, the total output price index for industry (except construction, sewerage, waste management, and remediation activities) normalized at 100 in 2015 is used for 2000–19. From 1995 to 1999, this index is spliced with an analogous index normalized at 100 in 2010. Both series are downloaded from Eurostat. IFS data are used to extrapolate euro area PPI for all remaining years prior to 1995 (Eurostat presents PPI data for the current 19 euro area countries, whereas the IFS does so for only the original 11 euro area members).

Bilateral exchange rates are computed by dividing exporter's exchange rate by importer's exchange rate, both expressed vis-à-vis the US dollar (specifically, as domestic currency per US dollar). All exchange rates are annual averages and come from the IFS database, except the euro area exchange rate, which is obtained from OECD's Main Economic Indicators database via Macrobond.

Computations of weights use US dollar–denominated value of goods flowing from an exporting to importing country, which is reported on a free on board (FOB) basis. Because of data availability issues, Taiwanese bilateral exports are based on bilateral imports reported by its trading partners on a cost, insurance, and freight (CIF) basis. Because euro area PPI data cover only the original 11 member countries before 1995, export weights before that are limited to the same 11 countries. All trade data come from the DOTS database.

Change in US producer price index (ΔDCPUS) is the logarithmic percent annual increase in US PPI converted into exporter currency. Data are from IFS.

Change in euro area producer price index (ΔDCPEA) is the logarithmic percent annual increase in euro area PPI converted into exporter currency. Data sources are described above under importer PPI.

Change in dominant currency producer price index (denoted ΔDCP since it is used to test the importance of the dominant currency paradigm) takes values of ΔDCPUS for Asian and Western Hemisphere countries (including Israel and Jordan) and values of ΔDCPEA for African and European countries (including Turkey).

Appendix B: A General model of export pricing

This appendix presents the simplest model of export pricing that nests both the baseline model estimated in this paper and the model of Gopinath et al. (2020). This enables a comparison of the coefficients reported by Gopinath et al. with those reported here. For simplicity of exposition, the model does not include lags, but it is easy to add lags.

$$\Delta \mathrm{PX}_{ijt} = \beta \Delta \mathrm{PPI}_{it} + \gamma \Delta \mathrm{PPI}_{jt} + \lambda \Delta \mathrm{ER}_{jit} + \mu \Delta \mathrm{PPI}_{Dt} + \delta \Delta \mathrm{ER}_{Dit} + \mathrm{u}_{ijt} \quad \text{(B1)}$$

Subscript i refers to the exporting country, subscript j the importing country, subscript D the dominant currency country, and subscript t the year. The residual, u_{ijt}, includes country fixed effects, year effects, and any remaining unexplained variation. ER_{ab} is the exchange rate that converts values from currency a to currency b, that is, units of currency b per unit of currency a. The parameters (lower-case Greek letters) differ from those used in the main regression equation above. Here β refers to the PCP effect, γ and λ to the

LCP effect, and μ and δ to the DCP effect.

The regressions of Table 1 are based on a version of equation (B1) with lags added and the restrictions $\gamma_1 + \gamma_2 = \lambda_1 + \lambda_2$ and $\mu_1 + \mu_2 = \delta_1 + \delta_2$ imposed, where the subscripts 1 and 2 refer to the coefficients on the contemporaneous and lagged variables. The restrictions are based on the assumption that exporters respond only to exchange-rate adjusted competitors' prices in the long run, with exchange rates and foreign prices possibly having independent effects only in the short run. The restrictions are based on the property of logarithmic changes, for which $\Delta\log(ab) = \Delta\log(a) + \Delta\log(b)$.

Gopinath et al. (2020) use import prices in terms of importer currency. Equation (B2) converts the general model into terms consistent with their regressions, where *i* continues to refer to the exporter and *j* to the importer. This conversion uses the identities: $\Delta PX_{ij} = \Delta PM_{ij} - \Delta ER_{ij}$ and $\Delta ER_{ij} = -\Delta ER_{ji} = \Delta ER_{iD} + \Delta ER_{Dj}$.

$$\Delta PM_{ijt} = \beta\Delta PPI_{it} + \gamma\Delta PPI_{jt} + (1 - \lambda - \delta)\Delta ER_{ijt} + \mu\Delta PPI_{Dt} + \delta\Delta ER_{Djt} + u_{ijt} \tag{B2}$$

Note that the exchange rates, ER_{ji} and ER_{Di}, have been replaced by ER_{ij} and ER_{Dj}. The coefficients on most terms are identical in B1 and B2. The exception is the coefficient on the exchange rate between the exporter and importer, which is affected by (1) the transition from exporter to importer currency and (2) the transition from dominant currency exchange rate against exporter to dominant currency exchange rate against importer. It is still possible, however, to calculate the LCP effect, λ, based on the estimated coefficients on the two exchange rates. In their Table 3, Gopinath et al. impose the restrictions $\gamma = 0$ and $\mu = 0$, including on lags.

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