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A further examination of the export-led growth hypothesis

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Abstract This article challenges the common view that exports generally contribute more to GDP growth than a pure change in export volume, as the export-led growth hypothesis predicts. Applying panel cointegration techniques to a production function with non-export GDP as the dependent variable, we find for a sample of 45 developing countries that: (i) exports have a positive short-run effect on non-export GDP and vice versa (short-run bidirectional causality), (ii) the long-run effect of exports on non-export output, however, is negative on average, but (iii) there are large differences in the long-run effect of exports on non-export GDP across countries. Cross-sectional regressions indicate that these cross-country differences in the long-run effect of exports on non-export GDP are significantly negatively related to cross-country differences in primary export dependence and business and labor market regulation. In contrast, there is no significant association between the growth effect of exports and the capacity of a country to absorb new knowledge.

Keywords Export-led growth · Developing countries · Panel cointegration

JEL Classification F43 · O11 · C23

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1 Introduction

The question of whether exports are a key factor in promoting growth in developing countries, as stated by the export-led growth hypothesis, has been the subject of numerous studies over the past decades. These studies can be divided into four groups.[1] The first includes cross-country studies, such as Michaely (1977), Balassa (1978), Heller and Porter (1978), Tyler (1981), Feder (1983), Kavoussi (1984), Ram (1985), and McNab and Moore (1998). Collectively, this series of studies supports a positive association between export growth and output growth in developing countries. However, they assume, rather than demonstrate, that export growth has a positive causal effect on GDP (or GNP) growth, thus ignoring the fact that a positive correlation between these two variables can also be compatible with causality running from output growth to export growth. Furthermore, the estimates in these studies may be biased if causality runs in both directions. In addition, country-specific factors may cause apparent differences in the effect of exports on growth across countries, but these factors cannot be fully controlled for in cross-country regressions. This gives rise to the classical omitted-variables problem.

In response to these criticisms, the second group of studies investigates the causal relationship between export growth and output growth for individual countries using Granger (1969) or Sims' (1972) causality test.[2] Among these studies are Jung and Marshall (1985), Chow (1987), Hsiao (1987), Bahmani-Oskooee et al. (1991), Dodaro (1993), Sharma and Dhakal (1994), Love (1994), and Riezman et al. (1996). Overall, these studies suggest that export growth has no causal effect on output growth in the majority of developing countries. However, they do not examine whether exports and GDP are cointegrated. Specifically, most of these studies test for causality by employing simple VAR models in growth rates or first differences. It is well known that the use of stationary first differences (or growth rates) avoids possible spurious correlations, but this approach precludes the possibility of a long-run or cointegrating relationship between the level of exports and the level of output a priori. Moreover, using first differences may lead to misspecification bias if a long-run or cointegrating relationship between the levels of the variables exists (Granger 1988). Indeed, there are some studies that estimate VAR models of the (log) level of exports and the (log) level of GDP. However, standard F tests for Granger causality based on VAR models in levels are not valid if the underlying variables are non-stationary and not cointegrated (Toda and Phillips 1993).

In light of these limitations, the third group of studies uses cointegration techniques to examine the long-run relationship between exports and output for individual countries. This group includes, for example, Bahmani-Oskooee and Alse (1993), Van den Berg and Schmidt (1994), Ahmad and Harnhirun (1995), Al-Yousif (1997), Abu-Quarn and Abu-Bader (2004), Love and Chandra (2004), Bahmani-Oskooee and Oyolola (2007), and Bahmani-Oskooee and Economidou (2009). Taken as a whole,

[1] For comprehensive reviews of the literature, see Edwards (1993) and Giles and Williams (2000).

[2] It should be noted that another group of studies uses time-series regressions estimated by OLS. This group includes, for example, Ram (1987), Salvatore and Hatcher (1991), and Greenaway and Sapsford (1994). Like the cross-country studies, these papers do not test the direction of causality.

these studies suggest that in most developing countries there is a positive long-run relationship between exports and output, and that causality is running from exports to output or in both directions. A limitation of these studies, however, is the low power of the tests due to the small sample size associated with the use of individual country time-series data.

Therefore, the fourth group of studies employs panel cointegration methods to examine the export-led growth hypothesis. Panel tests have higher power due to the exploitation of both the time-series and cross-sectional dimensions of the data. To our knowledge, this group includes only four studies and the results are mixed. While Bahmani-Oskooee et al. (2005) and Reppas and Christopoulos (2005) conclude that long-run causality is unidirectional from GDP to exports, the results of Parida and Sahoo (2007) suggest that increased exports are a cause of increased GDP; Jun (2007), on the other hand, finds support for positive long-run effects running from exports to GDP and vice versa. However, these studies also have limitations.

Reppas and Christopoulos (2005) and Parida and Sahoo (2007) consider only a relatively small number of countries. More specifically, Reppas and Christopoulos analyze a sample of 22 African and Asian countries, while the sample of Parida and Sahoo includes only four South Asian countries. Thus, it is questionable whether the results are representative for the group of developing countries as a whole. Another limitation is that Parida and Sahoo (2007) and Jun (2007) use within-dimension panel cointegration estimators, which, by construction, are unable to capture the heterogeneity of the long-run coefficients across countries. Hence, these studies do not allow conclusions regarding the long-run effects of exports (and thus the validity of the export-led growth hypothesis) for individual countries. Furthermore, the methods used in these studies do not take account of potential cross-sectional dependence, which could have biased the results.[3] In addition, and perhaps most importantly, Bahmani-Oskooee et al. (2005), Reppas and Christopoulos (2005), Jun (2007), and numerous other studies do not control for the simultaneity bias associated with the fact that exports, via the national income accounting identity, are themselves a component of GDP. Specifically, the problem is that a positive correlation may emerge simply because exports are part of GDP (rather than because of any extra contribution that exports make to GDP or, conversely, because of any extra contribution that GDP makes to exports), and that this simultaneity between exports and output may also lead to potentially misleading inferences on causality. Finally, a common feature of these cointegration studies is that they examine only the long-run relationship between exports and output, and thus do not account for possible differences between the long-run and short-run effects of exports.

This article contributes to the literature in several ways. First, panel cointegration techniques are applied to investigate the export-led growth hypothesis for 45 developing countries, both for the sample as a whole and for each country individually. In contrast to previous panel cointegration studies, we use so called second-generation panel unit root and cointegration methods to take the potential cross-sectional depen-

[3] Cross sectional dependence can arise due to several factors, such as omitted observed or unobserved common factors, or spatial spillover effects. For example, the data may be in part driven by common global business cycles.

dence into account. Second, we use non-export GDP instead of export-inclusive GDP to separate the influence of exports on output from that incorporated in the 'growth-accounting' relationship. Third, we examine both the long-run and short-run effects of exports on non-export GDP to obtain insights into the dynamics of exports over time.

Our main findings are as follows: (i) Exports exert a positive short-run effect on non-export GDP in developing countries and vice versa (short-run bidirectional causality), (ii) the long-run effect of exports on non-export output, in contrast, is negative on average, and (iii) there are large differences in the long-run effect of exports on non-export GDP across countries.

Given this latter finding, it is natural to ask how these differences can be explained. As a further contribution, we attempt to answer this question by examining whether the observed cross-country differences in the long-run effects of exports are linked to country-specific factors, such as the level of primary export dependence, business regulation, labor regulation, and the capacity to absorb foreign knowledge. Using cross-sectional regression analysis, we find that the cross-country differences in the long-run effects of exports on non-export GDP are significantly negatively related to cross-country differences in primary export dependence, business regulation, and labor regulation, whereas there is no statistically significant association between the growth effect of exports and absorptive capacity. Although caution is needed in drawing policy conclusions, we think that this is an important finding for countries which pursue export-oriented development strategies.

The rest of the article is organized as follows. Section 2 discusses the export-led growth hypothesis in more detail and sets out the empirical model. Section 3 describes the data and presents the econometric methodology. The empirical results are reported in Sects. 4 and 5 provides some concluding remarks.

2 Export-led growth hypothesis

2.1 Theoretical discussion

It is conventional wisdom among policy makers and academics that exports are a key factor in promoting economic growth in developing countries; there are several theoretical arguments supporting this hypothesis. From a demand-side perspective, it is argued that sustained growth cannot be maintained in domestic markets because of their limited size. Export markets, in contrast, are almost limitless and hence do not involve growth restrictions on the demand side, implying that they can act as a catalyst for output growth through an expansion of aggregate demand (Siliverstovs and Herzer 2007). This is the direct and intuitively obvious growth effect of exports that does not need to be investigated further. Given the fact that the export-to-GDP ratio in developing countries increased from about 10 % in 1970 to about 35 % in 2006, it immediately becomes clear that exports have played a major role in the growth process of developing countries, as part of domestic production demanded by foreign buyers. In the empirical analysis, however, this direct effect must be controlled for. The reason is that the export-led growth hypothesis, in its original form, predicts that exports have an indirect growth effect that goes beyond the mere change in export volume: an effect on output through productivity.

There are several ways in which exports can affect productivity. First, exports can provide the foreign exchange to finance imports that incorporate knowledge of foreign technology and production know-how, thereby promoting cross-border knowledge spillovers (Grossman and Helpman 1991). Second, exports can increase productivity by concentrating investment in the most efficient sectors of an economy, those in which the country has a comparative advantage (Kunst and Marin 1989. Third, since combining the international market with the domestic market facilitates larger-scale operations than does the domestic market alone, an expansion of exports allows countries to benefit from economies of scale (Helpman and Krugman 1985). Fourth, and perhaps most importantly, the export sector may generate positive externalities on the non-export sector (Feder 1983). The sources of these knowledge spillovers include, on the one hand, incentives for technological improvements, labor training, and more efficient management due to increased international competition and, on the other, direct access to foreign knowledge through relationships with foreign buyers (Chuang 1998).

Several arguments suggest, however, that the positive productivity effects predicted by the export-led growth hypothesis do not necessarily occur in developing countries. One concern is that many developing countries are heavily dependent on primary commodity exports. Such exports can lead economies to shift away from competitive manufacturing sectors in which many externalities required for sustainable growth are generated, while the primary export sector itself does not (by its nature) have many linkages with, and spillovers into, the economy (Sachs and Warner 1995; Herzer 2007). Furthermore, exports of primary goods tend to be subject to large price and volume fluctuations. Increased exports may therefore lead to increased macroeconomic uncertainty, which, in turn, may hamper efforts for economic planning and reduce the quantity as well as the efficiency of domestic investment (Dawe 1996).

Another concern is that the ability of the non-export sector to absorb potential knowledge spillovers from the export sector depends on its absorptive capacity. In particular, domestically oriented firms using very backward production technology and low-skilled workers may be unable to make effective use of knowledge spillovers. Similarly, it can be argued that a certain level of technology and human capital in the export sector itself may be necessary to acquire foreign technology (Edwards 1993).

Finally, many developing countries are subject to excessive business and labor regulations that limit both the mobility of factors between sectors and the flexibility of factor prices (World Bank 2009). In such a scenario of severe factor-market imperfections, an increase in exports may be associated with un- or underemployment and, as a consequence, with productivity losses (Edwards 1988).

From this discussion, it follows that the productivity effects of exports are ambiguous and depend upon several factors, such as the level of primary export dependence, the degree of absorptive capacity, and the degree of business and labor regulations. An important implication of this is that the effects of exports on output through productivity may differ significantly from country to country. Another implication of the above discussion is that the productivity effects of exports may differ over time, as well. For example, in the short-run, exports may increase productivity through specialization according to comparative advantage. If, however, the increase in exports induces an expansion of sectors that do not exhibit positive externalities while other sectors with positive externalities shrink, the associated productivity loss will more than offset the traditional static specialization gains in the long-run. Accordingly, exports may have positive short-run, but negative long-run effects.

2.2 Empirical specification

In order to capture the impact of exports on output through the productivity channel, we start with an *AK*-type production function:

$$Y_{it} = A_{it} K_{it}^{b_{1i}}, \tag{1}$$

where Y_{it} is the output of country i at time t, K_{it} is the capital of country i at time t, and A_{it} is a productivity parameter. Because we want to examine if and how exports affect economic growth via changes in productivity, it is assumed that the productivity parameter can be expressed as a function of exports, X_{it},

$$A_{it} = f(X_{it}) = X_{it}^{b_{2i}}. \tag{2}$$

Combining Eqs. (1) and (2) and taking natural logarithms yields

$$\ln(Y_{it}) = b_{1i} \ln(K_{it}) + b_{2i} \ln(X_{it}), \tag{3}$$

where the coefficients b_{1i} and b_{2i} denote the cross-country averages of the elasticities of output with respect to capital and exports, which are allowed to be country specific and thus to vary across countries.

However, the estimate of b_{2i} cannot be used to measure the average productivity effect of exports on output. Since exports are a part of output via the national accounting identity, a positive and significant relationship between exports and output is almost inevitable, even if there are no productivity effects. To remedy this problem, we separate the impact of exports on output from that incorporated through the national accounts identity, by considering real output net of exports, $N_{it} = Y_{it} - X_{it}$ (e.g., Greenaway and Sapsford 1994; Siliverstovs and Herzer 2007). By replacing the logarithm of total output, $\ln(Y_{it})$, with the logarithm of non-export output, $\ln(N_{it})$, we obtain

$$\ln(N_{it}) = c_{1i} \ln(K_{it}) + c_{2i} \ln(X_{it}). \tag{4}$$

The coefficient c_{2i} in this equation is 0, $c_{2i} = 0$, if the coefficient of the export variable in the augmented production function specification, indicated by Eq. (3), just reflects the share of exports in output.[4] If, in contrast, the coefficient c_{2i} is greater than 0,

[4] A multiplicative relationship of the form: $Y = X^{\alpha} N^{1-\alpha}$ is assumed, where a is the share of exports in GDP (for convenience the subscript i is omitted). Inserting this equation into Eq. (3) yields after some manipulations Eq. (4), with $c_1 = b_1/(1-\alpha)$, $c_2 = (b_2 - \alpha)/(1-\alpha)$. Thus, if $b_2 = \alpha$, then $c_2 = 0$.

$c_{2i} > 0$, the growth effect of exports goes beyond the mere increase in export volume, suggesting that exports increase output through increased productivity; whereas if $c_{2i} < 0$, exports contribute less to GDP growth than the increase in export volume, suggesting that exports are productivity-reducing (Siliverstovs and Herzer 2007).

To control for country-specific omitted factors that are relatively stable or evolve smoothly over time, we include country-specific fixed effects, c_{3i}, and country-specific deterministic time trends, $c_{4i}t$. While country fixed effects control for unobserved time-constant heterogeneity, country-specific time trends capture any unobserved factors that change gradually over time. Because reliable employment data are not available for many developing countries over a long enough time span and because several studies suggest that hours worked are stationary around a time trend (e.g., DeJong and Whiteman 1991; Leybourne 1995; Banerjee and Russell 2005), country-specific time trends can act, for example, as a proxy for labor input.

Adding the error term, ε_{it}, yields the following estimating equation:

$$\ln(N_{it}) = c_{1i}\ln(K_{it}) + c_{2i}\ln(X_{it}) + c_{3i} + c_{4i}t + \varepsilon_{it}. \tag{5}$$

Accordingly, unlike other studies, we do not include imports given the discussion in the previous section. If we included imports, the estimate of the effect of exports on output through productivity would preclude any effect operating through the import channel. Specifically, if export earnings are used to finance imports, then, by including imports in the regression, we would be omitting the productivity effect of exports that operates via imports.

Finally, for our cointegration tests (described in the next section), we assume that the variables in Eq. (5) can be decomposed into (global) common and (country-specific) idiosyncratic factors,

$$Z_{it} = \lambda_{it}F_t + E_{it},$$

where F_t is a vector of common factors, λ_{it} is a vector of factor loadings associated with F_t, and E_{it} is the idiosyncratic component of Z_{it}. The intuition is that macroeconomic data are typically not independent across countries due to common shocks, international technology diffusion, and cross-country spillovers, and thus are driven, in part, by common factors. While Bai and Ng (2004) propose using principal component analysis to estimate F_t, Pesaran (2006) suggests using cross-sectional averages of the observed variables as proxies for the unobserved common factors.

3 Data and empirical methodology

3.1 Data

We now describe the data used to estimate Eq. (5). The data are from the World Bank's (2008) World Development Indicators. Exports (X_{it}) include both goods and services; gross capital formation is our proxy for capital (K_{it}); and the non-export output (N_{it}) is measured by GDP minus exports of goods and services. All data are in constant

2000 dollars, and our sample includes all countries for which continuous data are available from 1971 to 2005. Of these countries, four are in North Africa (Algeria, Egypt, Morocco, and Tunisia), nineteen are in sub-Saharan Africa (Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Rwanda, Senegal, South Africa, Sudan, Swaziland, Togo, and Zambia), nine are in South America (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, and Uruguay), six are in Central America and the Caribbean (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, and Mexico), three are in East Asia (Indonesia, Thailand, and South Korea), and four are in South Asia (Bangladesh, India, Iran, and Pakistan).

3.2 Empirical methodology

Since all variables are integrated of order one (as shown in Sect. 4), our analysis is based on the cointegration approach. However, standard time series unit root and cointegration tests have low power against stationary alternatives in small samples (Campbell and Perron 1991). Panel tests make progress in this respect. Since panel tests exploit both the time series and cross-sectional dimension of the data, they are more powerful than conventional time series unit root and cointegration tests.

However, these tests have their own problems. Standard panel unit root and cointegration tests are based on the assumption of cross-sectional independence. Due to common shocks, this assumption is often violated in practice. The problem is that cross-sectional dependence can lead to severe size distortions, as shown by Banerjee et al. (2004) among others. The test statistics are not normally distributed and the usual critical values do not apply; the situation gets even worse when the number of cross sections is increased. To overcome this deficit, recent panel unit root and cointegration tests allow for cross-sectional dependence via common factors.

In fact, the cointegration property might be interpreted in different ways. A long-run relationship may exist between the cross sections and between the time series for single units in the panel. Gengenbach et al. (2006) propose a sequential testing strategy. They examine the case where non-stationarities are driven by a reduced number of common stochastic trends, and the case where both common and idiosyncratic stochastic trends are present in the data.

Following the idea in Sect. 2.2, the starting point is a decomposition of each variable into common factors, F_t, and idiosyncratic parts, E_{it}, as suggested by Bai and Ng (2004). If the common factors are integrated of order one, $I(1)$, but the idiosyncratic components are $I(0)$, the non-stationarity in the panel would be driven entirely by a reduced number of global stochastic trends. This applies to the case of cross-section cointegration. Such cointegration between the series occurs only if the common factors of the variables cointegrate. If both the common factors and the idiosyncratic components are $I(1)$, cointegration is explored separately for the common and idiosyncratic components. Cointegration requires that the null hypothesis of no cointegration is rejected for both the common and the idiosyncratic components.

The presence of a cointegrating relationship between the common factors can be tested using standard time-series cointegration tests such as the Johansen (1995) reduced rank approach. Since the idiosyncratic components are independent by construction, they can be analyzed by standard panel cointegration tests such as those of Pedroni (1999, 2004).

A potential problem with this stepwise testing procedure, however, is the propagation of estimation errors from one step to the next, and it is not clear what effect this has on the final test (Westerlund and Larsson 2009). Therefore, we also use the error correction model (ECM) cointegration test suggested by Gengenbach et al. (2008). This one-step test is based on the common correlated effects (CCE) approach introduced by Pesaran (2006) and involves estimating separate conditional ECMs for each country using the cross-section averages of the lagged levels and first differences of the dependent and independent variables as proxies for the unobserved common factors. Gengenbach et al. propose two test statistics to test the null hypothesis of no cointegration: the average t statistic associated with the coefficient of the lagged dependent variable and the average Wald chi-square test statistic of the hypothesis that all coefficients of the lagged levels are zero.

Once it is established that the variables are cointegrated, the next step is to estimate the parameters of the cointegrating equation (Eq. 5). To this end, we use the between-dimension group-mean panel DOLS estimator that Pedroni (2001) argues has a number of advantages over the within-dimension approach. First, it allows for greater flexibility in the presence of heterogeneous cointegrating vectors, whereas under the within-dimension approach the cointegrating vectors are constrained to be the same for each country. Second, the point estimates provide a more useful interpretation in the case of heterogeneous cointegrating vectors, as they can be interpreted as the mean value of the cointegrating vectors, which does not apply to the within estimators. Third, between-dimension estimators suffer from much lower small sample size distortions than is the case with the within-dimension estimators. The panel DOLS regression is given by

$$\begin{aligned}\ln(N_{it}) = {} & c_{1i}\ln(K_{it}) + c_{2i}\ln(X_{it}) + c_{3i} + c_{4i}t \\ & + \sum_{j=-k_i}^{m_i} \Phi_{1ij}\Delta\ln(K_{it-j}) + \sum_{j=-l_i}^{n_i} \Phi_{2ij}\Delta\ln(X_{it-j}) + \varepsilon_{it}\end{aligned} \tag{6}$$

where Φ_{1ij} and Φ_{2ij} are coefficients of lead and lag differences. The leads and lags account for possible serial correlation and endogeneity of the regressors, implying that the DOLS procedure generates unbiased estimators for variables that cointegrate even with endogenous regressors. In addition, the group-mean panel DOLS estimator is superconsistent under cointegration, and is robust to the omission of variables that do not form part of the cointegrating relationship. It is calculated as $\hat{c}_m = N^{-1}\sum_{i=1}^{N}\hat{c}_i$, where $t_{\hat{c}_m} = \sum_{i=1}^{N} t_{\hat{c}_i}/\sqrt{N}$ is the corresponding t statistic of $\hat{c}_m$ ($m = 1, 2$), and $\hat{c}_{mi}$ is the conventional time-series DOLS estimator applied to the ith country of the panel. According to Stock and Watson (1993), this estimator performs well in small samples (like ours) compared with other cointegration estimators, such as the maximum likelihood estimator of Johansen (1988) or the fully modified ordinary least squares estimator of Phillips and Hansen (1990).

Because, however, the DOLS estimates could be biased in the presence of cross-sectional dependence, we also use the CCE mean group estimator suggested by Pesaran (2006). Compared to the use of common time dummies (to control for cross-sectional dependence through common time effects), as is common practice in panel studies, the CCE mean group estimator has the advantage that it allows for cross-sectional dependencies arising from multiple unobserved common factors, and that it permits the individual responses to the common factors to differ across countries. It augments the cointegrating regression (given by Eq. 5) with the cross-sectional averages of the dependent variable and the observed regressors (as proxies for the unobserved factors). Kapetanios et al. (2011) have recently shown that the CCE estimator is consistent regardless of whether the common factors are stationary or non-stationary. A disadvantage of the CCE estimator is that it is intended for the case where the regressors are exogenous.

Finally, to test the direction of causality and to examine the short-run dynamics between the variables (in particular between exports and non-export GDP), we estimate a panel vector ECM given by

$$\begin{bmatrix} \Delta\ln(N_{it}) \\ \Delta\ln(K_{it}) \\ \Delta\ln(X_{it}) \end{bmatrix} = \begin{bmatrix} \mu_{1i} \\ \mu_{2i} \\ \mu_{3i} \end{bmatrix} + \sum_{j=1}^{p} \Gamma_j \begin{bmatrix} \Delta\ln(N_{it-j}) \\ \Delta\ln(K_{it-j}) \\ \Delta\ln(X_{it-j}) \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} \mathrm{ec}_{it-1} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \end{bmatrix}, \quad (7)$$

where μ_{1i}, μ_{2i}, and μ_{3i} are fixed effects, the lagged differenced variables represent the short-run dynamics, and the error correction term, ec_{it}, is the residual from the estimated DOLS long-run relationships of the individual countries:

$$ec_{it} = \ln(N)_{it} - \left[\hat{c}_{1i}\ln(K_{it}) + \hat{c}_{2i}\ln(X_{it}) + \hat{c}_{3i} + \hat{c}_{4i}t\right]. \quad (8)$$

If the coefficient on ec_{it-1} (a_1, a_2, a_3) is significant, the null hypothesis of weak exogeneity is rejected, implying long-run Granger causality from the regressors to the dependent variable(s) (see, e.g., Granger 1988). The short-run causal effects are captured by the short-run dynamics.

To allow for cross-section dependence, we follow the idea of Gengenbach et al. (2008) and augment the model with cross-sectional averages of $\Delta\ln(N_{it})$, $\Delta\ln(K_{it})$, $\Delta\ln(X_{it})$, $\Delta\ln(N_{it-j})$, $\Delta\ln(K_{it-j})$, $\Delta\ln(X_{it-j})$, and ec_{it-1} (according to the CCE approach). The averages are interacted with country-dummies to allow for country-specific parameters.

4 Empirical results

This section analyses the export-led growth hypothesis using panel cointegration techniques. Specifically, we examine the following questions:

1. Is there a long-run relationship between non-export GDP, capital, and exports?
2. If yes, how do exports affect non-export GDP in the long-run, and how is non-export GDP affected by exports in the short-run?

3. Are there significant differences in the long-run effects of exports on non-export GDP across countries?
4. If yes, can these differences be explained by cross-country differences in primary export dependence, absorptive capacity, and business and labor regulations, as hypothesized in Sect. 2?

4.1 Unit roots and cointegration

The first step of the analysis is to investigate the integration and cointegration properties of the variables. To allow for cross-unit cointegration, we test for unit roots and cointegration in the common and idiosyncratic components of the data (instead of the observed series).[5] The common and idiosyncratic components of the series are estimated using the principle component estimator of Bai and Ng (2004). Because the components can be non-stationary, the principal components are extracted from the differenced data, as suggested by Bai and Ng (2004). Once the factors have been estimated, they are re-cumulated to match the stochastic properties of the original series. The idiosyncratic components are computed as the projections of the observations onto their common components.

The number of common factors is estimated using the BIC3 criterion of Bai and Ng (2002). Since the cross-section and time-series dimensions of the panel are of similar magnitude, the BIC3 criterion may be superior to alternatives. However, this criterion does not converge in the present application, since a large number of factors is preferred. Therefore, the best strategy is to look at different settings to ensure the robustness of the analysis. The evidence presented below refers to six principal components per variable. To arrive at the common factors, they are weighted by their corresponding eigenvalues. The factors represent 50 % of the overall variation of the respective series. Fortunately, the results are very robust to this choice.[6] While the common factors appear to be non-stationary, the unit root hypothesis is rejected for the idiosyncratic components of the variables, as Table 1 shows. Thus, the variables can become cointegrated for the individual countries of the panel via the common non-stationary factors.

In fact, the Johansen (1995) trace statistics reported in Table 2 indicate that the common factors of $\ln(N_{it})$, $\ln(K_{it})$, and $\ln(X_{it})$ are cointegrated and exhibit a single cointegrating vector. Regarding the idiosyncratic components, the Pedroni (1999, 2004) statistics also provide evidence for cointegration (see Table 3). Admittedly, the Pedroni test does not provide further insight, since all variables are stationary in this case. Therefore, they should be regarded as a cross check.

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[5] We also tested for cointegration between the observed series (without allowing for cross-unit cointegration) and found strong evidence for cointegration. The results are reported in an earlier version of this article (see Herzer 2010).

[6] The results can be replicated, if the common factors are obtained as a combination of the first three, four, five, or even seven principal components of the variables. Results are available from the authors upon request.

Table 1 Unit root tests

Variables	Common components	Idiosyncratic components
Non-export GDP	−2.923	−3.633**
Capital	−3.356	−5.303**
Exports	−1.800	−4.942**

The optimal lag length was determined using the general-to-simple approach suggested by Campbell and Perron (1991). We employed the ADF test (with a constant and a linear time trend) for the common components and the panel unit root test of Im, Pesaran, and Shin (2003) (IPS) for the idiosyncratic components.
** Rejection of the unit root null hypothesis at the 1 % level

Table 2 Cointegration of common components

Rank null hypothesis	$r \leq 0$	$r \leq 1$	$r \leq 2$
Johansen (1995) trace statistics	34.85*	9.90	0.33

*Rejection of the null hypothesis of no cointegration at the 5 % level. The number of lags was determined by the Schwarz criterion. To correct for finite sample bias, the trace statistic was multiplied by $(T - pk)/T$, where T is the number of the observations, p number of the variables, and k the lag order (Reinsel and Ahn 1992)

Table 3 Cointegration of idiosyncratic components

	Panel cointegration statistics	Group-mean panel cointegration statistics
Variance ratio	2.042*	
PP *rho* statistics	−4.410**	−0.617
PP *t* statistics	−5.607**	−3.961**
ADF *t* statistics	−5.786**	−4.354**

** (*) Rejection of the null hypothesis of no cointegration at the 1 % (5 %) level. The statistics are the standard residual-based panel and group test statistics suggested by Pedroni (1999) and Pedroni (2004)). All test statistics are asymptotically normally distributed. The variance ratio test is right-sided, while the other tests are left-sided. The maximum truncation lags were set to 4 and determined using data-dependent criteria

Table 4 Gengenbach et al. (2008) cointegration test

ECM *t* statistic	ECM Wald statistic
−3.776**	35.023**

** Rejection of the null hypothesis of no cointegration at the 1 % level. The number of lags was determined by the Schwarz criterion. The 1 % critical value for the ECM *t* statistic is−3.681; the 1 % critical value for the corresponding Wald statistic is 21.389 (Gengenbach et al. 2008)

Finally, the results of the ECM cointegration test suggested by Gengenbach et al. (2008) are presented in Table 4. Both the *t* test and the chi-square test reject the null hypothesis of no cointegration at the at the 1 % level.

Table 5 Estimates of the long-run effects on non-export GDP

	$\ln(K_{it})$	$\ln(X_{it})$	Leads and lags
(1) Group-mean DOLS estimator (Pedroni 2001)	0.279** (35.25)	−0.152** (−11.69)	1
(2) Group-mean DOLS estimator (Pedroni 2001)	0.279** (29.97)	−0.102** (−9.77)	2
(3) Within-dimension DOLS estimator (Kao and Chiang 2000)	0.264** (19.99)	−0.167** (−9.85)	1
(4) CCE mean group estimator (Pesaran 2006)	0.224** (33.48)	−0.229** (−16.59)	

The dependent variable is $\ln(N_{it})$. ** Significance at the 1 % level. t Statistics in parentheses

4.2 Long-run elasticities

The DOLS group-mean estimates of the coefficients on capital and exports are reported in the first row of Table 5.[7] The results are based on a one lead/lag model, as suggested by the usual information criteria. The coefficient on $\ln(K_{it})$ is highly significant and positive, as expected. The coefficient of the export variable, in contrast, is highly significant and negative. More precisely, the coefficient on $\ln(X_{it})$ is estimated to be -0.152, implying that, in the long-run, a 1 % increase in exports leads to a 0.152 % decrease in non-export GDP on average for the countries in our sample.

Since this finding challenges the conventional view that exports generally contribute more to GDP growth than the mere change in export volume, we perform several sensitivity checks. First, we re-estimate the group-mean panel DOLS regression using two leads and lags. The results are reported in the second row of Table 5. They are very similar to those in row 1. Thus, the estimates appear to be not sensitive to the choice of the lead and lag length (although the usual information criteria select one lead/lag model).

Next, we examine whether the negative long-run relationship between exports and non-export output is robust to alternative estimation techniques. Specifically, we use the within-dimension DOLS estimator suggested by Kao and Chiang (2000), which differs from the between-dimension group-mean DOLS estimator in that it assumes homogeneous long-run coefficients (c_1 and c_2) for all countries. Since the estimated effect of exports may be biased by the presence of potential cross-sectional depen-

[7] Since the focus of our interest later in this article will be on examining the cross-country heterogeneity in the long-run effects of exports on non-export GDP, the average long-run relationship is estimated using the original series (consisting of non-stationary common and stationary idiosyncratic components). The capital and export elasticities from the Johansen estimator for the common components are, respectively, 1.090 and −0.233. Thus, consistent with the estimation results in Table 4, the Johansen estimator produces a negative coefficient on the export variable for the common components.

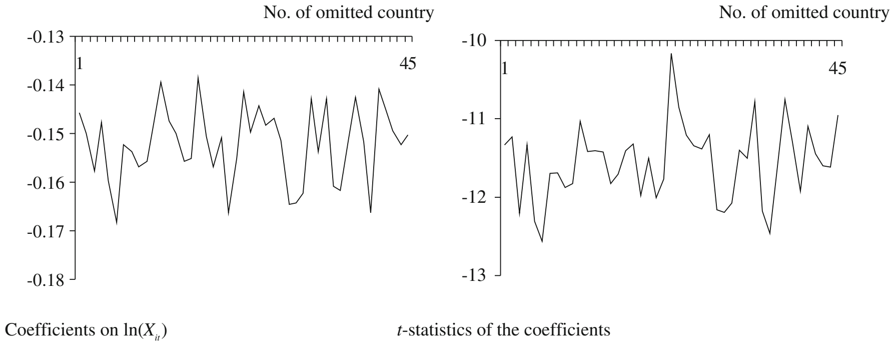

Fig. 1 Estimated export elasticity with single country excluded from the sample. The figures shows the coefficients on $\ln(X_{it})$ and their t statistics of the sequentially estimated regressions when one country is excluded at a time. Each tick marks the country omitted from the regression

dencies, we also report (in the third row) the result of the CCE mean group estimator suggested by Pesaran (2006).

As can be seen, all three estimators provide qualitatively similar results. As expected, the within-dimension estimator tends to produce somewhat lower estimates (in absolute value) than the group-mean estimator, which is in line with the findings of Pedroni (2001). Given, however, that the effects of exports on non-export GDP differ across countries (as demonstrated in Sect. 4.4), the results of the pooled within-dimension estimator (which assumes homogeneous coefficients) should be interpreted with caution. The CCE mean group estimator, on the other hand, is intended for the case in which the regressors are exogenous, so that we lose the ability to account for the potential endogeneity of exports. Therefore, we continue our (robustness) analysis with the group-mean panel DOLS estimator.

We examine whether the negative effect of exports and non-export GDP is the result of outliers. To this end, we re-estimate the group-mean DOLS regression excluding one country at a time from the sample. The sequentially estimated export coefficients and their t statistics are presented in Fig. 1. Since the coefficients are fairly stable around -0.15 and always significant at the 1 % level, we conclude that the results are not driven by outliers.

We also examine whether the negative long-run relationship between exports and non-export output in developing countries is due to sample-selection bias. Specifically, a group of countries in a particular region could have a significant effect on the results. To investigate this issue, we re-estimate Eq. (6), excluding countries from North Africa, sub-Saharan Africa, South America, Central America and the Caribbean, East Asia, and South Asia. The resulting group-mean values for c_2 are reported in Table 6. Regardless which of these regions is excluded from the sample, the long-run relationship between exports and non-export GDP remains negative and highly significant.

Finally, we check whether the results are sensitive to the sample period. For this purpose, we re-estimate the DOLS regression for two non-overlapping subperiods of equal length from 1971 through 1987 and 1988 through 2004. The results are presented

Table 6 DOLS estimation with regional country groups excluded from the sample

	$\ln(K_{it})$	$\ln(X_{it})$	Number of countries in the sample
Excluding North Africa	0.280** (31.81)	−0.136** (−11.09)	41
Excluding sub-Saharan Africa	0.337** (36.12)	−0.123** (−8.07)	26
Excluding South America	0.255** (29.96)	−0.185** (−12.44)	36
Excluding Central America and the Caribbean	0.296** (33.43)	−0.178** (−11.80)	39
Excluding East Asia	0.252** (29.25)	−0.125** (−9.17)	42
Excluding South Asia	0.273** (33.79)	−0.161** (11.26)	41

** Significance at the 1 % level. t Statistics in parentheses. The DOLS regressions were estimated with one lead and one lag. The countries included in each region are: North Africa: Algeria, Egypt, Morocco, Tunisia; sub-Saharan Africa: Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Rwanda, Senegal, South Africa, Sudan, Swaziland, Togo, Zambia; South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay; Central America and the Caribbean: Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico; East Asia: Indonesia, Thailand; South Korea; South Asia: Bangladesh, India, Iran, Pakistan

Table 7 DOLS estimation for different subperiods

	$\ln(K_{it})$	$\ln(X_{it})$
1971–1987	0.287** (33.25)	−0.117 (−6.36)**
1988–2004	0.295** (34.11)	−0.164** (−12.98)

** Significance at the 1 % level. t statistics in parentheses. The DOLS regressions were estimated with one lead and one lag

in Table 7. Once again, the estimated effect of exports is negative and statistically significant (although there is some variation in the coefficients). Thus, it can be concluded that the negative long-run effect of exports on non-export GDP in developing countries is robust to different estimation techniques, outliers, sample selection, and the sample period.

4.3 Short-run and long-run causality

The above interpretation of the estimation results is based on the assumption that long-run causality runs from capital and exports to GDP net of exports. In order to test this assumption, we use a panel vector ECM as given in Eq. (7). Following Gengenbach et al. (2008), we augment this model with cross sectional averages of the dependent variable(s) and the regressors to account for potential cross-sectional dependence. As in Herzer (2008), we begin with an overparameterized model. We then eliminate the insignificant short-run dynamics in the model successively according to the lowest t values until the remaining variables are significant at least at the 5 % level. The results are reported in Table 8.

Table 8 Vector error correction model, long-run causality, and short-run dynamics

Independent variables	(1) Dependent variable $\Delta \ln(N_{it})$	(2) Dependent variable $\Delta \ln(K_{it})$	(3) Dependent variable $\Delta \ln(X_{it})$
ec_{it-1}	−0.3655** (−15.17)	−0.054 (−0.83)	0.049 (1.18)
$\Delta \ln(N_{it-1})$	0.136** (5.38)	0.179* (2.53)	0.032** (3.28)
$\Delta \ln(N_{it-2})$	−0.085** (−3.61)	–	–
$\Delta \ln(K_{it-1})$	–	−0.098** (−3.20)	0.044* (2.29)
$\Delta \ln(K_{it-2})$	–	−0.112** (−4.26)	0.057** (3.11)
$\Delta \ln(X_{it-1})$	0.065** (4.12)	0.150** (3.73)	−0.081** (−3.05)
$\Delta \ln(X_{it-2})$	–	–	−0.082** (−3.15)

** (*) significance at the 1 % (5 %) level. t Statistics in parentheses. The maximum number of lags was determined by the Schwarz criterion. Insignificant short-run dynamics were eliminated successively according to the lowest t values, and hence are not reported here

According to the t statistics of the error correction terms, capital and exports can be regarded as weakly exogenous with respect to the cointegrating relationship, whereas the weak exogeneity hypothesis of GDP net of exports is decisively rejected. Thus, only non-export GDP reacts to deviations from the long-run equilibrium relationship, implying that long-run causality runs unidirectional from capital and exports to non-export GDP.

Another important result is that the coefficient on $\Delta \ln(X_{it-1})$ is statistically significant and positive in column 1, while the coefficient on $\Delta \ln(N_{it-1})$ is statistically significant and positive in column 3. Thus, there is evidence of short-run bidirectional causality between exports and non-export GDP, suggesting that, in the short-run, export growth leads to non-export GDP growth, which in turn leads to an increase in exports. As noted in Sect. 2, a possible explanation for the positive short-run effect of exports is static specialization gains, whereas, in the long-run, the negative dynamic effects of exports on non-export GDP, possibly associated with primary export dependence and/or excessive business and labor regulations, tend to offset the short-run gains.

There is also evidence of short-run causality from exports to capital and vice versa. The first difference of exports, lagged one period, is significant and positive in the capital equation in column 2, while the coefficients on $\Delta \ln(K_{it-1})$ and $\Delta \ln(K_{it-2})$, in turn, are statistically significant and positive in the export equation in column 3. From this it can be concluded that, in the short-run, increased exports are both a cause and a consequence of increased investment.

Summarizing, we find that the short-run relationship between exports and non-export GDP is positive, whereas the long-run effect of exports on non-export GDP is clearly negative. This result for the sample as a whole does, however, not imply that exports exert a negative long-run effect on non-export GDP in each individual country.

4.4 Individual country effects

Figure 2 plots the individual country DOLS estimates of the coefficients on $\ln(X_{it})$, $\hat{c}_{2i}$. The most striking feature of these estimates is the heterogeneity in the

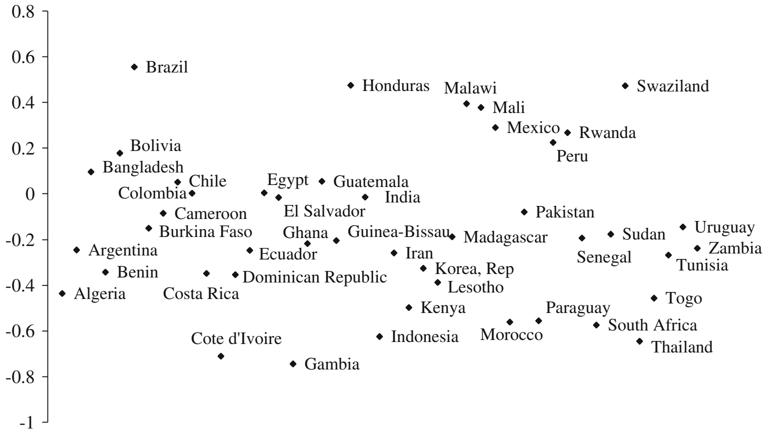

Fig. 2 Individual country DOLS estimates of the long-run impact of exports on non-export GDP

coefficients, ranging from −0.774 in Gambia to 0.555 in Brazil. Thus, although the long-run effect of exports on non-export GDP is negative in general or on average in developing countries, exports do not have a negative long-run effect on non-export GDP in all countries. More precisely, we find for 31 out of 44 countries (and thus in 69 % of cases) that an increase in exports is associated with a decrease in non-export GDP, while in 14 cases (and thus in 31 % of the countries) an increase in exports is associated with an increase in non-export GDP. But even within the country groups with negative and positive effects, the individual country estimates show considerable heterogeneity. For example, the point estimates suggest that Brazil, Honduras, Swaziland, and Malawi benefit markedly from exports. In contrast, in many countries, such as Columbia, Egypt, El Salvador, and India, both the positive and negative effects are marginal (close to 0), whereas in many other countries, such as Gambia, Cote d'Ivoire, Thailand, and Indonesia exports have a strong negative effect on non-export GDP. Of course, the estimates of the coefficient on $\ln(X_{it})$ from the group-mean panel DOLS estimator must be interpreted with caution given the relatively short sample period. Moreover, it should be noted that not all coefficients are significant in statistic terms.[8]

4.5 Explaining cross-country differences in the long-run impact of exports on non-export GDP

The cross-country differences in the long-run effect of exports on non-export GDP pose a new question: What factors can explain this heterogeneity or, in other words, what factors determine the long-run effect of exports on non-export GDP? Following the arguments of Sect. 2, a possible way to answer this question is to examine whether the observed pattern of the long-run effects of exports can be linked to cross-country

[8] The coefficients are insignificant for Burkina Faso, Cameroon, Chile, Colombia, Egypt, El Salvador, Guatemala, Honduras, India, Senegal, Swaziland, Tunisia, and Uruguay.

Table 9 Long-run export effects and country-specific factors

Independent variables	(1)	(2)	(3)	(1)
PR_i	$-0.014{*}(-2.25)$	$-0.014{*}(-2.13)$	$-0.015{*}{*}(-4.23)$	$-0.015{*}{*}(-4.14)$
$SCHOOL_i$	0.003(1.49)		0.002(1.52)	
$GDPPC_i$		0.00002(1.10)		0.00002(1.58)
$EASE_i$	$0.004*(2.16)$	$0.004*(2.05)$	$0.003*(2.21)$	$0.003*(2.16)$
RIG_i	$-0.011{*}(-2.02)$	$-0.012{*}(-2.22)$	$-0.007^{+}(-1.71)$	$-0.007{*}(-2.15)$
Diagnostic tests				
Adj. R^2	0.11	0.10	0.18	0.19
RESET	0.023(0.88)	0.637(0.43)	0.033(0.86)	0.015(0.90)
JB	2.833(0.24)	3.233(0.20)	0.574(0.75)	0.962(0.20)
Included observations	42	42	42	42

** (*) [+] Significance at the 1 % (5 %) [10 %] level. Reported t statistics (in parentheses) are based on White's heteroskedasticity-consistent standard errors; the numbers in parentheses behind the diagnostic test statistics are the corresponding p values: RESET is the usual test for general nonlinearity and misspecification, and JB is the Jarque–Bera test for normality. The dependent variable in the regressions in columns 1 and 2 is the estimated effect of exports on non-export GDP. In columns 4 and 5, the long-run effect of exports on non-export GDP was set equal to zero for the countries with insignificant coefficients

differences in the level of primary export dependence, absorptive capacity, business regulation, and labor regulation.

The ratio of primary exports to GDP (PR_i) is employed as measure of primary export dependence. The secondary school enrolment rate ($SCHOOL_i$) is taken as a proxy for absorptive capacity, and business regulation is represented by the ease-of-doing-business index ($EASE_i$). The higher this index, the more conducive the regulatory environment is to the operation of business. Labor market regulation is measured by the rigidity of employment index (RIG_i). A higher rigidity of employment index indicates more rigid labor regulations.

All data are from the World Bank's (2008) World Development Indicators and are averaged over the period from 1971 to 2005. An exception is the ease-of-doing-business index for which data before 2005 are not available, so that we are constrained to use values for that single year. Moreover, we do not have complete data on all variables for all countries, forcing us to exclude Gambia, Guinea-Bissau, and Swaziland from the sample.

To examine the relationship between the long-run impact of exports and the four variables, we regress $\hat{c}_{2i}$ on PR_i, $SCHOOL_i$, $EASE_i$, and RIG_i (and an intercept). Since it is well known that an estimated dependent variable may introduce heteroskedasticity into the regressions (Saxonhouse 1976), we use White's heteroskedasticity-consistent standard errors to compute the t statistics. The results of this regression are reported in column 1 of Table 9.

Since the diagnostic tests suggest that obvious nonlinearity and misspecification are absent, and that the residuals show no signs of non-normality or heteroscedasticity, the following inferences can be drawn from the results: the long-run effect of exports on non-export GDP is significantly negatively associated with primary export dependence, business regulation, and labor regulation.[9] In contrast, there is no statistically significant association between the long-run effect of exports and absorptive capacity, measured by the secondary school enrolment rate. As can be seen from column 2, this result does not change when alternative measures for absorptive capacity are used. This column shows the regression results when the secondary school enrolment rate is replaced by per capita PPP GDP. As in column 2, primary export dependence, business regulation and labor regulation are statistically significant (with the correct signs), while the coefficient of absorptive capacity, measured by per capita PPP GDP, is not.

Indeed, a potential problem with this analysis is that the estimated coefficients on $\ln(X_{it})$ are not statistically significant for all countries. However, as columns 3 and 4 show, the results do not change qualitatively if we set the long-run effect of exports on non-export GDP equal to zero for the countries with insignificant coefficients.

Without question, our sample is too small to draw definite conclusions about systematic variations in the long-run effect of exports across countries. In addition, the adjusted R^2s indicate that only about 10 % of the variation in the long-run effect of exports on non-export GDP is explained by the variables in the models, implying that the estimated regressions do not fit the data very well. Nevertheless, the results seem to suggest that cross-country differences in the long-run effect of exports on non-export GDP can be at least partly explained by cross-country differences in primary export dependence, business regulation, and labor regulation.

5 Conclusions

This article challenges the conventional view that exports generally contribute more to GDP growth than the mere change in export volume, as the export-led growth hypothesis predicts. We first examined the nature of the growth effect of exports by applying panel cointegration methods to a production function model with non-export GDP as the dependent variable. Our results, based on data from 1971 to 2005 for 45 developing countries, show that the short-run relationship between exports and non-export GDP is positive. In the long-run, however, an increase in exports leads to a reduction in non-export GDP in developing countries, on average. This effect is robust to alternative estimation techniques, outliers, sample selection, and different subperiods. Nevertheless, there are large differences in the long-run effect of exports on non-export GDP across countries. More specifically, we found that an increase in exports is associated with a long-run decrease in non-export GDP in 69 % of the countries; in 31 % of the cases, an increase in exports is associated with a long-run increase in non-export GDP.

Next, we examined whether the observed cross-country differences in the long-run effect of exports are linked to country-specific factors, such as the level of primary export dependence, business regulation, labor regulation, and the capacity of a country to absorb knowledge. Our results suggest that the long-run effect of exports on non-

[9] Note that the sign of the coefficient on EASE_i is positive, since a higher value of the ease-of-doing-business index indicates a lower level of business regulation.

export GDP is significantly negatively associated with primary export dependence, business regulation, and labor regulation, whereas there is no statistically significant association between the growth effect of exports and absorptive capacity. All in all, it can be (cautiously) concluded that economic reforms aimed at (i) removing primary export dependence by diversifying the economy, (ii) minimizing the regulatory burden on business, and (iii) increasing labor market flexibility can not only protect developing countries from the potential negative consequences of increased exports but also induce export-led growth in the long-run.

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