EXPORT DIVERSIFICATION: IS THERE ANYTHING TO THE HUMP?

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Abstract. We question the robustness of the quadratic shape of the development-diversification nexus that has dominated the applied trade diversification literature. Accounting for time specific heterogeneity reveals that this relationship is tenuous. Additional robustness checks further lend support that taking the quadratic relationship as a stylized fact may not be advisable.

1. Introduction

Economic theory suggests that export concentration is optimal, and yet we see a wide array of diversification behavior across countries and time. Consistent with the seminal work of Imbs & Wacziarg (2003), as countries migrate through different stages of development, trade diversification takes on differing levels of importance. Recently, Klinger & Lederman (2006), Parteka (2007) and Cadot, Carrère & Strauss-Kahn (2011) empirically investigate the presence, or lack thereof, of a quadratic, 'Kuznets' type relationship between export diversification (more appropriately concentration) and economic output (measured as GDP per capita). If the development story of Imbs & Wacziarg (2003) holds then one expects for low levels of income, countries are highly concentrated, then countries diversify as they grow, and once they reach a certain point of development they reconcentrate to exploit their natural comparative advantages. An important policy concern is where this level of development is.

International Monetary Fund and University of Miami
Date: March 24, 2016.
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* We benefited from discussions with Olivier Cadot and Nikola Spatafora. The views expressed in this study are the sole responsibility of the authors and should not be attributed to the International Monetary Fund, its Executive Board, or its management. This document was compiled in `knitr` using RStudio 0.98.977.

Given the concentrate-diversify-reconcentrate argument, a quadratic-type relationship between income per capita and trade diversification should emerge. The preeminent study on this topic is Cadot et al. (2011) who use an unbalanced panel of over 140 countries, across four different measures of trade diversification and estimate a turning point in the development-diversification nexus around $25,000 which is remarkably consistent across the four measures and robust to alternative econometric approaches which they take to the data.

A key finding of Cadot et al. (2011) is that if the Theil index is used, then an additive decomposition is available that allows one to determine if diversification is occurring along the intensive (new products-new trade partners) or extensive (higher volumes) margin. This decomposition is remarkable in its simplicity and ability to shed deeper insight into key policy issues regarding trade diversification.

With the importance of trade in the global economy, the study of the trade diversification-income nexus is paramount. Here we reexamine the study of Cadot et al. (2011), first attempting to replicate their initial estimates and then considering several alternative modeling exercises. Overall, we are able to successfully replicate the main findings of Cadot et al. (2011). We take issue with one key aspect of their panel estimation, the inclusion, or lack thereof, of time specific heterogeneity, which in turn, draws into question both the presence and location of the turning point in the diversification-development nexus. Amongst the four distinct measures of diversification that Cadot et al. (2011) propose, only the number of product lines appears robust. This is unfortunate given that the Theil index is the desired measure of diversification given the decomposition into the intensive and extensive margins. Further, several alternative estimation strategies do not help to fully rectify this uncertainty. Additionally, we also use a thicker granularity of export products which allows us to extend our data in the time dimension (while giving up little in the country dimension). With this more aggregated data we still reach the same conclusion: there is considerable uncertainty about the existence and location of the turning point within the diversification-development nexus.

2. The Replication

2.1. **The Baseline Empirical Specification.** In order to discern if a hump shape exists in the income-diversification nexus, Cadot et al. (2011) estimate a quadratic in income for four different measures of trade diversification for country i at year t:

$$TD_{it} = \beta_0 + \beta_1 GDPpp_{it} + \beta_2 GDPpp_{it}^2 + \alpha_i + \lambda_t + \varepsilon_{it}. \tag{1}$$

Here TD_{it} is either a Theil (T), Gini, or Herfindahl (HHI) index, or the number of product lines (Nber) that country i exports at time t and $GDPpp$ is gross domestic product per capita in 2005 purchasing power parity (PPP) dollars (scaled by \$10,000). A U-shaped export diversification path would require that $\beta_1 < 0$ and $\beta_2 > 0$ for the first three indices while the opposite is expected to be true for the number of open product lines. Using UNCTAD's COMTRADE HS6 (the finest level of granularity) over 4,991 product lines for 141 countries over the period 1988-2006, a turning point estimate of approximately \$20,000-\$30,000 is found across all four measures of diversification for a variety of assumptions placed on the estimation model in (1).

2.2. **The Empirical Results.** First, we simply aim to replicate the baseline findings of Cadot et al. (2011) by estimating model (1), and using, as these authors did, an unbalanced panel of 141 countries over the period 1988-2006. The data are sourced from the World Bank for income per capita and the UNCTAD COMTRADE database for trade measures.[1]

The main findings of Cadot et al. (2011) are replicated successfully in 1. As in Table 2 in Cadot et al. (2011) we estimate model (1) under three different scenarios for each of the four measures of trade diversification. First, we ignore the panel structure and estimate the model as a pooled panel with time dummies. Second, we exploit the panel structure and

[1]We mention that while Cadot et al. (2011) say they drop microstates, i.e. those countries with populations less than one million, in actuality, they drop countries whose average population over the entire sample period is less than one million. Thus, Gabon, The Gambia and Guinea-Bissau are not dropped, even though all three countries had populations under one million in the late 1980s and early 1990s. The results of Cadot et al. (2011) are robust if these three countries are not included in the analysis.

estimate the model under the fixed effects framework, but do not include time dummies to capture unobserved time heterogeneity. Third, we estimate a between effects version of model(1) by aggregating over time.[2]

TABLE 1. Replication of Within Estimates from Table 2 in Cadot et al. (2011). HHI is the Herfindahl index for trade diversification.

	Theil	HHI	Gini	Nber
GDPpc	-0.7794	-0.0650	-0.0263	3898.7918
	(0.1587)	(0.0293)	(0.0028)	(162.6998)
$GDPpc^2$	0.1832	0.0138	0.0059	-568.1568
	(0.0297)	(0.0055)	(0.0005)	(30.4266)
Turning Point ($)	21,269	23,531	22,447	34,311

Note: Using HS6 aggregation data from Cadot et al. (2011).

2.3. **Including Time Fixed Effects.** To our surprise though the most appropriate panel specification that would include both country *and* time fixed effect was not considered. Given the use of annual data (19 year horizon) and the level of granularity of the HS6 measurement, time effects would help smooth out year-to year fluctuations that might unduly influence the overall estimates. In fact correcting for both country and time fixed effects has become the baseline specification in the vast majority of cross-country regressions — and we do not see any theoretical or empirical reason why this paper should be an exception.

Perhaps one might argue that the time effects are simply not necessary and their inclusion only leads to a model which obfuscates the diversification-development nexus. Looking at the average of each of the four measures of diversification across time reveals interesting patterns (Figure 1). We see that for our three indices they are all decreasing over time whereas the number of product lines is increasing over time. Moreover, there appears to be more variation in each of the four measures in the early years of the data. Another

[2]To be exact, there is a small inconsistency in our results: our coefficient estimate for $GDPpcppp^2$ for the number of product lines (Nber) differs somewhat from that obtained by the authors, leading to a higher estimate of the turning point. This is inconsequential, however, as the main finding of Cadot et al. (2011) holds up, namely that there is a hump shape in the income-trade diversification nexus.

reason to account for time effects is that during the 1990s the technology boom was in full force and so new products, and means of constructing and delivering products was taking shape during this period. This is confirmed by looking at Figure 2, which plots the time period specific standard deviations of each of the four measures of trade diversification after standardization. Values greater than 1 indicate greater than normal time variation whereas values less than one indicate less than normal time variation, relative to the entire time frame. Both the Theil and Herfindahl indices display greater than normal time variation at the start of the study, whereas the Gini index has greater than normal time variation in the middle of the time period. The number of product lines has the least amount of variation across the time frame. With this graphical information, we therefore re-estimate model (1) accounting for time variation through the fixed effects framework and present estimates in Table 2.

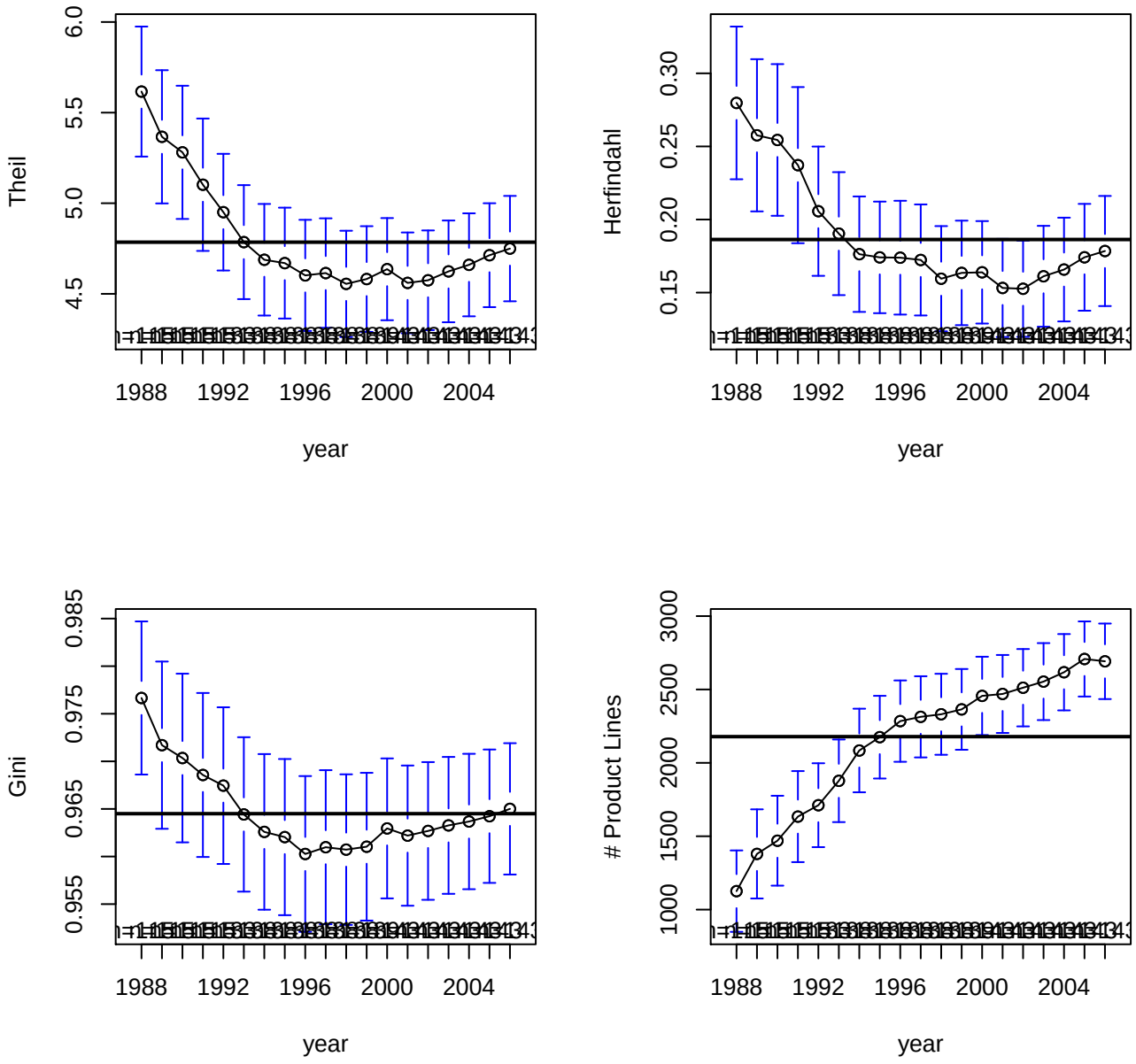
TABLE 2. Within Estimates including Time Effects. HHI is the Herfindahl index for trade diversification.

	Theil	HHI	Gini	Nber
GDPpc	0.7358	0.1313	-0.0107	1272.7926
	(0.1483)	(0.0312)	(0.0028)	(119.3932)
$GDPpc^2$	0.0349	-0.0057	0.0045	-299.5895
	(0.0255)	(0.0054)	(0.0005)	(20.5185)
Turning Point ($)	-105,360	115,763	12,006	21,242
Time Effects	0.000	0.000	0.000	0.000

Note: Using HS6 aggregation data from Cadot et al. (2011).

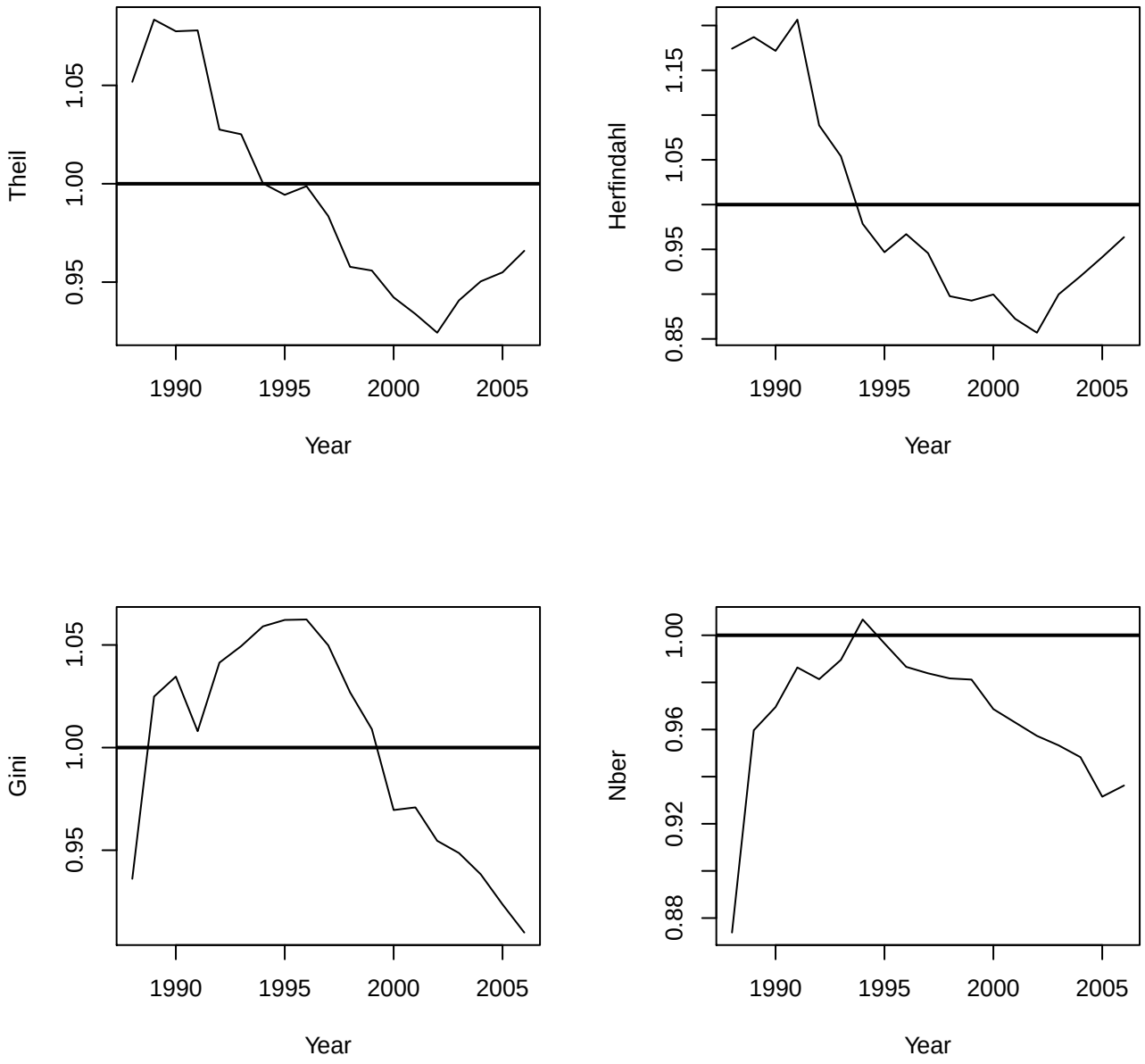
What is immediately noticeable is that coefficient estimates for the income turning point are strikingly different from those obtained by Cadot et al. (2011). For both the Theil and Herfindahl indices, there is no hump shaped relationship; in fact the relevant coefficient estimates do not have the correct signs to suggest the appropriate quadratic relationship. Moreover, the quadratic specification seems to suggest a negative turning point. Diversification, as measured by the Herfindahl index is strictly decreasing in income, whereas it is

FIGURE 1. Time Heterogeneity in Average of Trade Diversification Indices



strictly increasing for the Theil index over all positive income. Both the Gini index and the number of product lines confirm to initial findings of Cadot et al. (2011) though the

FIGURE 2. Time Heterogeneity in Variation in Trade Diversification Indices



estimated turning point is almost 50% smaller than what was originally estimated. In this case, there are an additional 17 countries above the turning point: Bahrain, Cyprus, Czech

Republic, Gabon, Hungary, Iceland, Kuwait, Luxembourg, New Zealand, Oman, Portugal, Qatar, Saudi Arabia, Slovak Republic, Slovenia, South Korea and United Arab Emirates.

We note that a working paper version of Cadot et al. (2011) (Cadot, Carrère & Strauss-Kahn 2007) does include time fixed effects. However, almost no discussion of the results are provided, with the authors mentioning "Indeed, the second block of Table 5, which reports estimates with time and country fixed effects, shows no turning point at all." Further, it seems somewhat inconsistent to include time effects when estimating the pooling model and then drop them when gravitating towards the fixed effects framework.[3]

One potential reason that the time effects may wipe away the quadratic impact of GDP is simply that they do not belong in the model. We can easily test for this using a standard F-test for the joint significance of the time effects. For each of the four within models, we reject at all conventional levels the null hypothesis that the time effects are jointly statistically insignificant, confirming their presence in the model. Further, the presence of the time effects does not render the impact of GDP on trade diversification insignificant. While the hump may disappear, in none of the four models is GDP a statistically insignificant predictor of trade diversification. It may simply be that there is no empirical support for a hump in the data. We note that this result in noway invalidates the seminal contribution of Cadot et al. (2011) on the decomposition of the Theil index into the intensive and extensive margin. We simply mention that the inclusion of time specific heterogeneity makes it difficult to detect the classic diversification-development nexus.

[3]Table 3 in Cadot et al. (2011) does provide robustness checks of their main results and, using system GMM with time effects does result in the appropriate hump shape for all four measures of trade diversification. However, given that the trade diversification relationship is sought as a stylized fact, our estimates here uncover some concerns. Moreover, the 'black box' nature of system GMM (Bazzi & Clemens 2013), coupled with the myriad array of potential instruments (Roodman 2009), warrants caution in interpreting these findings as stylized facts. Second, it reveals that the diversification-income U-shape relationship is at most a weak relationship and certainly when using export data.

3. Alternative Specifications

Perhaps it is unreasonable to think that trade diversification across countries varies much on an annual basis that inclusion of time specific heterogeneity assists in overfitting the model. However, it may be the case that changes occur over more lengthy periods, perhaps three to five years, where the HS classification has undergone changes in product lines which may affect overall accounting of diversification. A simple approach to this would be to use a time averaged version of the model in (1). Given that we have 19 years of data, we use three and six year averaging, dropping the 1988 observations from the data.[4]

Our estimates of the four within models under this scenario appear in Table 3. We see that in this case our estimates for both Theil and Gini indices are roughly consistent with Cadot et al.'s (2011) full panel results ignoring time effects. However, the estimated turning point for the number of product lines is considerably larger than their initial estimates. In fact, no countries would be above this turning point over the entire period. Lastly, we see that the HHI index of trade diversification again fails to display robustness, with the coefficient estimates having the wrong signs and the estimated turning point being almost four times as large as initially reported. Moreover, the estimated relationship is such that as countries grow beyond the turning point that diversification increases (as opposed to the general intuition that diversification decreases after the turning point).

4. Using an Alternative Dataset

Not obtaining the expected U-shaped relationship when using both country and time fixed effects for either the Theil or Herfindahl index (the most common indices in existing work) raises questions as to whether the relationship is indeed as robust as most of the literature believes. A consideration worth investigating further is the relatively short time dimension of the dataset used in Cadot et al. (2011). That is, perhaps the short period of study (1988-2006) could only capture partially the experience of different countries along different stages

[4]Our findings are qualitatively identical to dropping 2007, the last period as well.

TABLE 3. Within Estimates for (1) using 3 and 6 year averaging. HHI is the Herfindahl index for trade diversification.

	3-year Averaging				6-year Averaging			
	Theil	HHI	Gini	Nber	Theil	HHI	Gini	Nber
GDPpc	-0.5702	0.0348	-0.0207	2626.8371	-1.0936	-0.0201	-0.0298	3189.0510
	(0.2140)	(0.0376)	(0.0038)	(234.4974)	(0.3410)	(0.0583)	(0.0060)	(378.8831)
$GDPpc^2$	0.1248	-0.0017	0.0038	-310.6439	0.2091	0.0070	0.0048	-394.0497
	(0.0399)	(0.0070)	(0.0007)	(43.7313)	(0.0658)	(0.0113)	(0.0012)	(73.1577)
Turning Point ($)	22,848	99,907	27,489	42,281	26,145	14,320	30,847	40,465

Note: Using HS6 aggregation data from Cadot et al. (2011).

of their development process and therefore failing to adequately reflect the entire U-shape path of diversification.

A possible way to improve the time-dimension issue is by considering instead the HS4 level trade data. Moving to this lower level of granularity has the advantage of extending the time frame both backwards, to 1962, and forwards, to 2010, to determine if the hump appears over a longer time horizon. While there is loss of information at the cross-sectional dimension there is an significant increase in the time dimension (from 19 to 49 years). We use the data in Papageorgiou & Spatafora (2012) to reestimate model (1) focusing on the Theil index (that most commonly used in the literature).

Table 4 presents both pooled and within estimates using the HS4 trade data constructed Theil index. We present our estimates both for the full time frame available, 1962-2010, as well as the time frame specific to Cadot et al.'s (2011) analysis, 1988-2006. The within estimates are calculated both including and excluding time effects. The results are stark. First, using the 1988-2006 time frame (i.e. using HS4 data instead of HS6 data for the same time horizon as the one used by Cadot et al.'s (2011)) we show that the pooled data estimates are consistent with the expected hump shape and an estimated turning point of around $25,000, while when we allow for country and time fixed effects continue to show no evidence of the hump. Most importantly, when we use the HS4 level data of the entire time

TABLE 4. Estimates using HS4 level aggregation, Theil Index Only.

	Pooled		Within no time effects		Within time effects	
	1962-2010	1988-2007	1962-2010	1988-2007	1962-2010	1988-2007
GDPpc	-1.8857	-1.8956	-0.5282	0.1840	-0.0128	0.4357
	(0.0413)	(0.0646)	(0.0398)	(0.0812)	(0.0431)	(0.0892)
$GDPpc^2$	0.36917	0.37807	0.12283	0.00989	0.05947	-0.01744
	(0.01211)	(0.01919)	(0.00830)	(0.01482)	(0.00828)	(0.01524)
Turning Point ($)	25,539	25,070	21,502	**-92,967**	**1,078**	**124,934**
# Countries	131	134	131	134	131	134
# Observations	5,534	2,441	5,534	2,441	5,534	2,441

Note: Using HS4 aggregation data from Papageorgiou & Spatafora (2012).

period of 1962-2010 including both time and country effects we once again, and against our prior, fail to uncover the hump shape.

5. CONCLUSION

This work has investigated the shape of the trade diversification-development nexus. Following the seminal contribution of Cadot et al. (2011), we find that when time effects are accounted for within the panel structure that the seeming robustness of the trade diversification hump is much less obvious. What does this mean? First, the lack of empirical robustness of various measures of trade diversification suggests that the stylized fact of a hump shape in the trade diversification-development nexus requires more care and thought. Second, rather than the use of annual measures, more aggregated measures could be deployed to smooth out product lines or channels of trade that are short lived to aptly capture the long term effects of trade. Indeed, we see that, using the Theil index, the prominent hump shape is robust to both three and six year averaging even though several other measures are less resistant in this setting. Making strong arguments about reconcentration as a path that most countries will follow requires further investigation - and perhaps be more closely linked

to the emerging literature of quality upgrading (indices using trade data on prices rather than volumes).

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Paper title: Export Diversification: Is there Anything to the Hump?

Sources of financial support: No financial support

Interested parties that provided financial or in-kind support: None
(An interested party is an individual or organization that has a stake in the paper for financial, political or ideological reasons.)

Paid or unpaid positions in organizations with a financial or policy interest in this paper: None

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The Canadian Journal of Economics
La Revue canadienne d'économique

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Paid or unpaid positions in organizations with a financial or policy interest in this paper: None

If the paper was partly or wholly written under contract, please write the name of the organization:

Does the paper satisfy all CJE guidelines on originality, authorship, and conflicts of interest as set out in the CJE's Conflict of Interest and Ethical Guidelines for Authors? Yes

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