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# The Economic Complexity Index (ECI) and Output Volatility: High vs Low Income Countries

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# The Economic Complexity Index (ECI) and output volatility: High vs low income countries[1]

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## Abstract

In this study we explore whether more complex economies are better shielded against exogenous shocks. We contribute to the empirical literature on determinants of output volatility by introducing a relatively new index on productive capabilities of export goods, the Economic Complexity Index (ECI), developed by Hausmann et al. (2014). The ECI measures the productive capabilities of countries by explaining the knowledge accumulated in a population based on the goods they produce and export and to which countries they export. As such, not only does this measure capture diversification but also the technology embedded in the products. Using panel data analysis for a cross section of countries from 1984 to 2016, we find variations in the effects of ECI on output volatility between high and low income countries. For high income countries, increases in ECI reduce output volatility in the short to medium term (under 3 years), whereas we observe a longer delay in output volatility moderation for low income countries. The findings suggest that low income countries have less diversified and less complex export goods which leave them open to external shocks and reduce their ability to adjust quickly to the shocks. Furthermore, disaggregation by regions reveals that economic complexity in Asia is relatively more effective at reducing output volatility than in Africa. The difference between the two regions could be due to Africa's primary production and exports being in relatively homogenous goods with no differentiation and subject to the volatility of world markets.

Key words: output volatility, export diversification, economic complexity, panel data, high vs low income countries, fixed effects model, ECI

JEL classifications: E32, F10, C23, O57

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## 1. Introduction

It is widely acknowledged in the literature that high macroeconomic output volatility has adverse effects on long-term economic growth, welfare and poverty and is associated with lower investment in human capital (Aizenmann & Marion, 1999; Bruno & Easterly, 1998; Fatas & Mihov, 2006; Hakura, 2009). Furthermore, poor countries have been shown to experience higher output volatility than rich countries, mainly because poor countries are more vulnerable to exogenous shocks, such as terms of trade shocks and financial crises (Easterly et al., 2001). While several studies have reported declining volatility in high income countries in the past two decades (Blanchard & Simon, 2001), output fluctuations have remained persistently higher in low income countries (Hakura, 2009). This interesting trend in output volatility between the two income groupings may arise because the high income countries have been experiencing more stable economies in the last two decades than poor countries, which protects them from shocks in macroeconomic variables. On the other hand, low income countries are almost always in a state of economic uncertainty, which exposes them to volatile output changes (Easterly et al. 2001).

Given the volatility differences between high and low income countries, we contribute to the strand of literature that examines the causes of output volatility, with a particular focus on the role of export diversification. We are especially interested in observing if the differences in export diversification are one of the mechanisms that can explain the differences in output volatility between the high and low income countries. A novel aspect of this study is the introduction of a relatively new measure related to export diversification through the Economic Complexity Index (ECI) developed by Hausmann et al. (2014). According to Hausmann et al. (2014), countries with high GDP per capita tend to have more complex export baskets than countries with low GDP per capita. If this is the case, we expect to observe some variation in the effects of export complexity on output volatility between high and low income countries.

Using panel data from 1984 to 2016 for 109 countries, we find that low income countries experience a delayed effect in reducing output volatility from export complexity, compared to high income countries. The findings suggest that poor countries tend to specialise in less complex export goods which increase their exposure to real exogenous shocks (Krishna & Levchenko, 2009), and reduces their ability to adjust quickly to these risks compared to high income countries (Imbs & Wacziarg, 2003). As such, it may be important for low income countries to focus on increasing product differentiation and complexity in their export goods basket at early stages of development, thus reducing their dependence on volatile export markets, such as primary commodity markets, which tend to be susceptible to exchange rate fluctuations and international commodity price shocks.

## 2. Literature review

Output volatility has been shown to have potentially serious macroeconomic implications, with evidence from Ramey and Ramey (1995) showing that countries with higher output volatility have a tendency to grow more slowly. Several studies have focused on the sources of output volatility through terms-of-trade volatility, the degree of openness to trade, and country

size (Malik & Temple, 2009; Jansen, 2004; Easterly & Kraay, 2000; Rodrik, 1997). Malik and Temple (2009) emphasises the role of governance (domestic policy mismanagement resulting in high inflation, overvalued exchange rates or sustained budget deficits), the role of the financial sector and the role of institutional and political factors as important sources of output volatility. They use Bayesian methods to examine these structural determinants of output volatility and find that terms-of-trade volatility explains output volatility regardless of the choice of conditioning variables, which supports the view that external shocks are paramount in explaining volatility in poorer countries. They also find that export diversification has substantial explanatory power even though it is lower than that of terms of trade volatility. According to Cavallo et al. (2008), shocks could be of domestic or external origin and in the case of external shocks, transmitted through trade and/or financial channels.

Numerous papers also investigate the differences in volatility between developed and developing countries. These fall mainly in two broad categories. The first is that developing countries are subject to larger shocks than developed countries (Mendoza, 1995; Koren &Tenreyro, 2007; Imbs & Wacziarg, 2003; Uribe & Yue, 2006), and the second, that countries are more vulnerable to these shocks because government policy or structural characteristics (such as the degree of financial development or labor regulations) tend to amplify the real effects of shocks in developing countries whereas in developed countries they help to mitigate aggregate instability (Caballero & Krishnamurty, 2001; Fatas & Mihov, 2006). Radatz (2008) looks at the ability of these two types of explanations to account for differences in volatility between Latin America compared and other groups of countries. They determine the contribution of the volatility of external shocks (exposure) and of the responsiveness of output to these shocks (vulnerability) to the level of output volatility observed in Latin America and other regions. They use a comprehensive set of real and financial external shocks and find that higher output volatility of Latin America relative to countries in East Asia, the Pacific and Western Europe, or high income countries in general, is mainly driven by higher volatility of external shocks (i.e. a higher exposure), and not by a higher vulnerability to them.

Some researchers have proposed export diversification as a mitigating strategy to counter output volatility related to external shocks. Haddad, et al. (2013) shows that the effect of openness on volatility depends on the degree to which a country's export basket is diversified. Bacchetta, et al. (2007) focuses on the external sources of volatility and pay special attention to whether diversification affects developed and developing economies in different ways. They also distinguish between product and geographic diversification and find that for lower income countries product differentiation (export concentration in terms of product basket) plays an important role in income volatility. For richer countries, product diversification plays a smaller role, while geographical diversification (level of diversification of their export markets) plays a more significant role in determining income volatility.

Building on this research, Krishna and Levchenko (2009) investigates the linkage between trade openness, specialization, and volatility in terms of the complexity of goods being produced, using sectoral product complexity, instead of export diversification indices. Complexity is defined by them as the number of different inputs required for the production of one unit of the good. They show that sectoral output volatility depends on the complexity of goods produced in that sector. This is because when individual inputs to production are subject to shocks, the volatility of output will depend on how many such inputs there are. In particular,

the more complex goods are less volatile as the production in a sector that uses many inputs will be less affected, on average, by shocks to any particular input (a point also emphasized by Koren & Tenreyro, 2007). In summary, they find that less developed countries with low levels of human capital, or alternately, with lower institutional ability to enforce contracts, will specialise in less complex goods which are also characterised by higher levels of output volatility.

In this paper, we build on the work of these authors, especially the work by Krishna and Levchenko (2009) by investigating the link between economic complexity and output volatility. However, we contribute to the literature by 1) using a more comprehensive measure of economic complexity (ECI) related to the capacity of economies to diversify their exports, and 2) conducting a comparative study between low and high income countries with this relatively new measure. Export complexity is still a relatively underexplored theme in the current empirical literature on output volatility. The next section is devoted to briefly explain the ECI.

## 3. The Economic Complexity Index (ECI)

Economic complexity is a measure of the knowledge in a society that gets translated into the products it makes. A country is considered 'complex' if it exports not only highly complex products (determined by the Product Complexity Index), but also a large number of different products. For example, the heterogeneity between the economies of Germany and South Africa goes beyond differences in area, population size or policies. The South African economy has different inputs (productive capability) that can be used to produce a different mix of outputs compared to Germany.

However, measuring such different and complex productive capabilities is difficult. As such, Hausmann et al. (2014) proposes using a measure, called the *Economic Complexity Index*, which tries to measure capabilities indirectly by looking at the mix of products that countries export. The assumption is that productive capabilities determine the number and quality of products that a country can export; so export bundles tell us something about the underlying productive capabilities. For example, we might infer that Germany and Japan have similar productive capabilities, because they are both able to produce a similar set of goods.

The ECI takes data on exports, and reduces a country's economic system into two dimensions: (i) The 'diversity' (i.e. the number) of products in the export basket, and (ii) the 'ubiquity' of products in the export basket (i.e. the number of countries that export similar products). The least complex countries, at the bottom of the ECI rank, are those that export few different types of products (i.e. have export baskets that are not diversified), and those products that they do export are exported by many other countries. Therefore, a country like Germany ranks high in economic complexity, because it exports many different kinds of sophisticated products that are only exported by a handful of other countries with similarly diversified productive capacities.

We use Hausmann et al.'s (2014) analogy of Singapore and Pakistan to further explain the concept of ECI. The population of Pakistan is 34 times larger than that of Singapore. At market prices their GDPs are similar and therefore Singapore is 38 times richer than Pakistan in per

capita terms. They both export a similar number of different products, about 133. However, Pakistan exports products that are on average exported by 28 other countries, while Singapore exports products that are exported on average by 17 other countries. Moreover, the products that Singapore exports are exported by highly diversified countries, while those that Pakistan exports are exported by poorly diversified countries. In this case, Singapore has a higher ECI than Pakistan. According to Hausmann et al. (2014), countries with a high ECI are associated with accelerated growth in GDP per capita.

Ultimately, the ECI informs us that what countries make reveals their knowledge capabilities. Increased complexity is necessary for society to be able to hold and use larger amounts of productive knowledge. As a result, the ECI in effect captures significantly more growth-relevant information, such as human capital and technology capabilities than traditional export diversification measures, such as terms of trade shocks.

## 4. Empirical Analysis

### 4.1 Data and Methodology

The specification of our base model is:

$$Y_{it} = \alpha_i + \delta_t + \beta_1 ECI_{it-1} + \beta_i X_{it-1} + \mu_{it}$$

where $Y$ is output volatility in GDP per capita in country $i$ in year $t$, $ECI$ is the Economic Complexity Index, $X$ is a vector of controls obtained from the World Development Indicators and the Polity IV Project. $\alpha$ and $\delta$ are country and year fixed effects. The dependent variable ($Y$) is the output volatility calculated as the residual of the differenced log of the real gross domestic product per capita (GDP) at constant 2010 US$ between 1984 and 2016.[3] The time frame is limited by the availability of the ECI index.

We base our choice of control variables on past literature that identifies economic, monetary and fiscal policy indicators as determinants of output volatility (Balavac & Pugh, 2016; Hakura, 2009; Malik & Temple, 2009). We briefly present the variables and expected signs but a more detailed discussion of the variables and mechanisms follows in the Results section. Our economic indicators include the logs of trade openness (exports and imports as a percentage of GDP), financial development (domestic credit to private sector as a percentage of GDP), real gross domestic product (GDP) per capita as a measure of the size of the economy, and the residual of the net barter terms of trade index to measure terms of trade volatility (*totvol*). We use general government final consumption expenditure as a percentage of GDP for the fiscal indicator, and inflation measured as the annual percentage of consumer prices for the monetary indicator.

Trade openness exposes countries to exogenous shocks so we expect a positive association with output volatility (Balavac & Pugh, 2016). We also expect higher terms of trade volatility and inflation to increase output volatility through price shocks (Hakura, 2009, Rohn et al., 2009). According to Hausmann and Gavin (1996), developed financial markets can act as shock absorbers that stabilise a country's output in times of crisis. We therefore expect a negative

[3] The specific method is estimating

$$\Delta \ln(RGDPpc) = \ln(GDPpc)_{t-1} + \ln(GDPpc)_{t-2} + \ln(GDPpc)_{t-3}$$

and estimating the residual.

association between financial development and output volatility. Countries with higher GDP per capita are expected to have less volatility because richer countries are associated with better access to credit and more stable macroeconomic policies (Balavac & Pugh, 2016; Malik & Temple, 2009). We expect government expenditure to increase output volatility through mismanagement of public funds (Fatas & Mihov, 2006).

We also include an institutional variable, the polity score. The index is a revised combined score that is computed by subtracting the autocracy score from the democracy score. The resulting unified polity score ranges from -10 (strongly autocratic) to +10 (strongly democratic). A decrease/increase in the polity score will indicate a decrease/increase in democracy. The variable is normalised so that the values are between zero and one. The country's ability to manage external shocks is influenced by the quality of institutions. We therefore expect a negative association between the polity measure and output volatility (Rodrik, 1999).

Country and year fixed effects are captured by $\alpha_i$ and $\delta_t$ respectively. We use the fixed effects (FE) method that has been suggested in literature for estimating heterogeneous panels that are large in cross section and large in time series. The FE method gives more efficient estimates because it allows for unobserved country and time differences through individual specific effects, such as historical and colonial background, and ethnic and religious composition, thus minimising economic and statistical endogeneity. The method pools the time series data for each group and allows the intercepts to differ across the groups. We also use robust standard errors to deal with potential presence of heteroskedasticity and serial correlation which can result in biased estimates and inferences.

To further reduce the potential bias that may come from economic endogeneity in the form of reverse causality, we estimate a model with lagged explanatory variables.[4] The lagged terms also allow us to model a delay in the responsiveness of output volatility to changes in the determinants during the period under review. We are therefore able to distinguish between short-term and long-term effects of ECI on output volatility.

We split our sample of countries into high vs. low income. We create an indicator variable for high and low income by comparing each country's mean of GDP per capita relative to the World's mean. Low income countries have average means below the world mean income. The income classifications can be found in Table A1 in the Appendix.

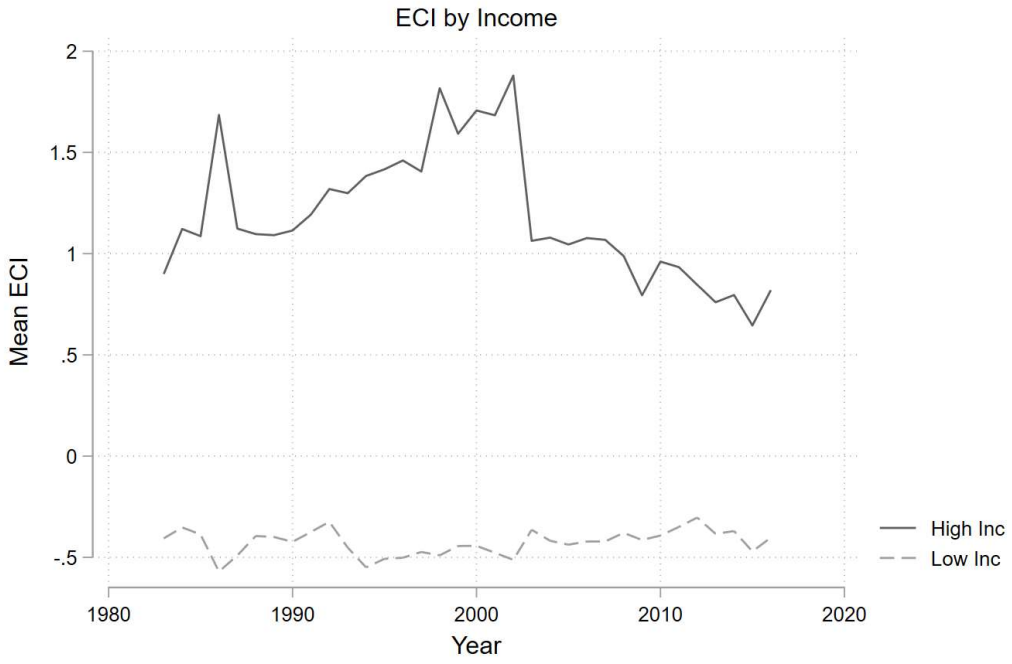
### 4.2 Descriptive Statistics

In Figure 1 we plot the mean ECI of high and low income countries over time. High income countries tend to have relatively higher levels of economic complexity in comparison to the low income countries. According to Hausmann et al. (2014), the more complex a country's economy, the more adaptable it is to market changes. We therefore expect a negative correlation between economic complexity and output volatility. However, when we perform a correlation analysis between ECI and output volatility (see Table 1), we find that ECI is positively

[4] We check for endogeneity in the main explanatory variable (eci) using the Hausman test and find that the variable is exogenous.

correlated with output volatility. We discuss this result in more detail in Section 4.3. The correlation of the control variables are mostly in line with what we expect from the literature; terms of trade volatility and trade openness are positively associated with output volatility, while countries with higher income per capita and financial development are less vulnerable to output shocks.

**Figure 1:** Mean Economic Complexity by mean income per capita




Source: Hausmann et al. (2014), World Development Indicators

We observe that for some of the control variables, the correlations are not in line with what we expect from the literature, such as democracy, government expenditure and inflation. Higher government expenditure and inflation are expected to contribute to higher output volatility (Klomp & de Haan, 2009; Hausmann & Gavin, 1996; Fatas & Mihov, 2006; Rohn et al., 2009). For example, since the 2000's, government instability in the form of uncertain monetary and fiscal policies in Zimbabwe has caused a sizable increase in output volatility by negatively influencing the business climate and discouraging domestic and foreign investment. Strong institutions are expected to reduce output volatility. According to Rodrik (1999) and Cavallo et al. (2008), countries with less democratic political institutions are more vulnerable to growth volatility as it can affect the country's ability to manage the risk from external shocks.

**Table 1:** Correlation Matrix

**Pairwise correlations**

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| (1) outputvol | 1.000 | | | | | | | | |
| (2) eci | 0.076* | 1.000 | | | | | | | |
| (3) totvol | 0.085* | -0.008 | 1.000 | | | | | | |
| (4) openness | 0.045* | 0.154* | 0.014 | 1.000 | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (5) democracy | 0.041* | 0.507* | 0.015 | 0.084* | 1.000 | | | | |
| (6) gdpcap | -0.001 | 0.608* | 0.020 | 0.275* | 0.362* | 1.000 | | | |
| (7) gvtexp | -0.067* | 0.315* | -0.017 | 0.161* | 0.080* | 0.189* | 1.000 | | |
| (8) inflation | -0.042* | -0.042* | -0.036* | -0.028* | 0.001 | -0.032* | -0.034* | 1.000 | |
| (9) financialdvpt | -0.003 | 0.627* | -0.006 | 0.211* | 0.378* | 0.420* | 0.113* | -0.024* | 1.000 |

* shows significance at the .05 level

### 4.3 Results

Table 2 reports the results for ECI and output volatility in the short-term period, whereas Table 3 shows results in the medium to long-term period. Although in Column 2 of Table 2, we initially observe a positive and significant association between ECI and output volatility for high income countries in the immediate period, we find that ECI decreases output volatility when we allow for longer lags (Column 2 of Table 3). On the other hand, we find that low income countries require a much longer time before we observe a negative and significant association between ECI and output volatility (Column 3 of Table 3). These findings imply that high income countries with more diversified exports and better productive capabilities may be able to manage risks that arise from exogenous shocks and adjust quicker to the shocks than low income countries. Low income countries tend to have export goods that are not diversified and that are exported by many other countries which makes them more susceptible to trade shocks and less able to adjust timeously.

The results are more in line with Bejan (2006) who finds a stabilising effect of export diversification on output volatility in advanced economies. According to Balavac and Pugh (2016), export diversification offers protection against adverse external trade shocks by providing countries with a broader range of commodities and services to trade on the global market. Similarly, Calderón and Schmidt-Hebbel (2008) and Haddad et al. (2013) find that output volatility decreases as a country's level of export diversification increases. However, diversification does take time and can leave low income countries exposed to external macroeconomic shocks, such as commodity price shocks or global financial shocks, during the development process.

The inclusion of the control variables does not attenuate the ECI effects on output volatility across the income groups. Volatility in the terms of trade increases output volatility through exposure to product price shocks and exposure to country specific shocks in trading partners (Bacchetta et al., 2007). Openness is significantly associated with output volatility. Trade openness exposes countries to external shocks that can be a source of macroeconomic instability (Di Giovanni & Levchenko, 2009; Rodrik, 1998; Easterly et al., 2001). Higher income per capita decreases output volatility. According to Bacchetta et al. (2007), richer countries with better institutions (especially financial) can diversify in capital markets. Linked to this explanation, we observe that financial development is negatively associated with output volatility. Domestic financial development can help mitigate output fluctuations through greater integration into global capital markets. Weaknesses in the country's financial institutions may matter little if firms in the country have access to banks abroad (Easterly et al. 2000; Malik & Temple, 2009). As such, deeper financial markets may provide a mechanism to smooth shocks. The other controls are statistically insignificant.

**Table 2:** ECI and Output volatility in the short-term period

| | (1) World | (2) High Income | (3) Low Income |
|---|---|---|---|
| $ECI_{t-1}$ | 0.005* | 0.032*** | 0.004 |
| | (0.003) | (0.010) | (0.003) |
| $Totvol_{t-1}$ | 0.018*** | 0.046** | 0.016** |
| | (0.007) | (0.020) | (0.007) |
| $Openness_{t-1}$ | 0.015*** | 0.040 | 0.013*** |
| | (0.004) | (0.030) | (0.005) |
| $Democracy_{t-1}$ | 0.002 | -0.029 | 0.001 |
| | (0.007) | (0.069) | (0.007) |
| $Gdpcap_{t-1}$ | -0.040*** | -0.111*** | -0.039*** |
| | (0.006) | (0.030) | (0.006) |
| $Gvtexp_{t-1}$ | -0.004 | -0.005 | -0.004 |
| | (0.005) | (0.028) | (0.005) |
| $Inflation_{t-1}$ | -0.002* | -0.005* | -0.001 |
| | (0.001) | (0.003) | (0.001) |
| $Financialdvpt_{t-1}$ | -0.006*** | -0.009 | -0.005** |
| | (0.002) | (0.007) | (0.002) |
| Country FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| R2 | 0.329 | 0.574 | 0.293 |
| Obs | 2036.000 | 410.000 | 1623.000 |

Coefficients reported. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**Table 3:** ECI and output volatility in the medium to long-term period

| | (1) World | (2) High Income | (3) Low Income |
|---|---|---|---|
| $ECI_{t-1}$ | 0.008* | 0.045*** | 0.003 |
| | (0.004) | (0.014) | (0.004) |
| $ECI_{t-3}$ | 0.000 | -0.051*** | 0.007 |
| | (0.005) | (0.012) | (0.005) |
| $ECI_{t-5}$ | -0.008* | 0.024 | -0.010** |
| | (0.004) | (0.016) | (0.005) |
| $Totvol_{t-1}$ | 0.019*** | 0.040** | 0.016** |
| | (0.007) | (0.020) | (0.007) |

| | | | |
|---|---|---|---|
| Openness $_{t-1}$ | 0.015*** | 0.040 | 0.014*** |
| | (0.004) | (0.030) | (0.004) |
| Democracy$_{t-1}$ | 0.002 | 0.001 | 0.001 |
| | (0.007) | (0.069) | (0.007) |
| Gdpcap $_{t-1}$ | -0.039*** | -0.092*** | -0.039*** |
| | (0.006) | (0.030) | (0.006) |
| Gvtexp $_{t-1}$ | -0.004 | -0.013 | -0.004 |
| | (0.005) | (0.028) | (0.005) |
| Inflation $_{t-1}$ | -0.002* | -0.004* | -0.001 |
| | (0.001) | (0.002) | (0.001) |
| Financialdvpt $_{t-1}$ | -0.006*** | -0.009 | -0.006** |
| | (0.002) | (0.007) | (0.002) |
| Country FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| R2 | 0.331 | 0.593 | 0.295 |
| Obs | 2031.000 | 410.000 | 1618.000 |

Coefficients reported. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

### 4.4 Additional analysis

The results for output volatility for high vs low income countries taken together may conceal different trends among regions. We therefore examine the effects of ECI on output volatility across regions in Tables 4 and 5. We observe significant heterogeneous effects for Asia in relation to Africa. Similar to the outcomes for low income countries, Africa requires a longer time to adjust to macroeconomic shocks. On the other hand, output volatility in Asia responds immediately to changes in ECI. This result may be driven by the countries with highly diversified and complex export goods, such as the Asian Tigers (Hong Kong, Singapore, South Korea and Taiwan) in the region. The delayed negative effects observed for Africa can be driven by the abundance of natural resources, which contributes to the low diversity of their export baskets and concentration of exports in less complex goods. African countries primarily export homogeneous primary commodities which are subject to global price changes. According to findings by Hakura (2009), output volatility is much higher in sub-Saharan Africa than in East Asia due to increased volatilities in government spending and terms of trade shocks. The effects of the control variables on output volatility are consistent with previous results.

**Table 4:** Regional analysis in the short-term period

| | (1) World | (2) Europe | (3) Africa | (4) Asia |
|---|---|---|---|---|
| ECI $_{t-1}$ | 0.005* | -0.014 | -0.000 | -0.016*** |
| | (0.003) | (0.013) | (0.005) | (0.005) |
| Totvol $_{t-1}$ | 0.018*** | 0.057** | 0.020* | 0.065*** |

| | | | | |
|---|---|---|---|---|
| | (0.007) | (0.026) | (0.012) | (0.020) |
| Openness $_{t-1}$ | 0.015*** | 0.048** | 0.002 | 0.014** |
| | (0.004) | (0.022) | (0.007) | (0.006) |
| Democracy$_{t-1}$ | 0.002 | 0.077 | 0.003 | -0.018* |
| | (0.007) | (0.074) | (0.012) | (0.010) |
| Gdpcap $_{t-1}$ | -0.040*** | -0.128*** | -0.052*** | -0.026*** |
| | (0.006) | (0.032) | (0.015) | (0.010) |
| Gvtexp $_{t-1}$ | -0.004 | -0.030 | -0.002 | -0.003 |
| | (0.005) | (0.028) | (0.005) | (0.010) |
| Inflation $_{t-1}$ | -0.002* | -0.004* | 0.001 | -0.010*** |
| | (0.001) | (0.002) | (0.002) | (0.002) |
| Financialdvpt $_{t-1}$ | -0.006*** | -0.002 | 0.001 | -0.007 |
| | (0.002) | (0.003) | (0.004) | (0.005) |
| Country FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| R2 | 0.329 | 0.637 | 0.234 | 0.522 |
| Obs | 2036.000 | 404.000 | 563.000 | 389.000 |

Coefficients reported. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**Table 5:** Regional analysis in the medium to long-term period

| | (1) World | (2) Europe | (3) Africa | (4) Asia |
|---|---|---|---|---|
| ECI $_{t-1}$ | 0.008* | -0.013 | 0.001 | -0.026** |
| | (0.004) | (0.015) | (0.006) | (0.012) |
| ECI $_{t-3}$ | 0.000 | -0.003 | 0.002 | 0.018 |
| | (0.005) | (0.016) | (0.007) | (0.014) |
| ECI $_{t-5}$ | -0.008* | 0.004 | -0.012* | -0.008 |
| | (0.004) | (0.017) | (0.006) | (0.013) |
| Totvol $_{t-1}$ | 0.019*** | 0.057** | 0.020* | 0.063*** |
| | (0.007) | (0.026) | (0.011) | (0.021) |
| Openness $_{t-1}$ | 0.015*** | 0.048** | 0.003 | 0.014** |
| | (0.004) | (0.023) | (0.007) | (0.006) |
| Democracy$_{t-1}$ | 0.002 | 0.075 | 0.004 | -0.017* |
| | (0.007) | (0.075) | (0.012) | (0.010) |
| Gdpcap $_{t-1}$ | -0.039*** | -0.128*** | -0.052*** | -0.026*** |
| | (0.006) | (0.031) | (0.015) | (0.010) |

| | | | | |
|---|---|---|---|---|
| Gvtexp $_{t-1}$ | -0.004 | -0.030 | -0.002 | -0.003 |
| | (0.005) | (0.028) | (0.005) | (0.010) |
| Inflation $_{t-1}$ | -0.002* | -0.004* | 0.001 | -0.010*** |
| | (0.001) | (0.002) | (0.002) | (0.002) |
| Financialdvpt $_{t-1}$ | -0.006*** | -0.002 | 0.000 | -0.007 |
| | (0.002) | (0.003) | (0.004) | (0.005) |
| Country FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| R2 | 0.331 | 0.638 | 0.240 | 0.524 |
| Obs | 2031.000 | 404.000 | 558.000 | 389.000 |

Coefficients reported. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

## 5. Conclusions

This study contributes to the literature by reconsidering the nexus between export diversification and output volatility by using a relatively new measure (the economic complexity index) that captures not only the diversity of goods exported, but also the human capital embedded in the exported goods (i.e. the productive capabilities). We find that output volatility is mitigated as the economic complexity of a country increases, however low income countries take longer to respond to changes in ECI. We also find that Africa's relatively homogeneous export goods have a delayed effect in reducing output volatility compared to Asia. The findings underscore the importance of product differentiation and strive toward the inclusion of more complex goods in the export basket for countries at early stages of development. Diversifying exports, particularly including complex goods in the basket, will allow countries to trade in markets that are less volatile, reduce imported fluctuations and smooth output volatility.

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## Appendix

### Table A1: Income classifications

| High Income | Low Income | Low Income |
|---|---|---|
| Australia | Albania | Lithuania |
| Austria | Algeria | Macedonia |
| Belgium | Angola | Madagascar |
| Canada | Azerbaijan | Malaysia |
| Croatia | Bangladesh | Mauritania |
| Czech Republic | Belarus | Mexico |
| Denmark | Bolivia | Moldova |
| Estonia | Botswana | Mongolia |
| Finland | Brazil | Morocco |
| France | Bulgaria | Namibia |
| Germany | Burma | Nicaragua |
| Greece | Cambodia | Nigeria |
| Hungary | Cameroon | Pakistan |
| Ireland | Chile | Panama |
| Israel | China | Paraguay |
| Italy | Colombia | Peru |
| Japan | Costa Rica | Philippines |
| Kuwait | Cote d'Ivoire | Poland |
| Netherlands | Democratic Republic of the Congo | Republic of the Congo |
| New Zealand | Dominican Republic | Romania |
| Norway | Ecuador | Russia |
| Oman | Egypt | Senegal |
| Portugal | El Salvador | Serbia |
| Qatar | Gabon | South Africa |
| Saudi Arabia | Ghana | South Korea |
| Singapore | Guatemala | Sri Lanka |
| Slovakia | Guinea | Sudan |
| Slovenia | Honduras | Tanzania |
| Spain | India | Thailand |
| Sweden | Indonesia | Togo |
| Switzerland | Iran | Tunisia |
| United Arab Emirates | Jamaica | Turkey |
| United Kingdom | Jordan | Ukraine |
| United States | Kazakhstan | Uruguay |
| Venezuela | Kenya | Vietnam |
| | Laos | Zambia |
| | Latvia | Zimbabwe |
| | Lebanon | |