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Growth Gains from Trade

Abstract

This paper revisits the relationship between international trade and economic growth. We measure trade openness indices separately with respect to intermediate inputs and final goods and find that it is the former which turns out to be significant in explaining growth gains from trade. Using sectoral level data from WORLD KLEMS Database on industrial productivity and output and global input output tables to construct the measures of trade openness, our empirical analysis covering 21 countries, 30 industries and 15 years reveals that trade openness in terms of intermediate and capital goods lead to economic growth. Openness in terms of final consumer goods turns out to be insignificant in most specifications. We also estimate traditional cross country growth regressions where we use trade data to construct the two trade openness indices for 174 countries. Here again, we find that it is import of intermediate and capital goods that results in real per-capita income growth. Our empirical results are in line with our theoretical model, where we show, without imposing any transplanted structure in our model that trade in intermediate goods directly leads to higher growth relative to autarky as opposed to trade in final goods.

JEL-Codes: C100, F100, O400.

Keywords: trade, openness, growth, gains from trade, per capital income.

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I. INTRODUCTION

The relation between international trade and growth is an age old question which has given rise to extensive research by theoretical and empirical economists alike. The question, by itself, is a very fundamental one: Does participating in trade lead to economic growth? The answer, on the other hand, has not been so simplistic. Lucas (1988) noted that basic neo-classical models of trade could not generate a mechanism that would naturally allow trade to have a positive impact on growth. International trade is primarily about reallocation of global resources in the most efficient manner, a story that leads to a one shot rise in real income. However, Ricardo (1817) observes that trade can have a positive effect on growth if *the rate of profit* increases, which in turn requires a decline in the price of the wage good. If opening up of the economy leads to a fall in the price of commodities consumed by the wealthy it shall not translate into a rise in the rate of profit. Instead, it shall only lead to an increase in the quantity and variety of consumer goods in the market. Ricardo's framework, based on the wage-fund approach, showed that if Britain could import cheaper corn, it would automatically stimulate the rate of profit by reducing the relative price of the wage good. The Repeal of Corn Law in 1846 was a consequence of his argument. Findlay (1974) provides a modern treatment of the wage-fund growth relationship.

Another stream of literature on the relation between international trade and growth are the endogenous growth models advocated by Rivera Batiz and Romer (1991), Grossman and Helpman (1993) and others. These studies show positive effects of trade on growth, but they do so by bringing in additional structures into the basic trade model. For example, without innovation or technological change, the rate of growth could not be increased simply by the act of trade i.e. just by specialising according to comparative advantage. Baldwin and Robert-Nicoud (2008) use a firm heterogeneity model to show when trade may or may not lead to a higher growth rate; however, it still depends on technological diversity and innovations to generate a relationship between trade and growth. Acemoglu and Ventura (2002) focus on a different type of endogenous growth, that through capital inflows, which lower the cost of capital. Earlier models such as discussed extensively in Findlay (1995), use a basic two sector dynamic model but do not show an automatic and unambiguous sustained increase in growth rate due to trade. If secular impact of trade and growth has to be identified, the pattern of comparative advantage should automatically lead to a higher growth rate, independent of any external structure that is imposed on the basic model of trade.

Given this backdrop, the purpose of this paper is to show, both theoretically and empirically, that the growth effect of trade is conditional on what types of products are traded. Any openness index that includes all kinds of trade would lead to measurement error in the independent variable and may falsely predict a weak or no relationship between trade and growth. This is where the theoretical mechanism becomes critical in formulating the empirical strategy.

In this paper we aim to answer the following question: *trade in which type of products actually stimulates growth?* We find that in order to establish a relation between the two, it is important to include trade in intermediate goods and in final consumer goods as separate components in the analysis. The distinction between the contribution of trade in final goods and intermediates towards growth rates has never been explicitly modelled. Naito (2012) uses a Ricardian continuum model to explore growth. But the issue of the distinction between final goods and intermediates as catalysts for growth is not discussed here. Very much like in Ricardo (1817), Marjit and Mandal (2017) have developed a model of virtual trade and growth to show how trade can automatically lead to gains in terms of a higher growth rate. But a general approach must demonstrate when trade will or will not contribute towards growth. Our theoretical proposition includes the well-known Ricardian outcome, as exhibited in Findlay (1974) and more recent works of Kikuchi and Marjit (2011), Marjit and Mandal (2017) on time zone and growth where opening up for trade is good enough to raise the growth rate. This paper first carries out a detailed empirical exercise on how different types of trade affect growth and then formulate an endogenous growth model with intermediate goods to show how trade can by itself lead to growth without any other transplanted structure on the model.

Our empirical results are in line with the findings of our theoretical model. In empirical literature, traditional measures of trade openness, like trade to GDP ratio, do not distinguish between trade in final goods and trade in intermediate goods. In this paper, using global Input-Output tables, we bifurcate the measure of trade openness into two components: one with respect to intermediate inputs and the other with respect to final products and find that it is the former which contributes significantly to productivity and output growth. This implies that if such a distinction is not made then it could be interpreted as a measurement error in the openness index and hence its estimated effect on growth could be biased. Our method of constructing the two openness indices is novel and appropriate to understand the specific channels through which trade openness can influence growth. Using panel data consisting of a number of country-sector observations, we analyse the effect of the two kinds of openness indices on productivity and value added. We obtain productivity and output data from WORLD KLEMS database which provides comparable industry level estimates across European Union (EU) countries as well as some non-EU countries (*Refer to Appendix B for list of countries*). We further corroborate our conclusions by presenting the results of conventional cross-country growth regressions where we find that openness, with respect to capital and intermediate goods trade, has a positive and significant effect on the growth rate of per-capita income. Although there are numerous cross country macro studies (Dollar, 1992; Sachs et al, 1995; Frankel and Romer, 1999) that have focused on the impact of trade openness and growth, our empirical analysis differs from them in a number of ways.

First, our analysis is not at the macro level; instead, we carry out the analysis at the sector level, consisting of 30 industries in several countries. Second, our explained variable is not country level per capita income; instead, we use sectoral productivity and sectoral value added. Our analysis also differs from a large number of firm level productivity studies (Amiti and Konings, 2007; Goldberg et al, 2010) which analyse the impact of imported inputs on firm productivity. Most of the previous firm level studies focus on a single country whereas ours is a cross country, sectoral level analysis. Most of these studies usually analyse the impact of tariff reduction on firm level productivity. We, on the other hand, estimate trade openness using actual trade values obtained from input output tables. An advantage of this is that we consider not only the tradable sectors but also the service sector in our analysis. Thus, our paper, although linked strongly to both the macro as well as the micro streams of literature, differs significantly from them in several aspects.

The rest of the paper is structured as follows. Section II provides an overview of the empirical literature review. Section III describes the data and methodology utilised in our empirical analysis. It describes the variables used, the methodology followed in the construction of the openness measures, the estimation technique employed as well as the description of the data sets that have been used. Section IV presents the summary statistics of the variables and a descriptive analysis of the relation between the openness measures and growth. In Section V we discuss the results of our econometric analysis. Section VI constructs a theoretical model that demonstrates the possibility, as noted in the empirical work, that trade in intermediate good leads to higher growth but not trade in final goods. This framework is capable of capturing the fundamental Ricardian intuition as well. The final section concludes.

II. EMPIRICAL LITERATURE REVIEW

The question of whether openness in terms of international trade translates into increased growth for the economy has given rise to vehement debates in the field of trade and development. A rich empirical literature has flourished as an outcome. Our empirical analysis is related to three broad strands of literature: conventional cross-country macro studies, firm level productivity studies and empirical applications of endogenous growth models. A detailed discussion of these is provided below.

There are numerous cross country macro studies which have studied the impact of trade openness on income growth. However, the way in which trade openness has been captured or measured varies across papers (Rodriguez and Rodrik 2001). Dollar (1992) quantifies two aspects of openness- a low level of protection for imports and low variability in the exchange rate. The first ensures that the exchange rate is not misaligned i.e. there is no under or over valuation of the exchange rate, thereby incentivizing exporters, and the second ensures that these incentives are not fluctuating over time. For a sample of 95 developing countries, over the period 1976-85, Dollar finds that growth is negatively correlated with both distortion (misalignment) and variability (fluctuation) of the exchange rate. He claims that a possible explanation behind why the African and Latin American nations lagged behind Asian countries in that time period could be explained by their lower outward orientation (as indicated by their higher distortion of the exchange rate) as well as higher exchange rate variability as compared to Asian nations. Sachs, Warner, Åslund, & Fischer (1995), in their seminal paper treated openness as a dummy variable, which took the value of 0 if the economy was closed and 1 if it was open[1]. Regressing income growth between 1970 and 1989 on the open dummy, they find that open economies grew at a significantly faster rate than closed economies.

Rodriguez and Rodrik (2001) point out the shortcomings of both these influential papers. For Dollar's paper, they find the use of exchange rate distortion as a measure of outward orientation to be faulty and not a robust correlate of growth. The distortion measure is appropriate only under certain restrictive circumstances and hence does not give an accurate picture in reality. As for Sachs and Warner's measure of openness, Rodriguez and Rodrik (2001) find that the two components- black market premium and state monopoly over exports are driving the result and question its reliability as a measure of trade openness.

Frankel and Romer's (1999) oft cited paper titled "Does Trade cause Growth" was one of the first empirical papers to address the problem of endogeneity by using the instrumental variable approach. To avoid the problem of reverse causality, they use a country's geographical characteristic to construct an instrument for trade share and find that the IV estimates have a greater impact on income than the OLS estimates. However, the use of geographical characteristics as a valid instrument has also been criticized. Rodriguez and Rodrik (2001) point out that the exclusion restriction criterion is not satisfied since geography can impact income through channels other than trade as well. In fact, in Rodrik et al (2004) it is shown that, to determine income, once institutions are controlled for, the coefficient on trade becomes insignificant in most of the cases.

Brückner and Lederman (2012) use GDP growth rate of OECD countries to instrument for trade openness in Sub Saharan countries and come to the conclusion that openness impacts their growth positively. Didier and Pinat (2013) claim that not all trade is beneficial, some forms of trade relations have a greater impact on growth than others. They go on to identify the channels through which trade results in higher growth. Intra-industry trade, greater integration in the global value chain and trading with major world growth pole countries leads to positive spillover effects, resulting in higher growth.

[1] They defined an economy as closed if any one of these five conditions were met: i) its average tariff was higher than 40% ii) its non-tariff barriers covered more than 40% of imports iii) it had a socialist economic system iv) its major exports were under state monopoly v) its black market premium was greater than 20%.

All the studies above are cross-country, macro studies which as we have already seen are plagued with the problems of endogeneity and reliability of the openness measure. There also exists a rich literature on micro studies that estimate the relation between firm productivity and imported inputs (Kasahara and Rodrigue, 2008; Goldberg et al, 2009). Others analyse the impact of output and input tariffs at the firm level (Amiti and Konings, 2007; Goldberg et al, 2010; Yu, 2015). Amiti and Konings use data on Indonesian firms to show that reducing tariffs on intermediate inputs leads to a double gain in productivity as compared to reducing output tariffs. Goldberg et al (2009) quantify the gains accrued to Indian firms from the new imported varieties of inputs post trade liberalization. They find that access to new varieties of inputs led to an increase in the manufacture of new products by Indian firms using these inputs. The importance of the role of imported intermediate inputs in enabling domestic firms to introduce new varieties is again emphasized in Goldberg et al (2010). Their estimates reveal that during the period 1989-1997, a decline in input tariffs accounted for nearly 30% of the new products by domestic firms. Halpern, Koren & Szeidl (2015) use Hungarian firm level data and find that there are substantial revenue as well as productivity gains accruing to the firms if it imports all varieties of inputs. Such studies serve as evidence in establishing the role of imported intermediates inputs resulting in dynamic gains for the importing country.

Again, these analyses are not free of shortcomings. Since most of them capture the impact of tariff reduction on firm level productivity, simultaneity problems can arise. This is because tariffs, being a policy variable, can be correlated with productivity. For instance, the government may decide that tariff rates should only be reduced for those commodities in which domestic firms are efficient producers. This may be because the poorly performing domestic firms may not be able to survive the foreign competition that will be brought about by the reduction in tariff. As a result, tariff reduction may be endogenous to growth.

Another related branch of literature which talks about the impact of trade openness and productivity are the empirical studies inspired by the endogenous growth models of Romer (1990) and Grossman and Helpman (1991). Like the ones undertaken by Coe and Helpman (1995) or Feenstra et al (1999), such studies do not link trade openness to productivity or output growth *directly*. In Coe and Helpman, trade openness leads to growth in country level domestic productivity through increased foreign R&D spillovers. Their sample consists of OECD countries and they find that more open economies benefit more from international R&D as compared to less open economies. While Coe and Helpman use country level data, Keller (2002) uses sectoral data to estimate the impact of partner country's R&D expenditures on domestic productivity for 14 OECD countries. He finds that spillovers are highly localized in the sense that foreign spillovers are much higher when the partner country is geographically closer. Feenstra et al (1999), on the other hand, explore the role of increased product variety in raising domestic productivity using sectoral productivity data for South Korea and Taiwan. They find that changes in relative export variety raise productivity in nine out of 16 sectors.

Although our study is different in terms of data and the measures used, the insights from all the three branches of literature relate very closely to our hypothesis. Our hypothesis of import of intermediate inputs leading to rise in productivity is similar to a situation of reduction in input tariff, as opposed to output tariff. However, tariff is a policy variable. This chapter deviates from this literature by using actual trade data to measure trade openness instead of tariff rates. An advantage of this is that unlike most of the studies using change in tariffs to capture the impact of trade openness, our analysis is not limited to tradable sectors only. Our sectoral level analysis covers 30 industries, including the service sector. Further ours is not a firm level study. It is a cross-country sectoral level study spanning 15 years and 30 sectors. As far as the macro studies are concerned, we differ from them in terms of the variables and measures used to capture growth and openness. The usage of the IO tables to capture the backward and forward linkages of the economy, for measuring trade openness, is also a novel approach undertaken in this study. Further, the macro studies do not distinguish between openness in terms of intermediate and final goods. As for the empirical work related to the endogenous growth models, as mentioned previously, this study differs from them by directly estimating the dynamic gains of trade openness, instead of measuring it via the channels of spillovers or change in variety.

III. DATA AND METHODOLOGY

We show our results using two specifications. Our first analysis is at the sectoral level, covering several countries and 15 years (2000 to 2014). We primarily use KLEMS and WIOD data for this study. The second specification that we estimate is conventional cross-country growth regressions, where country-level real per-capita income growth is regressed on trade openness. Note that this is not at the sectoral level. We use data from UN COMTRADE and World Development Indicators for this analysis. In the following sub sections we discuss the variables used and the methodology followed to estimate both the specifications and then provide a list of the data sources for both.

III.1. INDUSTRY LEVEL STUDY

III.1.A. Description of Variables

The primary objective of this paper is to estimate the effect of the two kinds of trade openness- openness with respect to intermediate products and openness with respect to final goods, on sectoral productivity and output across countries and over time. In order to do so, we need comparable industry level estimates of our explained variables, which we obtain from WORLD KLEMS Database. The primary explanatory variables of interest, i.e. the two measures of trade openness; have been constructed using the global input output tables provided in World Input-Output Database (WIOD). In this paper, we hypothesise that the following equations determine productivity and output:

$$TFP_{i,j,t} = \alpha + \beta_1(TFP_{i,j,t-1}) + \beta_2(Open\_inter_{i,j,t}) + \beta_3\left(Open\_final_{i,j,t}\right) + \beta_4 X_{i,j,t} + \beta_5 W_{i,t} + \gamma_i + \delta_j + \delta_{i,j,t} \quad (1)$$

$$VA_{i,j,t} = \alpha + \beta_1(VA_{i,j,t-1}) + \beta_2(Open\_inter_{i,j,t}) + \beta_3\left(Open\_final_{i,j,t}\right) + \beta_4 X_{i,j,t} + \beta_5 W_{i,t} + \gamma_i + \delta_j + \delta_{i,} \quad (2)$$

where;

$\boldsymbol{TFP_{i,j,t}}$ is Total Factor Productivity estimate for country *i*, industry *j*, year *t*. TFP estimates have been taken from KLEMS database, which uses the growth accounting methodology to derive the productivity estimates. Further, the TFP values have been provided in a standardized form such that the TFP value of each country and each industry for the year 2010 is 100.

$\boldsymbol{VA_{i,j,t}}$ is gross value added in country *i*, industry *j*, year *t*. This variable has also been obtained from the EU KLEMS database.

Open_inter and Open_final, are the main explanatory variables of interest. The former measures the share of imported intermediate inputs used in total inputs used by a particular industry *j* in country *i* and year *t*. It basically captures the degree of outward orientation of that particular industry in terms of its intermediate products (or inputs). *Open_final*, on the other hand, captures the share of goods of a particular industry, imported by a country, for final consumption. This captures the degree to which the economy is open in terms of importing final goods of a particular industry. The greater the outward orientation of an economy, the higher would be these openness measures. The two measures would differ depending upon whether the country is more open with respect to intermediate inputs or with respect to final goods. The detailed description of the methodology behind constructing the indices is given in subsection III.1.B. Our coefficient of interest is β_2 and we hypothesise in this paper that it shall have a significant effect on our outcome variables.

$\boldsymbol{X_{i,j,t}}$ are the following (country, industry) level variables which we expect to be important determinants of productivity:

- ***Export Ratio*:** This is the share of output that is exported by a particular industry *j* in country *i* and year *t*. This variable has been constructed using global input output tables using the following formula:

$$\boldsymbol{Export\_Ratio_{i,j,t}} = \frac{\sum_{l \neq i} y_{lj,i\,t}}{\sum_{l} y_{lj,i\,t}}$$

where;

i, l represents countries

k, j represents industries/sectors

$\boldsymbol{y_{lj,i\,t}}$ is the output of the j^{th} industry in country *i*, used by the l^{th} country in year *t.*

We control for the export ratio of every sector since it is a vital factor that could possibly impact productivity. There exists an enormous cross-country (Balassa, 1978; Feder, 1983; Michaely, 1977) as well as firm-level (Aw and Hwang, 1995; Wagner, 2007) evidence on the link between exports and productivity. The literature discusses two reasons as to why export oriented firms tend to be more productive than non-exporting firms. The self-selection hypothesis points out that at the onset, firms that are more productive shall self-select themselves into the export market. The second hypothesis is that of learning by doing which argues that firms which cater to the world market can gain knowledge (in terms of superior techniques, inputs etc.) from their foreign competitors which help in improving their performance. Further, exporting firms face tougher and more intense competition in the international market and are thus challenged to improve their productivity quickly as compared to firms that cater to the domestic market only.

- ***R&D Labour Ratio:*** This is the ratio of R&D undertaken by the j^{th} industry in country *i* and year *t* to the total number of employees in industry *j* in country *i* and year *t*. It can be expressed in terms of the following formula:

$$\boldsymbol{RD\_ratio_{ij,t}} = \frac{\boldsymbol{RD_{ij,t}}}{\boldsymbol{employees_{ij,t}}}$$

where;

$RD_{ij,t}$ is the real fixed Research and Development stock of the j^{th} industry in country *i* and year *t*.

$employees_{ij,t}$ is the number of employees in industry *j* in country *i* and year *t*.

R&D stock per capita is expected to impact productivity positively. Greater R&D undertaken by an industry can directly raise productivity by stimulating innovation and also can indirectly increase the industry's performance by raising its absorptive capacity, thereby resulting in gains through technological spillovers. The empirical evidence in favour of this is aplenty (Griliches & Lichtenberg, 1984; Jaffe, 1986; Wakelin, 2001; Griffith et al, 2004).

- ***Number of Employees:*** This is the total number of employees in industry *j* in country *i* and year *t*. We include this variable to control for scale effects. Henderson (1986), Biesebroeck (2005), Diaz & Sánchez (2008) are some of the works that discuss the relation between firm/industry size and productivity.

$\boldsymbol{W_{i,t}}$ represents the following country level control variables:

- ***Institutions*:** A country's institutional characteristics like rule of law, regulatory quality, political stability etc. play a major role in determining growth. In fact, in the seminal paper by Rodrik et al (2004), it is shown that institutions alone can explain variation in income levels across countries and that once institutions is controlled for, the role of other factors become insignificant. For our paper, we take data on institutions from World Governance Indicators database. They provide country wise estimates of six governance indicators from the year 1996 onwards, namely: *Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption.* For our purpose, we want the institutions variable to capture the information in all these six dimensions of governance, without compromising on our degrees of freedom by adding all of them individually. In order to do so, we run a principle component analysis on all the indices. We find that the first principal component itself captures more than 90% of the variability in all the indicators and therefore use this component as a proxy for institutional quality in our analysis.

- ***Secondary School Enrolment Rate*:** It is the ratio of total secondary school enrolment to the population of the age group that corresponds to secondary school level of education. This is essentially a measure of human capital and it has been shown to be a significant factor in explaining growth in various cross country settings (Barro, 1991; Barro, 2001; Fleisher et al, 2010).

- ***Human Capital Index***: This variable has been taken from the Penn World Table (PWT) version 9.1. We have used human capital index in some of our specifications since the data on secondary school enrollment is missing for many of the countries. The human capital index, as constructed in the PWT, is based on the average years of schooling data taken from either Barro and Lee (2003) or Cohen and Leker (2014) and an assumed rate of return to education, based on the Mincer equation estimates, taken from Psacharopoulos, George (1994). [2]

- ***GDP per capita***: GDP per capita in constant 2010 US dollars is the Gross Domestic Product of a country divided by mid-year population. The per capita GDP of a country can be taken to be a proxy for any other time varying country characteristics that have not explicitly been taken into account like infrastructure, degree of urbanisation etc.

$\boldsymbol{\gamma_i}$ and $\boldsymbol{\delta_j}$ are country and industry fixed effects respectively. These are essentially those industry or country specific factors that are time invariant, for instance, a country's geographical characteristics or the location of an industry.

III.1.B. Construction of the Openness Variables

In this subsection we shall attempt to outline the methodology followed to construct the two openness indices: openness with respect to intermediate products (*open_inter*) and openness with respect to final goods (*open_final*) for each country and each industry (sector). As mentioned above, we use WIOD database to do so. Moving vertically along a column of the IO table provides information on the value of inputs sourced by a particular (*industry, country*) pair from other (as well as own) industries and countries. Moving horizontally across a row provides the value of output of that particular (*industry, country*) pair being used in other (as well as own) industries and countries. Apart from use of the output as inputs in other (*industry, country*) pairs, it is also used as final goods by households, non-profit organisations serving households and government. Note that WIOD provides data in millions of US dollars. The two trade openness measures which we construct using the WIOD tables are:

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[2] For more details on the construction of this index, see Note on Human Capital Index PWT

- ***Open_inter***: *Ratio of imported intermediate goods to total intermediate goods used in industry j by country i in year t. Open_inter* for country *i* and industry *j* in year *t* can be represented as:

$$\boldsymbol{Open\_inter_{ij,t}} = \frac{\sum_{l \neq i} \sum_{k,j} \boldsymbol{m_{lk,j\,t}}}{\sum_{l} \sum_{k,j} \boldsymbol{m_{lk,j\,t}}}$$

  where;

  i, l represents countries

  k, j represents industries/sectors

  $\boldsymbol{m_{lk,j\,t}}$ represents the value of the inputs used by the *j* th industry in *i* th country from *k* th industry(as well as *j* th industry itself) in *l* th country in year *t.*

- ***Open_final***: *Ratio of imported final goods consumed to total final consumption (by households, non-profit organisations serving households and government) in industry j by country i in year t. Open_final* for each industry *j* of each country *i* for year *t* can be represented as:

$$\boldsymbol{Open\_final_{ij,t}} = \frac{\sum_{l \neq i} \boldsymbol{x_{lj,i\,t}}}{\sum_{l} \boldsymbol{x_{lj,i\,t}}}$$

  where;

  i, l represents countries.

  j represents industries/sectors.

  $\boldsymbol{x_{lj,i\,t}}$ represents the value of the output produced by the *j* th industry in *l* th country that is consumed as a final good in country *i*.

III.1.C. Estimation Methodology

In this sub-section we provide an overview of the methodology used to carry out the empirical analysis. We do not employ standard panel data techniques (fixed and random effects) to estimate equations (1) and (2) due to several reasons. Primarily, due its dynamic nature, there is persistence in our explained variable (productivity/ value added; in the sense that current year's productivity shall be correlated to its past year values (Topalova and Khandelwal, 2011; Bilotkach, 2015). As we shall see from the estimation results provided in Section VI of the paper, the lagged value of the dependent variable turns out to be highly significant in all the specifications. Ignoring this would lead to omitted variable bias, rendering our estimates biased and inconsistent. However, once we include the lagged dependent variable as an explanatory variable, employing standard fixed/random effects model would again lead to inconsistent estimates since the lagged dependent variable is correlated with the error term, violating the exogeneity assumption between the error term and independent variables. Thus we resort to dynamic panel estimation techniques in order to obtain consistent estimates (Arellano and Bond, 1991; Blundell and Bond, 1998). Again, we estimate equations (1) and (2) by taking the variables (except those which have zero or negative values) in their log forms. Doing so enables us to express the equations as growth of the explained variable as is evident below:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \alpha + \gamma ln(y_{i,t-1}) + \beta' X + \epsilon_{i,t}$$

The presence of the lagged value of the dependent variable in the equations requires us to employ dynamic panel estimation in order to obtain unbiased results. The Arellano Bond estimation takes first difference of the equation and then it uses past lags of the potentially endogenous explanatory variables as instruments. The Blundell-Bond estimator on the other hand augments the Arellano Bond estimator by adding more instruments by way of instrumenting the levels of the endogenous variables with differences. At this juncture it is important to note that for the instruments to be valid, we need to satisfy the post-estimation serial correlation test and the Hansen over-identification test (Roodman; 2009). Since both Arellano Bond and Blundell-Bond estimators use Generalised method of moments (GMM), the former is referred to as difference GMM and the latter as system GMM. Further, Roodman (2009) points out that dynamic panel estimation technique is suitable when we have large cross-section but few time periods, a dynamic dependent variable, independent variables that are not strictly exogenous, and individual fixed effects, all of which are characteristics of our dataset. The advantage of using dynamic panel estimation technique is not only that it takes into account the simultaneity of the lagged dependent variable, but one can also instrument other potential endogenous explanatory variables with their lagged values. In our analysis this serves an important purpose of addressing potential endogeneity between trade openness and productivity growth.

III.2. CROSS-COUNTRY REGRESSIONS

III.2.A. Description of Variables

Conventional cross country macro have been the most popular approach taken to quantify the impact of trade openness on income growth (Dollar, 1992; Sachs et al, 1995; Frankel and Romer, 1999). In addition to the sectoral analysis described above, we also estimate such cross country growth regressions. We regress income growth over 6 five year periods on the initial values of the openness indices and other country level controls. Here too we construct two types of trade openness measures: one with respect to capital and intermediate goods and the other with respect to final goods. However, we don't use input output tables to do so. Instead, we use highly disaggregated trade data. We quantify the effect of the two kinds of trade openness by using the following traditional cross country time series specification:

$$r_{i,t} = \alpha + \beta_1\left(Open\_inter_i^{initial}\right) + \beta_2\left(Open\_final_i^{initial}\right) + \beta_3\left(X_i^{initial}\right) + \varepsilon_{i,t} \qquad (3)$$

where;

$r_{i,t}$ is the average growth rate (compound) of real per capita income of country *i* over 6 five year periods denoted by *t:* 1993-1997, 1997-2001, 2001-2005, 2005-2009, 2009-2013, 2013-2017. We obtain $r_{i,t}$ by estimating the following regression for each country and over each of these five year periods:

$$Y_{i,T} = Y_{i,0}\left(1 + r_{i,t}\right)^T$$
$$\Rightarrow \ln(Y_{i,T}) = \ln(Y_{i,0}) + T\ln(1 + r_{i,t})$$

where;

$Y_{i,T}$ is the per capita real income of country i in year *T*.

$Y_{i,0}$ is the per capita income of the initial year (*T*=0)

$r_{i,t}$ is the compound rate of growth of *Y* for a particular five year period *t*.

ln($\boldsymbol{Open\_inter_i^{initial}}$ and $\boldsymbol{Open\_final_i^{initial}}$ are the two trade openness measures of interest. The former is trade openness with respect to intermediate and capital goods in country *i* for the initial year in period *t*. For instance, the initial year for the period 1993-1997 is 1993, for the period 2009-2013 is 2009 and so on. $\boldsymbol{Open\_final_i^{initial}}$, on the other hand, represents trade openness with respect to final goods in country *i* for the initial year in period *t*. The coefficient of interest in the above specification is β_1, which we hypothesise to have a positive and significant effect on income growth of a country. The detailed methodology followed in the construction of the above two trade openness measures have been provided in subsection III.2.B.

$X_i^{initial}$ denotes the following country level controls that have been included in the specification:

- ***Initial GDP:*** This is the real per capita GDP level of country *i* in the beginning of period *t*. If the coefficient of this term is negative, then it essentially implies income convergence. A negative coefficient implies that a country with lower levels of per capita income is growing at a faster rate, implying convergence.

- ***Export share***: This is the share of exports of country *i* in its GDP. There is a widely held view that exports are associated positively with economic growth (Balassa, 1978; Tyler, 1981; Bahmani-Oskooee, 1993). We control for this by including share of exports in country's GDP in our regression specification.

- ***Secondary enrolment:*** This is the ratio of total secondary school enrolment to the population of the age group that corresponds to secondary school level of education. The reasons for including this variable have been mentioned already in Section III.1.A.

- ***Human capital index:*** The description and justification for including this variable have been discussed already in Section III.1.A.

- ***Institutions*****:** As explained in subsection III.1.A, this variable has been calculated by running a principle component analysis on six institutional indices provide by the World Governance Indicators (WGI), namely, *Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption.*[3]

- ***Population growth:*** This is the growth rate (compound) of population of country i over the 6 five year periods. This variable has been constructed in a similar manner as the dependent variable, using population data for a country instead of real per capita income. We add this variable in order to control for growth in labour supply. This is a conventional control used in conventional cross country regressions as seen in the studies undertaken by Barro (1992) or Sachs & Warner (1997).

Unlike the previous specification, since these cross-country growth regressions are not estimated at the industry level, the number of countries in this case is not limited by the KLEMS database. We have a total of 174 countries (*refer to Table A4 in Appendix A*) in our dataset. As we do not have data on all variables for all countries encompassing all years, we estimate an unbalanced panel.

III.2.B. Construction of the Trade Openness Measures

In order to construct the country level measures of trade openness, we have used HS (Harmonised System) 1992 six-digit import data from UN COMTRADE accessed through WITS software. The traditional trade openness measure is typically a ratio depicting the share of a country's trade ($Export + Import$) in its total GDP. A higher value of this ratio would indicate a higher degree of openness of an economy. In our case we have split this traditional openness measure into two branches: one with respect to final goods and the other with respect to capital and intermediate goods. In order to do so we have used the concordance between the 6 digit HS

[3] Since the WGI database provides data from the year 1996 onwards, we have replaced the initial value of the governance indicators for the first five year period, i.e. 1993-1997 with those provided for the year 1996.

codes and the Broad Economic Categories (BEC) codes, which we avail from WITS itself. The BEC Revision 4 codes can be classified into three basic classes of goods according to the System of National Accounts (SNA): capital, intermediate and consumer (*Refer to Table C1 in Appendix C for a list of BEC codes classified as capital and intermediate goods*).[4] Once we match the BEC codes with the HS codes, we are able to identify the HS codes which represent consumer goods, capital goods and intermediate goods. The indices are constructed using the following formula:

$$\boldsymbol{Open\_inter_i = \frac{Import\ value\ of\ Capital\ and\ Intermdiates\ goods\ by\ country\ i}{GDP\ of\ country\ i}}$$

$$\boldsymbol{Open\_final_i = \frac{Import\ value\ of all\ consumer\ goods\ by\ country\ i}{GDP\ of\ country\ i}}$$

$Open\_inter_i$ measures the share of imported capital and intermediate goods whereas $Open\_final_i$ represents the share of imported final (or consumer) goods in a country's GDP. In this paper, we hypothesise that it is the former which plays a crucial role in explaining economic growth.

III.3. Data Sources

Data for our dependent variable (TFP and value added) at the industry level has been obtained from the KLEMS database. Our initial analysis utilises the 2017 release of the EU KLEMS data which is also classified according to ISIC Rev. 4, same as that of the WIOD, which we use for the construction of some of our independent variables. EU KLEMS provides comparable sectoral data on output, productivity, employment and capital for the EU countries and USA spanning across several years. We then proceed to add four other countries (India, Japan, Canada and Russia) from the WORLD KLEMS database. These additional countries are classified according to ISIC Rev. 3.1. The data provided is at the one or two digit level so we use our judgment to match the KLEMS data with the WIOD data[5]. The choice of countries, industries and years is dictated by data availability (*refer to appendix B for a list of countries and industries*). As for the

[4] BEC codes 321, 51 & 7 are not classified into any of three categories explicitly. In order to avoid ambiguity, we do not take these three codes into consideration.

[5] The concordance tables that are provided officially by the United Nations Statistics division are at a much disaggregated level, not at the two digit level.

dependent variable in the cross country regressions, data for real per capita income is obtained from the World Bank Database for all the 174 countries used in the analysis.

To construct the two openness indices and the export ratio at the sectoral level, we have used the 2016 release of the WIOD which provides global input output tables for 43 countries and 56 sectors for the years 2000-2014, classified according to the International Standard Industrial Classification Revision 4 (ISIC Rev. 4). The set of countries that have been covered by the KLEMS database are a subset of these 43 countries. In case of the country level measures of openness and export ratio, as explained before, we use trade data from UN COMTRADE, which we access through WITS software. Since the data is provided in current US dollars, we divide the numerators of all the three variables using GDP in current dollars.

Both our industry level control variables (R&D labour ratio and number of employees) have been obtained from the KLEMS database. Although the variable R&D labour ratio is not provided directly in the database, both its numerator and denominator have been obtained from the KLEMS database itself.

Country level secondary school enrollment rates have been obtained from the World Development Indicators database provided by the World Bank. The data on the six components of the variable institutions have been obtained from the World Governance indicators database. Further, data on population of a country has been obtained from World Bank Database and human capital index has been acquired from Penn World Tables 9.1. A table containing the variables and their respective data sources have been provided in Appendix C.

IV. DESCRIPTIVE ANALYSIS

Tables 1 & 2 given below provide the summary statistics (number of observations, mean value, standard deviation, minimum and maximum) of the variables that have been used to estimate sector-specific TFP and VA across countries over time, respectively. The variable R&D Labour Ratio has limited observations since KLEMS database does not provide data for this variable for all the countries. Note that the total number of observations increases when we take Value Added as our explained variable instead of TFP.

Table 3 provides the same information on the variables that have been used in the cross-country growth regressions. Note that since the number of observations for secondary school enrollment is significantly less than those of other variables, we use the human capital index in some specifications instead.

Table 1: Description of Variables Used in Sectoral Analysis for TFP Estimation

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
TFP	7,053	107.7	222.9	1.250	11,506
Open_inter	7,053	0.239	0.168	0.0110	0.933
Open_final	7,053	0.256	0.282	0	1
R&D Labour Ratio	5,436	43.6145	181.402	0	3112.783
Export Ratio	7,053	0.243	0.260	0	1
Number of Employees	7,052	61,685	463,668	0.250	7.277e+06
Institutions	7,053	0.194	2.251	-7.022	2.823
Human Capital Index	7,053	3.260	0.380	1.782	3.734
Secondary School Enrolment	6,602	108.0	20.68	45.08	162.3
Real GDP per capita	6,634	38,365	17,166	813.0	108,577

Table 2: Description of Variables Used in Sectoral Analysis for VA Estimation

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Value Added	11,532	73,153.13	238,807.7	0.3	2.841e+06
Number of Employees	11,532	408.75	1,394.1	0	20,188
Export Ratio	11,532	0.261	0.262	0	1
Open_inter	11,532	0.286	0.178	0.000333	0.933
Open_final	11,532	0.279	0.288	4.19e-05	1
R&D Labour Ratio	6,352	43.54	195.41	0	3,112.8
Secondary School Enrolment	11,005	105.6	15.30	79.27	162.3
Institutions	11,532	-0.00616	2.251	-5.707	3.943

Table 3: Description of Variables Used in Cross-Country Analysis

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Real per capita GDP growth	812	2.322	2.801	-12.73	17.23
Initial GDP	812	13,634	17,751	199.1	103,722
Open_inter	812	0.227	0.154	0.0365	1.814
Open_final	812	0.0794	0.0621	0.00296	0.570
export_share	805	0.270	0.228	0.00286	1.939
Export Ratio	585	79.60	29.22	5.634	160.9
Secondary School Enrolment	665	2.470	0.685	1.057	3.726
Human Capital Index	794	0.386	2.144	-4.266	4.805
Institutions	812	1.385	1.417	-1.986	16.62

Figures 1 and 2 shown below are a scatter plot of TFP growth with *open_inter* and *open_final* respectively. For each country, we have calculated the average values of these variables across years and industries. Doing so enables us to get rid of the trend in the data. Since in Figure 1 the scatter plot is upward rising, it can be claimed that the relation between *open_inter* and TFP growth is positive. However, from Figure 2, the relation between TFP growth and *open_final* seems to be negative since the plot seems to be downward sloping. This is in line with our hypothesis of trade in intermediate goods having an important role to play in determining output and productivity growth, as opposed to trade in final goods.

TFP growth and Open_inter

TFP growth and openness with respect to intermediate goods, averaged over 15 years and 30 industries, for KLEMS countries.

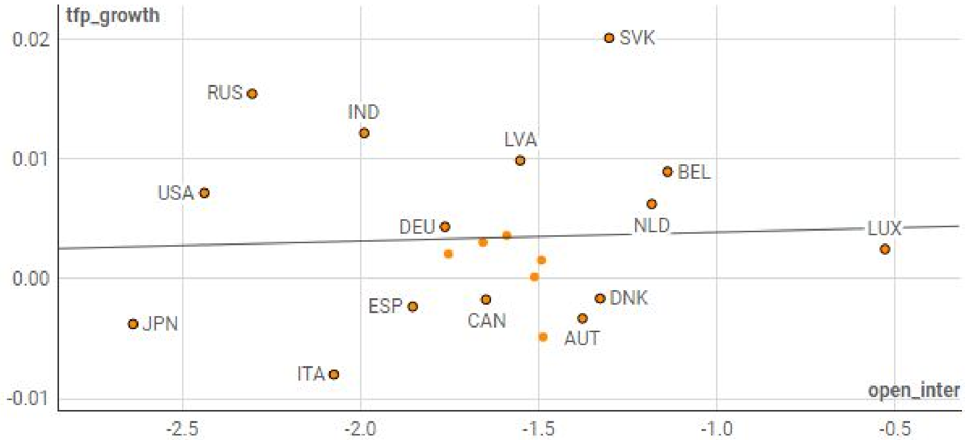

Figure 1

TFP growth and Open_final

TFP growth and openness with respect to final goods, averaged over 15 years and 30 industries, for KLEMS countries.

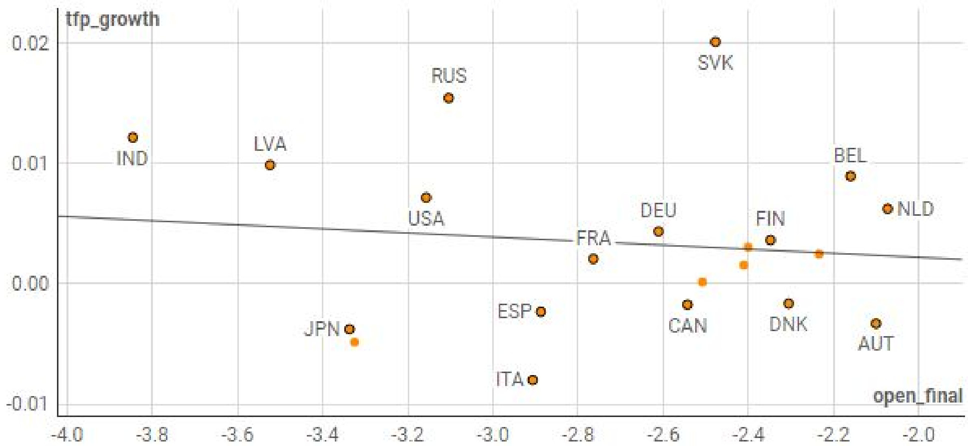

Figure 2

From Figures 3 and 4 we see that the relation between growth in VA and openness with respect to intermediate goods is stronger, as is evident from a steep line of best fit, as compared to that for final goods, where the line of best fit is much flatter.

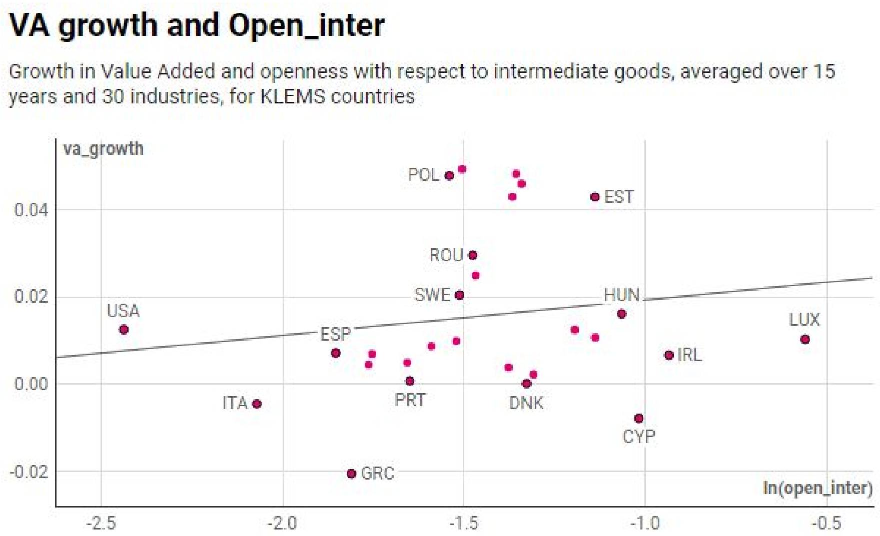

Figure 3

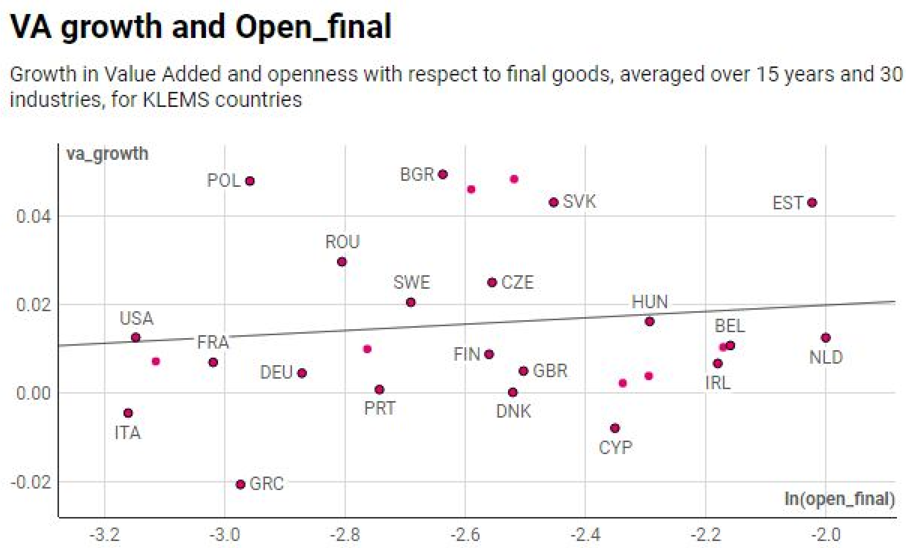

Figure 4

We plot similar graphs for the relation between country level average growth in real per capita income and the two kinds of trade openness. Figure 5 shows a positive linear relation between *open_inter* and income growth. Further, from figure 6 we observe a negative relation between income growth and *open_final*.

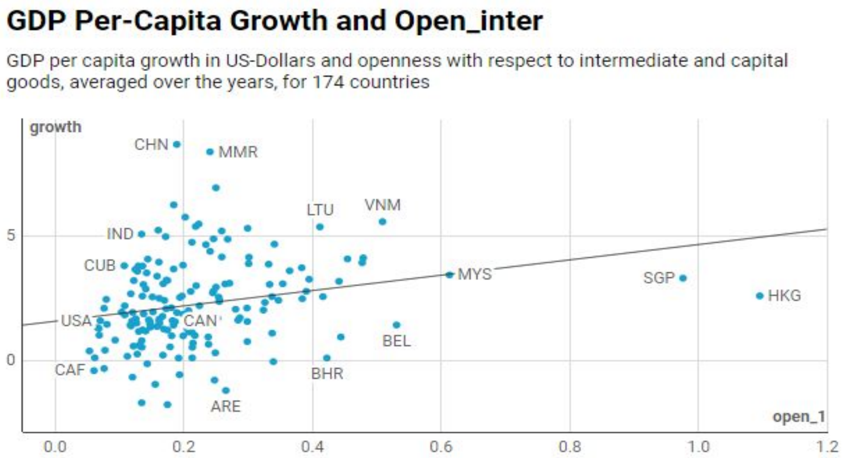

Figure 5

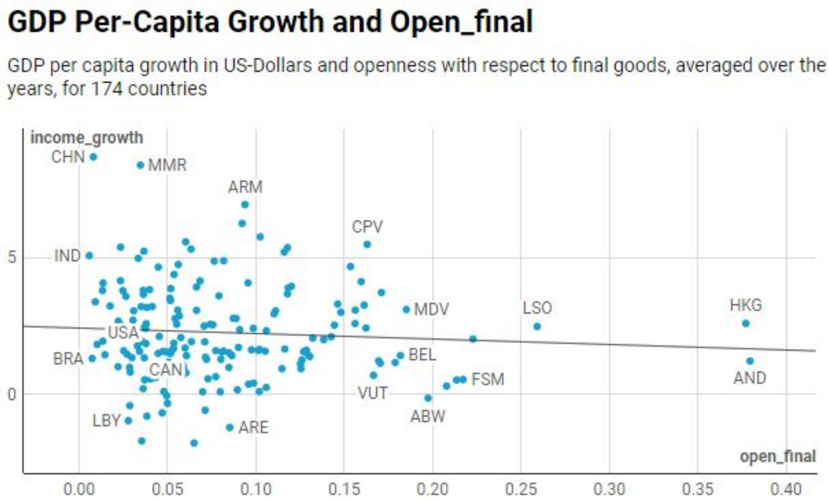

Figure 6

Although such visual analyses provide us with a starting point, we cannot deduce much from it for multitude reasons. Primarily, our data is in panel format and hence when we attempt to plot it in a two dimensional space, we need to take average values over the other dimensions (years and industries in this instance). Thus a lot of variation in the data gets lost when we do so. In such graphical analyses, we also ignore other variables that could possibly affect economic growth. In the following section we undertake a more comprehensive regression analysis and discuss the empirical results of our entire model.

V. RESULTS

In Part 1 of this section we discuss the estimation results of the industry-level study done using KLEMS data. In Part 2 of the same section we analyse the results obtained from the cross-country growth regressions. Note that for the industry level study undertaken using KLEMS data, we first show the results of the analysis using only the EU KLEMS data (i.e. EU countries and USA) and then go on to show results by incorporating four other countries (Canada, India, Japan and Russia) in our analysis.

V.1. INDUSTRY- LEVEL STUDY

V.1. A. INDUSTRY- LEVEL STUDY USING ONLY EU KLEMS DATA

Tables 4 and 5 given below estimate Equation (1), i.e., the regressions using TFP as the explained variable whereas Tables 6 and 7 estimate Equation (2), i.e., those regressions where real VA is the dependent variable. All the four specifications have been estimated taking only countries of the EU KLEMS database into account (*refer to table B1 in Appendix B*). For each dependent variable, we have two sets of regressions: one including all goods: *exportables as well as non-exportables* and the other where we consider *only exportables.* We define non-exportables as those whose export ratio, as calculated from WIOD, turns out to be zero. Note that all variables (except RD Labour Ratio, Institutions, and Export Ratio; since they have zero or negative values) have been taken as logs.

In order for the instruments used in the GMM estimation to be valid, the Hansen statistic (test of overidentification) and the second order serial correlation test need to be satisfied. The p-values of both these tests are provided at the bottom of each table; an insignificant p-value would indicate the satisfaction of both these conditions and therefore the validity of the instruments. For all the specifications that have been shown, we have reported only the two-step GMM estimates. Since the standard errors in the two-step results are biased downwards, we have reported the Windmeijer corrected standard errors. The two-step estimation with Windmeijer corrected standard errors is considered to be superior to the one-step estimation (Roodman, 2009). Further, we have controlled for year fixed effects by adding years dummies in all our specifications.

The results in Table 4 and 5 show that openness with respect to intermediate inputs have a consistently positive and significant impact on productivity. Column 1 of Table 4 has been estimated using Difference GMM (Generalised Method of Moments) whereas columns 2 and 3 have been estimated using System GMM. As explained previously, in Difference GMM the regressors are first transformed by differencing and then estimated using GMM. In System GMM on the other hand, which is considered to be more efficient, a system of equations is built: the original equation as well as the transformed one. Dynamic panel estimation also enables us to specify regresssors as endogenous and instrument them with their lagged values.

In column 1 of Table 4, all variables excluding the country-level controls have been considered to be endogenous. We have done so because all the sectoral level explanatory variables can be affected by the productivity of that sector. Higher trade openness with respect to intermediate or final goods can arise because of the fact that the industry itself is a highly productive one. Similar is the case for other variables like R&D labour ratio, number of employees and export ratio. Higher industrial productivity could be the reason for that sector being export oriented, or for undertaking greater R&D. Column 2 shows a more parsimonious specification where both the openness variables as well as the number of employees have been considered to be endogenous and the equation has been estimated using system GMM. In column 3 the entire model has been estimated using system GMM with the two openness variables and number of employees considered to be endogenous. Since System GMM takes more instruments into account as compared to Difference GMM, we are unable to categorise all the variables as endogenous like we did in column 1. Doing so leads to a significant Hansen statistic, implying over identification. Therefore, we restrict the number of endogenous variables in all our system GMM specifications.

From column 1 we can also see that apart from openness, secondary school enrollment as well as R&D labour ratio contributes positively to growth in industrial productivity. The coefficient of Column (1) implies that a 10% increase in *open_inter*, on an average, leads to a 1.9% increase in productivity. System GMM on the other hand estimates a lower value of the coefficient (a 10% increase in *open_inter*, on an average, leads to a 0.3% increase in productivity), but is nonetheless statistically significant. From column (1) we also note that the coefficient of *open_final* is significant (at 7% level of significance); however the value of the point estimate is much lower than that of *open_inter*. Similar results hold when we consider *only exportables* in Table 5. The full model has been estimated using both Difference and System GMM (columns 1 and 2 respectively). In addition to secondary school enrollment and R&D labour ratio, Export Ratio in column 1 of Table 5.2 also turns out to affect productivity positively in this case.

Tables 6 and 7 estimate Equation (2). The effect of *open_inter* on VA is similar to that on TFP. In column (3) of Table 5.3, the full model has been estimated using difference GMM and by considering all the industry level variables to be endogenous. Columns (4) and (5) on the other hand have been estimated using System GMM. Both estimate the full model and they differ only in terms of the variables that have been considered to be endogenous. In column (4) we consider only *open_inter, open_final* and R&D labour ratio to be endogenous whereas in column (5) we consider all industry level variables, except *open_final* to be endogenous. *Open_inter* turns out to be positive and significant in all the three specifications of Table 6. We also observe that number of employees and R&D Labour Ratio are important determinants of VA growth in an industry. Table 7 estimates the exact same specifications of Table 6 with the exception that only exportables are considered here (i.e. we consider only those observations whose Export Ratio is positive). In addition to the variables that turn out to be significant in Table 6, from Column (1) of Table 7 we can see that Export Ratio also has a positive effect on VA, implying that for those sectors which export, a higher export ratio is associated with more growth.

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Table 4 Regression Results for EU KLEMS Countries and pooling Exportables and Non-Exportables

Dependent variable: $\ln(TFP)$

VARIABLES	(1) Difference_1	(2) System_1	(3) System_2
Lag[ln(TFP)]	0.765***	0.857***	0.855***
	(0.0495)	(0.0268)	(0.0281)
Ln(Open_inter)	0.191**	0.0499**	0.0382*
	(0.0943)	(0.0200)	(0.0223)
Ln(Open_final)	0.0293*	-0.00195	-0.00127
	(0.0162)	(0.00276)	(0.00416)
R&D Labour Ratio	0.000188***		3.94e-06
	(5.03e-05)		(7.85e-06)
Ln(No of Employees)	-0.00489	0.0116	0.00939
	(0.0730)	(0.00773)	(0.00786)
Export Ratio	-0.0847		-0.0269
	(0.105)		(0.0350)
Ln(Secondary enrolment)	0.0977**	-0.00129	0.0397
	(0.0462)	(0.0149)	(0.0313)
Institutions	-0.0187		-0.00158
	(0.0127)		(0.00118)
Constant		0.665***	0.478*
		(0.189)	(0.260)
Observations	4,644	5,501	5,039
Year dummies	Yes	Yes	Yes
AR(1) test p-value	0.0108	0.00727	0.01000
AR(2) test p-value	0.362	0.373	0.385
Hansen Stat p-value	0.740	0.368	0.864
No of instruments	421	430	433

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 Regression Results for EU KLEMS Countries and Exportables only

Dependent variable: $\ln(TFP)$

VARIABLES	(1) Difference_2	(2) System_3
Lag[ln(TFP)]	0.763***	0.864***
	(0.0513)	(0.0309)
Ln(Open_inter)	0.172**	0.0474*
	(0.0841)	(0.0250)
Ln(Open_final)	0.0226	-0.00325
	(0.0168)	(0.00549)
R&D Labour Ratio	0.000178***	-2.38e-06
	(5.80e-05)	(8.48e-06)
Ln(No of Employees)	0.0323	0.0123
	(0.0670)	(0.00913)
Ln(Export Ratio)	0.0303*	-0.00108
	(0.0157)	(0.00400)
Ln(Secondary enrolment)	0.0853*	0.0437
	(0.0441)	(0.0331)
Institutions	-0.0180	-0.00191
	(0.0131)	(0.00138)
Constant		0.405
		(0.269)
Observations	4,608	5,009
Year dummies	Yes	Yes
AR(1) test p-value	0.0111	0.00998
AR(2) test p-value	0.358	0.385
Hansen Stat p-value	0.926	0.850
No of instruments	445	434

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 Regression Results for EU KLEMS Countries and pooling Exportables and Non-Exportables

Dependent variable: $\ln(VA)$

VARIABLES	(1) Difference_3	(2) System_4	(3) System_5
Lag[ln(VA)]	0.663***	0.978***	0.982***
	(0.0613)	(0.00683)	(0.00600)
Ln(Open_inter)	0.134**	0.0477**	0.0563*
	(0.0619)	(0.0219)	(0.0296)
Ln(Open_final)	0.0119	-0.00756	-0.00653**
	(0.0199)	(0.00613)	(0.00284)
Ln(No of Employees)	0.181***	0.0261***	0.0274**
	(0.0607)	(0.00835)	(0.0126)
Export Ratio	0.207	-0.0350	-0.0260
	(0.146)	(0.0446)	(0.0395)
R&D Labour Ratio	0.000166	5.57e-05***	5.01e-05***
	(0.000102)	(1.57e-05)	(1.65e-05)
Ln(Secondary enrolment)	0.0793	0.0155	0.0131
	(0.0537)	(0.0323)	(0.0315)
Institutions	-0.00276	-0.00230	-0.00270
	(0.0112)	(0.00174)	(0.00183)
Constant		0.0674	0.0437
		(0.121)	(0.140)
Observations	5,454	5,903	5,903
Year dummies	Yes	Yes	Yes
AR(1) test p-value	0.00418	0.00297	0.00294
AR(2) test p-value	0.455	0.517	0.516
Hansen Stat p-value	0.609	0.443	0.460
No of instruments	447	434	437

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 Regression Results for EU KLEMS Countries and Exportables only

Dependent variable: $\ln(VA)$

VARIABLES	(1) Difference_4	(2) System_6	(3) System_7
Lag[ln(VA)]	0.666***	0.979***	0.979***
	(0.0634)	(0.00683)	(0.00689)
Ln(Open_inter)	0.148**	0.0524**	0.0487**
	(0.0608)	(0.0245)	(0.0244)
Ln(Open_final)	0.00888	-0.0106	-0.0176**
	(0.0163)	(0.00833)	(0.00827)
Ln(No of Employees)	0.149***	0.0271***	0.0292**
	(0.0457)	(0.00846)	(0.0146)
Ln(Export Ratio)	0.0546***	0.000938	0.0130
	(0.0178)	(0.00879)	(0.0102)
R&D Labour Ratio	0.000199**	4.79e-05***	4.78e-05***
	(9.52e-05)	(1.58e-05)	(1.37e-05)
Ln(Secondary enrolment)	0.0874*	0.0176	0.0175
	(0.0494)	(0.0329)	(0.0322)
Institutions	-0.00182	-0.00312	-0.00345*
	(0.0122)	(0.00210)	(0.00193)
Constant		0.0328	0.0319
		(0.139)	(0.142)
Observations	5,418	5,873	5,873
Year dummies	Yes	Yes	Yes
AR(1) test p-value	0.00443	0.00296	0.00297
AR(2) test p-value	0.450	0.516	0.515
Hansen Stat p-value	0.611	0.483	0.229
No of instruments	447	434	402

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

V.1. B. INDUSTRY- LEVEL STUDY USING WORLD KLEMS DATA

The above analysis took into account only EU KLEMS countries. In this subsection we add four other countries, namely, Canada, India, Japan and Russia. The primary reason we conduct the two studies separately is that the classification between KLEMS and WIOD is not a perfect match in the case of these four additional countries, as it was for the EU KLEMS countries. As mentioned previously, WIOD follows ISIC Rev 4 classification whereas the KLEMS data for these four countries follow ISIC Rev 3.1. Also, the data for these four countries are limited. For instance, industry level data on real VA and R&D is not available for all these four countries. Secondary school enrollment data is also sparse. As a result, we use human capital index from Penn World Tables to substitute for secondary school enrollment. We also use an additional country level control, per capita real GDP, in these regressions.

In Table 8 we have provided the results of the regression analysis of Equation (1) using System GMM, where we consider all sectors (exportables and non exportables). The first two columns show partial specifications whereas the third and fourth column present results of the full model. The coefficient of *open_inter* is positive and significant in all the specifications. Open_final, on the other hand, does not seem to have a significant effect on TFP growth. However, we find that the coefficient of the variable capturing the institutional quality in Column (3) is negative and significant, which is unexpected. Note that higher values of the institution variable imply better quality of institutions. In Column (4) we exclude India and run the exact same specification as that in Column (3). Once we do so, the variable becomes insignificant. A reason for this could be the extremely poor quality of institutions in India (relative to the other countries). The average institutional value, taken over all years for all countries is 0.089 whereas the mean of India is extremely low at -4.8. Thus, our guess is that the anomalous result in Column (3) is being driven by the presence of India in the sample. In our earlier regression tables, secondary enrolment ratio turned out to be positive and significant in quite a few cases. Here too we find the human capital index to be positively impacting industrial TFP growth.

In Table 9 we consider only exportables (i.e. those observations where the export ratio is positive). Column (1) presents results of the partial model. Column (2) estimates the full model. Here again we find that the institutions variable is significant and its sign is negative. On removing India, we find that the anomaly vanishes as before. In fact the overall results become stronger. Here too we find that openness with respect to intermediate inputs is consistently positive and significant. Openness with respect to final goods does not turn out to be significant in any of the specifications, reestablishing our hypothesis that it is *open_inter* which is the more important ingredient for growth.

Table 8 Regression Results for KLEMS Countries and pooling Exportables and Non-Exportables

Dependent variable: $\ln(TFP)$

VARIABLES	(1) System_1	(2) System_2	(3) System_3	(4) System_4
Lag[ln(TFP)]	0.860***	0.863***	0.864***	0.851***
	(0.0296)	(0.0282)	(0.0262)	(0.0257)
Ln(Open_inter)	0.0309*	0.0339*	0.0400*	0.0308*
	(0.0167)	(0.0191)	(0.0231)	(0.0176)
Ln(Open_final)	-0.00249	-0.00407	-0.00636	-0.00543
	(0.00352)	(0.00516)	(0.00424)	(0.00390)
Ln(No of Employees)	-0.00162		0.000922	0.00509
	(0.00365)		(0.00350)	(0.00372)
Export Ratio		0.00668	0.0122	0.0410
		(0.0501)	(0.0326)	(0.0257)
Ln(GDP per capita)	-0.0101***	-0.00923**	0.00877*	-0.00185
	(0.00386)	(0.00407)	(0.00463)	(0.0144)
Ln(Human Capital Index)	0.0488**	0.0494**	0.0266	0.00490
	(0.0206)	(0.0215)	(0.0194)	(0.0282)
Institutions			-0.00701***	-0.00298
			(0.00215)	(0.00360)
Constant	0.741***	0.710***	0.523***	0.683***
	(0.135)	(0.103)	(0.109)	(0.162)
Observations	6,129	6,129	6,129	5,898
Year dummies	Yes	Yes	Yes	Yes
AR(1) test p-value	0.00592	0.00586	0.00584	0.00656
AR(2) test p-value	0.386	0.386	0.385	0.375
Hansen Stat p-value	0.0960	0.0933	0.745	0.913
No of instruments	431	431	536	536

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 Regression Results for KLEMS Countries and Exportables only

Dependent variable: $\ln(TFP)$

VARIABLES	(1) System_5	(2) System_6	(3) System_7
Lag[ln(TFP)]	0.851***	0.854***	0.852***
	(0.0310)	(0.0307)	(0.0310)
Ln(Open_inter)	0.0314*	0.0414**	0.0406**
	(0.0172)	(0.0204)	(0.0171)
Ln(Open_final)	-0.00220	-0.00540	-0.00884
	(0.00549)	(0.00658)	(0.00721)
Ln(No of Employees)	-0.00116	0.000654	0.00230
	(0.00373)	(0.00338)	(0.00353)
Export Ratio	-0.00427	-0.00188	0.00219
	(0.00364)	(0.00396)	(0.00452)
Ln(GDP per capita)	-0.00847**	0.00844	0.0137
	(0.00389)	(0.00562)	(0.0173)
Ln(Human Capital Index)	0.0426**	0.0262	0.0344
	(0.0203)	(0.0176)	(0.0323)
Institutions		-0.00665***	-0.00739
		(0.00256)	(0.00476)
Constant	0.747***	0.585***	0.516**
	(0.137)	(0.144)	(0.219)
Observations	6,078	6,078	5,868
Year dummies	Yes	Yes	Yes
AR(1) test p-value	0.00597	0.00595	0.00671
AR(2) test p-value	0.386	0.384	0.376
Hansen Stat p-value	0.107	0.0924	0.161
No of instruments	433	434	434

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

V.2. COUNTRY- LEVEL STUDY

Now we go on to estimate the effect of openness with respect to intermediate and final goods in a traditional cross-country growth regression framework. In Tables 10, 11 and 12 we have estimated different versions of the specification written in Equation (3) above, using different estimation techniques. We show results using pooled OLS, Random Effects as well as Difference GMM.

The reason for not using country fixed effects lies in the fact that we have a large cross section (174 countries), but limited number of time periods. In our specification, we should ideally have six observations per country since our dependent variable is average growth rate of per capita income over six five year periods. However, due to data limitations, we have less than six data points for many countries. Thus, using country fixed effects would lead to the elimination of a lot of cross sectional information on the countries (Barro, 1997). However, our purpose of this study is to make use of this very piece of information, which we would lose out if we first difference the data before estimation. In addition to this, according to the Hausman Test, the null hypothesis claiming that the difference in the coefficients between the random and fixed effects model are not systematic, could not be rejected for the partial as well as the complete specifications, thereby proving econometrically as well that the random effects model is appropriate.

Even though we don't use country fixed effects, we include region and income-group fixed effects to control for time invariant factors that are common to countries belonging to the same income group or located in the same geographical region. The World Bank has classified all countries according to the following income and region groups:

Income groups:

1. High Income
2. Upper middle Income
3. Lower middle Income
4. Low Income

Regions:

1. East Asia & Pacific
2. Europe & Central Asia
3. Latin America & Caribbean
4. Middle East & North Africa
5. North America
6. South Asia
7. Sub-Saharan Africa

Including the above dummies help us in controlling for important factors that could influence growth, without losing out on critical information and degrees of freedom. Apart from these, we have included year fixed effects as well. Table 10 estimates the baseline model where the average income growth rates are regressed on initial per-capita GDP, *open_final, open_inter* as well as the year, region and income group dummies. The coefficient on openness with respect to intermediate goods is positive and significant in both the specifications, whereas openness with respect to final goods seems to be negatively influencing growth in column (1).

In Table 11 we add further controls like export share, institutions, population growth and secondary school enrolment ratio, and estimate our equation using pooled OLS. Openness with respect to intermediate goods continues to be positive and significant in all the three specifications. Apart from *open_inter*, initial per-capita GDP is negative and significant in all the specifications. This is nothing but the conditional convergence term. *Open_final* also has a negative influence on growth in all three specifications of Table 11.

Table 10 Cross Country Growth Regressions: Baseline Model

Dependent variable: Average Growth Rate of Real Per-Capita Income

VARIABLES	(1) Base_OLS	(2) Base_Panel (Random Effects)
Initial GDP	-5.27e-05***	-6.08e-05***
	(7.20e-06)	(1.12e-05)
Open_inter	1.888***	1.839**
	(0.656)	(0.783)
Open_final	-3.449**	-2.220
	(1.660)	(2.307)
Constant	3.715***	3.891***
	(0.482)	(0.606)
Observations	812	812
R-squared	0.186	
Year dummies	Yes	Yes
Region Fixed Effects	Yes	Yes
Income-Group Fixed Effects	Yes	Yes

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

In Table 12 we estimate the full model, using all our country level control variables. Here again, both the pooled OLS as well as the random effects model, show that the coefficient on *open_inter* is positive and significant. Apart from the conditional convergence term, we observe from Column (1) that population growth also affects income growth negatively. In column (3) we conduct a robustness check for our results by using dynamic panel estimation technique. Difference GMM also yields a positive and significant (at 7% level of significance) influence of *open_inter* on growth. Here we have considered our openness variables to be endogenous so that they can be instrumented with their lagged values. Hansen statistic and serial correlation tests are also satisfied, implying that our instruments are exogenous.

Table 11 Cross Country Growth Regressions: OLS with Additional Controls

Dependent variable: Average Growth Rate of Real Per-Capita Income

VARIABLES	(1) OLS_1	(2) OLS_2	(3) OLS_3
Initial GDP	-5.87e-05***	-4.99e-05***	-4.98e-05***
	(9.53e-06)	(1.02e-05)	(9.28e-06)
Open_inter	2.550*	2.334*	2.538*
	(1.333)	(1.321)	(1.479)
Open_final	-5.250**	-5.166**	-5.939**
	(2.049)	(2.032)	(2.618)
Export Share	-0.585	-0.345	-0.544
	(0.869)	(0.861)	(1.029)
Institutions	0.105	0.0618	0.174
	(0.107)	(0.112)	(0.118)
Population Growth		-0.236	
		(0.152)	
Secondary Enrolment			0.00425
			(0.00712)
Constant	3.797***	3.991***	3.141***
	(0.528)	(0.557)	(0.723)
Observations	789	789	577
R-squared	0.196	0.203	0.135
Year dummies	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Income-Group Fixed Effects	Yes	Yes	Yes

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

Table 12 Cross Country Growth Regressions: Full Model

Dependent variable: Average Growth Rate of Real Per-Capita Income

VARIABLES	(1) OLS_4	(2) Panel Random Effects	(3) Difference GMM
Initial GDP	-4.02e-05***	-5.05e-05***	
	(9.41e-06)	(1.55e-05)	
Lag(dependent variable)			0.221***
			(0.0812)
Open_inter	2.849**	2.210*	20.04*
	(1.354)	(1.156)	(11.26)
Open_final	-3.776	-1.922	7.251
	(2.455)	(5.223)	(25.26)
Export Share	-0.717	-0.647	-11.84
	(0.895)	(0.695)	(7.678)
Institutions	0.167	0.180	-0.259
	(0.130)	(0.280)	(0.162)
Human Capital Index	-0.0206	-0.0329	0.666
	(0.336)	(0.308)	(0.679)
Population Growth	-0.374**	-0.372*	-0.141
	(0.155)	(0.201)	(0.315)
Constant	3.286***	3.761***	0
	(1.014)	(0.463)	(0)
Observations	664	664	598
R-squared	0.157		
Year dummies	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	
Income-Group Fixed Effects	Yes	Yes	
AR(1) test p-value			0.000175
AR(2) test p-value			0.190
Hansen Stat p-value			0.281
No of instruments			24

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

VI. THEORETICAL MODEL

We have a 3-sector economy producing X, M and Y. X and Y are final goods and M is the intermediate good used in X. Capital is only input for production.

Production functions and full-employment conditions are given by

$$X_t = AK_{xt}^{\alpha}M^{1-\alpha} \tag{1}$$

$$M_t = BK_{mt} \tag{2}$$

$$Y_t = CK_{yt}^{\beta} \tag{3}$$

$$K_{xt} + K_{yt} + K_{mt} = \overline{K}_t \tag{4}$$

$(A, B, C) > 0, 0 < \alpha < 1, 0 < \beta < 1$

Before trade entire M_t is absorbed in X_t. After cumbersome calculations (see Appendix A) one could show that the relative supply of X and Y depends only on P_x, the relative price between X and Y, with Y as the numeraire ($P_x \equiv \frac{P_x}{P_y}, P_m \equiv \frac{P_m}{P_y}, P_y = 1$)

$$\frac{X^s}{Y^s} = f(P_x)\,, \quad f' > 0 \tag{5}$$

We assume homothetic demand function

$$\frac{D_x}{D_y} = \phi(P_x)\,, \quad \phi' < 0 \tag{6}$$

(5) and (6) determine the autarkic equilibrium price P_x. One can show that $\left(\frac{P_x}{P_m}\right)$ will be constant.

i.e. $\frac{P_x}{P_m} = \left[\frac{B/\alpha}{A^{\frac{1}{\alpha}}.(1-\alpha)^{\frac{1-\alpha}{\alpha}}}\right]^{\alpha}$ (7)

This is a standard static model. If the country faces either a different relative price P_x or $\frac{P_x}{P_m}$ and engages in trade, standard welfare gains will follow.

VI.A. DYNAMICS

We assume K and X are same goods. So X is also investment good. (P_x, P_m) are autarkic relative price with free trade prices denoted as (P_x^*, P_m^*).

Autarkic Endogenous Growth

Simple dynamic programming problem

$$\text{Max}L_t = U(D_{xt}, D_{yt}) + \beta V(K_{t+1}) + \lambda_t[(P_x X_t + Y_t + P_m M_t) + P_x(K_{t+1} - K_t)$$
$$-P_x D_{xt} - P_m M_t - D_{yt}] \qquad (8)$$

Note that $P_x X_t - P_m M_t = \alpha P_x X_t$ (9)

and

$$V'(K_t) = \lambda_t \left[\alpha P_x . \frac{\delta X}{\delta K_{xt}} . \frac{dK_{xt}}{dK_t} + P_m \frac{\delta M_t}{\delta K_{mt}} . \frac{dK_{mt}}{dK_t} + \frac{\delta Y_t}{\delta K_{yt}} . \frac{dK_{yt}}{dK_t} + P_x\right] \qquad (10)$$

$$\alpha P_x \frac{\delta X}{\delta K_{xt}} = P_m \frac{\delta M_t}{\delta K_{mt}} = P_y \frac{\delta Y_t}{\delta K_{yt}} \qquad (11)$$

Also $\frac{\delta X}{\delta K_{xt}} = \tilde{A}$ with $X_t = \tilde{A} K_{xt}$, where $\tilde{A} = \left[A^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}\right] . \left(\frac{P_x}{P_m}\right)^{\frac{1-\alpha}{\alpha}}$ (12)

And from (11) the full employment condition we get

$$V'(K_t) = \lambda_t \left[\alpha P_x \tilde{A} + P_x\right] \qquad (13)$$

The growth trajectory is given by

$$\beta \lambda_{t+1}(\alpha P_x \tilde{A} + P_x) = \lambda_t P_x \qquad (14)$$

as from F.O.C. $\beta V'(K_{t+1}) = \lambda_t P_x$ (15)

To get a closed form solution let us suppose a log linear utility function. Then

$$\frac{\lambda_t}{\lambda_{t+1}} = 1 + g_t \qquad (16)$$

From (14) – (16)

$$g_t \simeq (\alpha\tilde{A} - \rho) \tag{17}$$

with $\beta = \frac{1}{1+\rho}$

Note that P_x does not appear in (17).

<u>Proposition</u>: <u>Endogenous growth rate does not change if only final goods are traded. Trade in intermediates may increase the growth rate.</u>

Proof: Note that $\tilde{A}$ depends on $\left(\frac{P_x}{P_m}\right)$. If $\left(\frac{P_x}{P_m}\right)$ remains the same under free trade, just variation in P_x does not affect the growth rate.

Now suppose P_x remain the same, but P_m falls, so that $\left(\frac{P_x}{P_m}\right)$ goes up. This will increase g as $\tilde{A}$ will rise. **QED.**

As long as a rise in the price of X is matched by a rise in price of M, the productivity of capital does not change. Though rise in P_x implies a rise in the price of X relative to Y, since Y is not the investment good accumulation is not rewarding just because relative price of X is high or that of Y is low. If M is cheaper it increases the productivity of capital and the endogenous growth rate.

A RICARDIAN ANALOGUE

Even if we do not use a wage-fund approach of Ricardo and instead only highlight his idea that corn (Y) is needed to determine the worth of the wage basket and labor is the immediate input (M), (if $\overline{w}$ amount of corn is needed per unit of labor, the cost to the employer is $P_y\overline{w}$) then we can redo the whole exercise to get

$$(1-\alpha)\frac{P_x.X}{\overline{w}.P_y} = L^{\alpha} \tag{18}$$

with $X = A^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}.\left(\frac{P_x}{\overline{w}.P_y}\right)^{\frac{1-\alpha}{\alpha}} K_x$ (19)

And eventually

$$g \simeq \alpha\left(A^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}\right).\frac{1}{\overline{w}^{\frac{1-\alpha}{\alpha}}}.\left(\frac{P_x^*}{P_y^*}\right)^{\frac{1-\alpha}{\alpha}} - \rho$$

(20)

Here g increases iff $\frac{P_x^*}{P_y^*}$ increases. It is as if relative price of final good X determines growth. But here a drop in P_y relative to P_x imply that labour cost is cheaper as $(\overline{w}.P_y)$ drops. Thus a decline in the price of the intermediate will stimulate growth. Y, though a final good, is making the intermediate good, labour, cheaper. Hence , it is fundamentally the same story as in the basic model. Thus it made sense to import corn and specialised in industrial production. Cheaper corn will not only lead to gains from trade in consumption but also to a higher growth rate.

VI. CONCLUSION

This paper revisits the relationship between international trade and growth. In particular, it attempts to identify the type of trade that would eventually lead to productivity and output growth. Although static gains shall accrue from trade in both intermediate inputs as well as final goods, we hypothesise that it is the former that matters for growth.

In order to show the differential effects of these two types of trade on industrial output and productivity, using global input-output tables, we construct two new measures of sectoral trade openness; openness with respect to intermediate goods and openness with respect to consumer goods. Our study spans across 21 countries, 15 years and 30 sectors. In line with our hypothesis, our econometric analysis reveals that industries which are more open with respect to intermediate goods are the ones that also experience higher TFP and value-added growth.

In addition to the above sectoral analysis, we also present results of cross-country growth regressions where we estimate the effect of country-level trade openness indices on per-capita income growth. Using trade data, we find that countries that are more open in terms of import of capital and intermediate goods, as compared to final consumer goods, have higher income growth. Our empirical results corroborates the findings of our theoretical model, according to which, trade in intermediate goods leads to growth, as opposed to trade in final goods.

This paper highlights the fact that in our attempts to analyse the relation between trade and growth, it is important to take in to account the type of commodities being traded. Specifically, it is import of intermediate and capital goods that matters for economic growth, as opposed to import of final goods. Combining both these types of trade in to a single trade openness index, as is done frequently in the literature, would not present a complete picture on the impact trade has on productivity and income growth. In this paper, we have attempted to disentangle the effects of these two types of trade.

We conclude that since it is the import of capital and intermediate inputs that matter for productivity and output growth of domestic industries, the relative costs of protecting these goods, by way of imposing higher tariffs or non-tariff barriers on them, are much higher for the economy as compared to that imposed on final goods. Therefore, as a policymaker, one should keep in mind that in the process of putting restrictions on import of intermediate and capital goods or in making them more expensive, it is the domestic industries that stand to lose.

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APPENDIX A

$$X_t = AK_{xt}^{\alpha}M^{1-\alpha}$$
(1)

$$M = BK_{mt}$$
(2)

$$Y = CK_{yt}^{\beta}$$
(3)

$$K_{xt} + K_{yt} + K_{mt} = \overline{K}_t$$
(4)

$$\underset{M_t}{\text{Max}}\, \Pi(X_t) \Rightarrow \frac{P_x}{P_m} AK_{xt}^{\alpha}(1-\alpha)M^{-\alpha} = 1$$
(5)

$$\left[P_x = \frac{P_x}{P_y}, P_m = \frac{P_m}{P_y}, P_y \equiv 1\right]$$

<u>F.O.C.s</u>

$$(1-\alpha)P_x X_t = M_t^d$$
(6)

$$X_t = AK_{xt}^{\alpha}X_t^{1-\alpha}\left(\frac{P_x}{P_m}(1-\alpha)\right)^{1-\alpha}$$

$$X_t = \left[A^{\frac{1}{\alpha}}\left(\frac{P_x}{P_m}(1-\alpha)\right)^{\frac{1-\alpha}{\alpha}}\right].K_{xt}$$
(7)

$$X_t = \tilde{A}K_{xt}$$
(8)

$K_{mt} = \frac{(1-\alpha)PX_t}{B}$

(9)

$X_t = \left[A^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}\right].\frac{P_x}{P_m}^{\frac{1-\alpha}{\alpha}}.K_{xt}$

(10)

$$\left[Also\ P_x\alpha\tilde{A} = P_m B \implies \frac{P_x}{P_m}\tilde{A} = \frac{B}{\alpha}\right]$$

Or, $K_{mt} = \frac{(1-\alpha)\left(\frac{P_x}{P_m}\right)^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}.K_{xt}}{B}$

(11)

$$K_x\left[1 + \frac{(1-\alpha)\left(\frac{P_x}{P_m}\right)^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}}{B}\right] + K_y = \overline{K} \quad (12)$$

From (12)

$K_x\left[1 + \frac{(1-\alpha)Z(1-\alpha)^{\frac{1-\alpha}{\alpha}}}{B}\right] + K_y = \overline{K}$

(13)

$P_x\tilde{A} = C\beta K_y^{\beta-1}$

$K_y^{\beta-1} = \frac{P_x\tilde{A}}{C\beta}$

$$= \frac{P_x\left[A^{\frac{1}{\alpha}}(1-\alpha)^{\frac{1-\alpha}{\alpha}}\right]\left(\frac{P_x}{P_m}\right)^{\frac{1-\alpha}{\alpha}}}{C\beta}$$

K_y will fall as $P_x \uparrow$.

K_x will rise as $P_x \uparrow$.

$X \uparrow$ as $P_x \uparrow$.

$\frac{X^S}{Y^S} = f(P_x)$

(14)

$\frac{D_x}{D_y} = \phi(P_x)$ $\phi' < 0$ [Demand function]

(15)

(15) and (16) determine P_x.

Dynamics

$Max \sum_{t=0}^{\infty} \beta^t U(D_{xt,}D_{yt})$

s.t. $[(P_x X_t + P_m M_t + Y_t)] - P_m M_t - P_x D_{xt} - D_{yt} - P_x[K_{t+1} - K_t]$

(17)

$(P_x, P_m) \rightarrow$ Autarkic prices. $(P_x^*, P_m^*) \rightarrow$ Free trade prices.

$$L \equiv U(D_{xt,}D_{yt}) + \beta V(K_{t+1}) + \lambda_t[(P_x X_t + Y_t + P_m M_t) + P_x(K_{t+1} - K_t)$$
$$-P_x D_{xt} - P_m M_t - D_{yt}] \quad (18)$$

F.O.C.s

$\frac{\delta U}{\delta D_{xt,}} = \lambda_t P_x$ (19)

$\frac{\delta U}{\delta D_{yt}} = \lambda_t$

(20)

$\beta V'(K_{t+1}) = \lambda_t P_x$ $\rightarrow$ λ_t

(21)

From (17) $\beta V'(K_{t+1}) = \lambda_{t+1}(\alpha P_x \tilde{A} + 1) = \lambda_t$

$P_x X_t - P_m M_t = \alpha P_x X_t$

So, $V'(K_t) = \lambda_t \left[\alpha P_x \frac{\delta X}{\delta K_{xt}} . \frac{dK_{xt}}{dK_t} + P_m \frac{\delta M_t}{\delta K_{mt}} . \frac{dK_{mt}}{dK_t} + \frac{\delta Y_t}{\delta K_{yt}} . \frac{dK_{yt}}{dK_t} + P_x\right]$ (22)

As $\alpha P_x \frac{\delta X}{\delta K_x} = P_m \frac{\delta M_t}{\delta K_{mt}} = \frac{\delta Y_t}{\delta K_{yt}} = \alpha P_x \tilde{A}$ and $K_{xt} + K_{yt} + K_{mt} = K_t$

$V'(K_t) = \lambda_t [\alpha P_x \tilde{A} + P_x]$ (23)

$\beta V'(K_{t+1}) = \beta \lambda_{t+1} P_x (\alpha \tilde{A} + 1)$

(24)

(21) and (24) imply

$\beta \lambda_{t+1} P_x (\alpha \tilde{A} + 1) = \lambda_t P_x$

(25)

Or, $\beta(\alpha \tilde{A} + 1) = \frac{\lambda_t}{\lambda_{t+1}} = \frac{\frac{\delta U}{\delta D_{xt}}}{\frac{\delta U}{\delta D_{xt+1}}}$ (26)

Let $U(D_{xt}, D_{yt}) = lnD_{xt} + lnD_{yt}$

$\frac{\lambda_t}{\lambda_{t+1}} = \frac{D_{xt+1}}{D_{xt}} = (1 + g_t)$ (27)

From (26) and (27)

$(\alpha \tilde{A} + 1) = (1 + g_t)(1 + \rho)$

(28)

$\frac{1}{\beta} = (1 + \rho)$

$g_t \simeq (\alpha \tilde{A} - \rho)$ (29)

Note that

$$g_t \simeq \alpha[A(1-\alpha)^{1-\alpha}]^{\frac{1}{\alpha}}.\left(\frac{P_x}{P_m}\right)^{\frac{1}{\alpha}} \quad (30)$$

$$= \alpha[A(1-\alpha)^{1-\alpha}]^{\frac{1}{\alpha}}.Z$$

$$= g_A \quad (31)$$

g_{At} denotes autarkic growth rate.

APPENDIX B

Table B1: List of Countries in EU KLEMS Database with TFP Data

Serial No.	Country Name	Serial No.	Country Name
1	Austria	10	Latvia
2	Belgium	11	Netherlands
3	Czech Republic	12	Slovakia
4	Denmark	13	Slovenia
5	Finland	14	Spain
6	France	15	Sweden
7	Germany	16	United Kingdom
8	Italy	17	United States of America
9	Luxembourg		

Source: EU KLEMS Database.

Note: The above table gives a list of countries provided in EU KLEMS with TFP data. We also add four countries to this list from WORLD KLEMS database, namely, Canada, India, Japan and Russia.

Table B2: List of Countries in EU KLEMS Database with Value Added Data

Serial No.	Country Name	Serial No.	Country Name
1	Austria	15	Italy
2	Belgium	16	Lithuania
3	Bulgaria	17	Luxembourg
4	Croatia	18	Latvia
5	Cypress	19	Netherlands
6	Czech Republic	20	Poland
7	Denmark	21	Portugal
8	Estonia	22	Romania
9	Finland	23	Spain
10	France	24	Slovakia
11	Germany	25	Slovenia
12	Greece	26	Sweden
13	Hungary	27	United Kingdom
14	Ireland	28	United States of America

Source: EU KLEMS Database

Table B3: List of Industries/Sectors

S. No.	Industries/Sectors
1	Accommodation and Food Service Activities
2	Activities of Households as Employers; Undifferentiated Goods and Services Producing Activities of Households for Own Use
3	Agriculture, Forestry and Fishing
4	Arts, Entertainment, Recreation and Other Service Activities
5	Basic Metals and Fabricated Metal Products, Except Machinery and Equipment
6	Chemicals and Chemical Products
7	Coke and Refined Petroleum Products
8	Construction
9	Education
10	Electrical and Optical Equipment
11	Electricity, Gas and Water Supply
12	Financial and Insurance Activities
13	Food Products, Beverages and Tobacco
14	Health and Social Work
15	IT and Other Information Services
16	Machinery and Equipment N.E.C.
17	Mining and Quarrying
18	Other Manufacturing; Repair and Installation of Machinery and Equipment
19	Professional, Scientific, Technical, Administrative & Support Services Activities
20	Public Administration and Defence; Compulsory Social Security
21	Publishing, Audiovisual and Broadcasting Activities
22	Real Estate Activities
23	Rubber and Plastics Products, and Other Non-Metallic Mineral Products
24	Telecommunications
25	Textiles, Wearing Apparel, Leather and Leather Products
26	Transport Equipment
27	Transportation And Storage
28	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
29	Wood and Paper Products; Printing and Reproduction of Recorded Media
30	Activities of Extraterritorial Organizations and Bodies

Source: KLEMS & WIOD Database

Table B4: List of Countries used in Cross-Country Analysis

Serial No.	Country Name	Serial No.	Country Name	Serial No.	Country Name
1	Afghanistan	39	Comoros	77	Iran, Islamic Rep.
2	Albania	40	Congo, Rep.	78	Ireland
3	Algeria	41	Costa Rica	79	Israel
4	Andorra	42	Cote d'Ivoire	80	Italy
5	Angola	43	Croatia	81	Jamaica
6	Antigua and Barbuda	44	Cuba	82	Japan
7	Argentina	45	Cyprus	83	Jordan
8	Armenia	46	Czech Republic	84	Kazakhstan
9	Aruba	47	Denmark	85	Kenya
10	Australia	48	Dominica	86	Kiribati
11	Austria	49	Dominican Republic	87	Korea, Rep.
12	Azerbaijan	50	Ecuador	88	Kuwait
13	Bahamas, The	51	Egypt, Arab Rep.	89	Kyrgyz Republic
14	Bahrain	52	El Salvador	90	Lao PDR
15	Bangladesh	53	Estonia	91	Latvia
16	Barbados	54	Eswatini	92	Lebanon
17	Belarus	55	Ethiopia	93	Lesotho
18	Belgium	56	Fiji	94	Libya
19	Belize	57	Finland	95	Lithuania
20	Benin	58	France	96	Luxembourg
21	Bermuda	59	Gabon	97	Macao SAR, China
22	Bhutan	60	Gambia, The	98	Madagascar
23	Bolivia	61	Georgia	99	Malawi
24	Bosnia and Herzegovina	62	Germany	100	Malaysia
25	Botswana	63	Ghana	101	Maldives
26	Brazil	64	Greece	102	Mali
27	Brunei Darussalam	65	Greenland	103	Malta
28	Bulgaria	66	Grenada	104	Mauritania
29	Burkina Faso	67	Guatemala	105	Mauritius
30	Burundi	68	Guinea	106	Mexico
31	Cabo Verde	69	Guinea-Bissau	107	Micronesia, Fed. Sts.
32	Cambodia	70	Guyana	108	Moldova
33	Cameroon	71	Honduras	109	Mongolia
34	Canada	72	Hong Kong SAR, China	110	Morocco
35	Central African Republic	73	Hungary	111	Mozambique
36	Chile	74	Iceland	112	Myanmar
37	China	75	India	113	Namibia
38	Colombia	76	Indonesia	114	Nepal

Serial No.	Country Name	Serial No.	Country Name
115	Netherlands	154	Tanzania
116	New Zealand	155	Thailand
117	Nicaragua	156	Togo
118	Niger	157	Tonga
119	Nigeria	158	Trinidad and Tobago
120	North Macedonia	159	Tunisia
121	Norway	160	Turkey
122	Oman	161	Tuvalu
123	Pakistan	162	Uganda
124	Palau	163	Ukraine
125	Panama	164	United Arab Emirates
126	Papua New Guinea	165	United Kingdom
127	Paraguay	166	United States
128	Peru	167	Uruguay
129	Philippines	168	Vanuatu
130	Poland	169	Venezuela, RB
131	Portugal	170	Vietnam
132	Qatar	171	West Bank and Gaza
133	Russian Federation	172	Yemen, Rep.
134	Rwanda	173	Zambia
135	Samoa	174	Zimbabwe
136	Sao Tome and Principe		
137	Saudi Arabia		
138	Senegal		
139	Seychelles		
140	Singapore		
141	Slovak Republic		
142	Slovenia		
143	Solomon Islands		
144	South Africa		
145	Spain		
146	Sri Lanka		
147	St. Kitts and Nevis		
148	St. Lucia		
149	Vincent and the Grenadines		
150	Sudan		
151	Suriname		
152	Sweden		
153	Switzerland		

APPENDIX C

Table C1: Identification of Capital and Intermediate goods by BEC Codes

Product Groups	BEC Codes	BEC Descriptions
Capital goods	BEC 41	Capital Goods, except Transport Equipment
	BEC 521	Industrial Transport Equipment
Intermediate Goods	BEC 111 & 121	Food and Beverages, mainly for industry
	BEC 21& 22	Industrial Supplies, not elsewhere classified
	BEC 31	Primary Fuels and Lubricants
	BEC 42	Parts and Accessories of Capital Goods, except Transport Equipment
	BEC 53	Parts and Accessories of Transport Equipment
	BEC 322	Other Processed Fuels and Lubricants

Source: Statistical Division Staff, & United Nations. Statistical Division. (2003)

Table C2: Data Sources

Variable	Data Source
TFP, Value Added	World KLEMS
Open_inter, Open_final, Export Ratio (*for sectoral analysis)*	WIOD
R&D Labour Ratio	World KLEMS
Number of Employees	World KLEMS
Institutions	World Governance indicators
Secondary School Enrolment Rate	World development Indicators, World Bank
Real per capita income	World Bank Database
Human capital Index	Penn World Tables 9.1
Population	World development Indicators, World Bank
Open_inter, Open_final, Export Ratio (*for cross country estimation)*	UN COMTRADE (accessed through WITS)