Global Value Chain Participation and Current Account Imbalances*

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December 30, 2015

Abstract

This paper draws a causal link between increased levels of global value chain participation (GVCP) and increases in a country's current account. We formulate an international real business cycle model with trade in intermediate and final goods, where increased GVCP reflects an increased efficiency in the use of imported intermediates in home production or exported intermediates in foreign production—consistent with empirical evidence that GVCP is largely driven by declines in transportation costs, the adoption of trade-liberalising policies, or advances in information technologies. To the extent that the shocks driving GVCP are transitory, the rise in income that results from increased exports is partly saved, raising the home economy's current account. We find empirical support for the effect of GVCP on the current account implied by the theoretical model. In particular, widely-used reduced-form current account regressions based on the IMF's EBA model suggest that economies which exhibit stronger GVCP also display larger current account surpluses. According to our estimates, cross-country differences in GVCP reduce the hitherto unexplained part of current account surpluses substantially; for example, for Germany the unexplained current account surplus falls from 5.8% relative to GDP in 2009 to 4% when controlling for GVCP.

Keywords: Global value chain participation, current account imbalances, EBA model.
JEL-Classification: F32, F41, F62.

*We would like to thank Philip Lane as well as conference and seminar participants at the ECB, the 2015 Silver Jubilee Conference of the International Trade and Finance Association, and the 11^{th} World Congress of the Econometric Society. The views expressed in the paper are those of the authors and do not necessarily reflect those of the ECB or of the ESCB.

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1 Introduction

One salient feature of the global economy during the last decades has been the existence of large and persistent external imbalances. For example, the years prior to the global financial crisis were marked by some emerging market economies—in particular China—running large current account surpluses, matched by deficits in some advanced economies—in particular the US. Several papers have shown that a large part of these global imbalances can be rationalised by the lack of financial market development in emerging market surplus economies (see Mendoza et al., 2007; Caballero et al., 2008). At the same time, the debate about the driving forces underlying large current account surpluses in several advanced economies—such as Germany—is still ongoing. Understanding the determinants of external imbalances is critical for academics and policymakers, because they play a critical role in the transmission of spillovers in an ever more integrated world.

Another salient feature of the global economy has been the marked rise of global value chains. Spurred by the decline in transportation costs, the adoption of trade-liberalising policies as well as advances in information and communication technologies, firms increasingly disperse stages of production across countries (see, for example, Elms and Low, 2013; Baldwin, 2013; UNCTAD, 2013). By fragmenting production chains internationally, the share of intermediate goods in total trade has risen continuously relative to that of final goods (Antras, 2005). Specifically, data suggest that trade in intermediate goods and services nowadays accounts for 56% and 73% of overall trade flows in goods and services (Miroudot et al., 2009). The regional dispersion of the research and development underlying the iPod, the manufacturing of its components, their assembly as well as its sale and distribution in local markets is a famous example of global value chain fragmentation (Dedrick et al., 2010); another is the role of Germany as the regional hub in "Factory Europe" (Baldwin, 2013).

It is no wonder, thus, that global value chains have attracted considerable interest. Several papers have improved our understanding of global value chains by documenting the increasing fragmentation of production across borders. Drawing on newly developed input-output tables, these papers have developed frameworks to measure trade in valued added and an economy's integration in global value chains (see, for example, Hummels et al., 2001; Trefler and Zhu, 2010; Johnson and Noguera, 2012; Koopman et al., 2014). Building on these frameworks, other papers have been concerned with the economic implications of global value chains. For example, participation in global value chains appears to boost growth (IMF, 2013c), to amplify cross-country macroeconomic spillovers (Georgiadis, forthcoming), to render an economy's income distribution more uneven (Timmer et al., 2013), and it has improved our understanding of competitiveness (CompNet Task Force, 2014).

In this paper we bring together these two strands of the literature by studying the role of global value chain participation for current account imbalances. We first set up a two-country

international real business cycle model with trade in final and intermediate goods. In the model, domestic and imported intermediates are imperfect substitutes in production. Furthermore, the efficiency of imported intermediates in production is subject to shocks. These shocks reflect a decline in transportation costs, the adoption of trade and capital flow-liberalising policies or advances in information and communication technologies, which have been identified as driving forces of the rise of global value chain participation in the literature.[1] In the model, a positive shock to the efficiency in the use of imported intermediates in Home production results in a larger share of foreign value added embodied in Home exports, a widely-used measure of global value chain participation. Moreover, as the shock to the efficiency in the use of imported intermediates in Home production boosts the competitiveness of Home exports, foreign demand for Home goods and thereby Home income rise as well. In equilibrium, as the shock to the efficiency in the use of imported intermediates in Home production is only transitory, in order to smooth consumption over time the Home economy saves part of the income gains, resulting in a current account surplus. A similar mechanism plays out in case of a shock to the efficiency in the use of Home intermediates in the rest of the world, which also results in a rise of the current account in the Home economy.

We then test the theoretical predictions of our theoretical model in a well-established empirical framework for the analysis of current account imbalances. Specifically, rather than putting forth yet another empirical model for the current account we adopt the IMF's current framework for the assessment of external imbalances: the External Balance Assessment model (EBA; see IMF, 2012, 2013b). While it is widely recognised that the EBA model does have its weaknesses (for a discussion see Phillips et al., 2013), it is our preferred empirical framework given that it has become the main reference for the assessment of current account imbalances in the IMF's Article IV and External Sector Reports. After replicating the IMF baseline EBA results, we augment the set of explanatory variables by measures of economies' global value chain participation. To construct these measures at the country level, we use newly-released data from the World Input-Output Database (WIOD; see Timmer et al., 2015). In particular, we construct a measure for "backward" ("forward") participation to test the prediction from the theoretical model regarding the effect of shocks to the efficiency in the use of imported (Home) intermediates in Home (rest of the world) production on the Home economy's current account.

The empirical results are consistent with the predictions from the theoretical model: Economies which participate more in global value chains exhibit larger current account surpluses. While this result holds for both directions of global value chain participation, a rise in backward participation has a stronger impact on the current account than a rise in forward participation. The regression results also suggest that the impact of global value chain participation on current

[1] A large literature documents that stronger participation in internationally fragmented production networks improves firm productivity (see Görg and Hanley, 2005; Egger and Egger, 2006; Crinò, 2008; Görg et al., 2008; Kasahara and Rodrigue, 2008; Amiti and Wei, 2009; Morrison Paul and Yasar, 2009; Hijzen et al., 2010; McCann, 2010; Winkler, 2010; Ito et al., 2011; Wagner, 2011; Schwörer, 2013). For a survey of the literature see Amador and Cabral (2014).

account imbalances is economically significant: For example, Germany's unexplained current account surplus of 5.8% relative to GDP in 2009 is reduced by about a third when its participation in global value chains is controlled for.[2]

The results of this paper have important policy implications. First, in contrast to widely-held views in policy discussions, for many economies persistent current account imbalances are not due to domestic distortions, but are optimal outcomes given differences in economies' competitiveness arising due to differences in their degrees of global value chain participation. As a consequence, policies to narrow global imbalances should focus more on measures that level the playing field to participate in global value chains. For example, lowering protectionist burdens may be an important measure in order to improve economies' competitiveness by fostering their global value chain participation; similarly, multilateral initiatives aiming at trade and financial liberalisation may also have an important effect on the reduction of external imbalances by fostering their global value chain participation. Second, the empirical relevance of trade in intermediates for the current account suggests that structural open economy models should include such trade and production structures in order to be consistent with the data and to be useful for policy advice.

The remainder of the paper is organised as follows. Section 2 puts forth a structural model of international trade in intermediate and final goods to examine the impact of global value chain participation on current account imbalances. In Section 3 we test the predictions of our theoretical model empirically. Finally, Section 5 concludes.

2 Global Value Chain Participation and Current Account Imbalances: A Model

We aim to shed light on how changes in a country's relative ability to make use of foreign and domestic intermediate inputs in production generate variations in income that in turn allow to link changes in its position in global value chains to movements in its current account. To this end, we study an international real business cycle (IRBC) model with trade in both final consumption goods and intermediate inputs in production. The model setup is thus similar in spirit to various quantitative models that have studied comovement and amplification of business cycles across countries (see, for example, Backus et al., 1992; Heathcote and Perri, 2002; Johnson, 2014b). However, in contrast to earlier contributions, we utilize the model to study the general equilibrium effects of input-augmenting shocks on the structure of international trade, income, and savings behavior.

[2]This is consistent with the finding that "the 'super-competitiveness' of the German economy is in large part derived from the increasing use of imported intermediates" (see Timmer et al., 2013, p. 5).

To simplify, we model two countries, a home economy, indexed by H, and its foreign counterpart, denoted by F, which represents the rest of the world. The home country and the foreign country are both populated by a continuum of households, with mass 1 and L respectively. In each period, the world experiences an event $s_t \in S$. As usual, we denote by s^t the history of events up to and including t, by Σ the set of such histories, and by $\pi\left(s^t\right)$ the probability of event history s^t. We will consider input-augmenting shocks, in particular to the use of foreign intermediates in home production and vice versa—the "home" shock and the "foreign" shock.

2.1 Technology and the Firms' Problem

Production in each country is carried out by perfectly competitive firms using a CES-production function F that utilizes labor, l_i, domestically produced intermediates, x_{ii}, and intermediates sourced from abroad, x_{ji}

$$x_i = F_i\left(l_i, x_{ii}, x_{ji}, \tau_i\right) = \left[\alpha^{1-\eta} l_i^{\eta} + (1-\alpha)^{1-\eta} M_i\left(x_{ii}, x_{ji}, \tau_i\right)^{\eta}\right]^{1/\eta}, \tag{1}$$

where M_i is a CES-aggregate of domestic and imported intermediates

$$M_i\left(x_{ii}, x_{ji}, \tau_i\right) = \left(\omega_i^{1-\phi} x_{ii}^{\phi} + (1-\omega_i)^{1-\phi}\left(\tau_i x_{ji}\right)_{ji}^{\phi}\right)^{1/\phi}. \tag{2}$$

The parameter ω_i captures the home bias in production and $\phi < 1$ implies an elasticity of substitution of $1/(1-\phi)$ between domestic and foreign intermediate goods. η in turn governs the elasticity of substitution between labour and intermediate inputs, whilst α is the value added share in production. τ_i is an exogenous, factor specific productivity shock to the usage of imported intermediates. While we remain agnostic with regards to the nature and origin of this shock, it can be related to various factors that have been studied when micro-founding the determinants of offshoring and outsourcing in the production process.

As the final output good of each country can be used for consumption and as an intermediate input to production both at home and abroad, the aggregate resource constraints read as

$$x_H = x_{HH} + x_{HF} + c_{HH} + c_{HF}, \tag{3}$$

$$x_F = x_{FH} + x_{FF} + c_{FF} + c_{FH}. \tag{4}$$

We denote the price of the foreign good by p_H, and denote the price of the home good by p_H. Firms maximize profits, taking goods prices and wages, denoted by w_H and w_F respectively, as given. The problem of the firm in the home economy then reads as

$$\max_{l_H, x_{HH}, x_{FH}} p_H x_H - w_H l_H - p_H x_{HH} - p_F x_{FH}, \tag{5}$$

and the problem for the foreign country is analogous.

2.2 Households and Financial Markets

The representative household in both countries maximizes expected life-time utility from consumption of goods sourced both domestically and abroad. Preferences for $i \in \{H, F\}$ are given by the lifetime utility function

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u\left(c_i(t)\right) \right] = \sum_{t=0}^{\infty} \beta^t \sum_{s^t} \pi\left(s^t\right) u\left(c_i\left(s^t\right)\right), \tag{6}$$

where $\beta \in (0,1)$ is the time-discount factor.

Period utility is assumed to be of the standard CRRA form with a coefficient of relative risk aversion σ:

$$u(c) = \begin{cases} \frac{1}{1-\sigma} c^{1-\sigma} & , \sigma < 1 \\ log(c) & , \sigma = 1 \end{cases}. \tag{7}$$

The variable c_i entering the utility function of country i is a CES-aggregator over both consumption goods produced domestically, c_{ii}, and imported from abroad, c_{ji} given by

$$c_i = \left(\nu_i^{1-\psi} c_{ii}^{\psi} + (1-\nu_i)^{1-\psi} c_{ji}^{\psi} \right)^{1/\psi}, \tag{8}$$

where ν_i measures the degree of home bias in consumption in economy i and $\psi < 1$ governs the elasticity of substitution between domestic and imported goods.

This consumption price index in country i can thus be written

$$p_i^C = \left(\nu_i p_i^{\frac{\psi}{\psi-1}} + (1-\nu_i) p_j^{\frac{\psi}{\psi-1}} \right)^{\frac{\psi-1}{\psi}}. \tag{9}$$

Households supply labour inelastically and trade bonds on incomplete international asset markets. Market incompleteness and thus the absence of insurance against country-specific shocks imply that such idiosyncratic shocks have real wealth effects. We restrict trade to a one-period bond with market-determined price $Q\left(s^t\right)$. This bond entitles the holder to a weighted unit of domestic and foreign consumption, where the weight depends on the relative size of the home and foreign economy. Households are not allowed to default but face no other limitations on borrowing. Denoting the current bond holding choice of the home country's representative household by $b^H(s^t)$, the budget constraint of the household in the home economy is

$$p_H\left(s^t\right) c_{HH}\left(s^t\right) + p_F\left(s^t\right) c_{FH}\left(s^t\right) + Q\left(s^t\right) b^H\left(s^t\right) = w_H\left(s^t\right) + b^H\left(s^{t-1}\right) \left(\frac{p_H\left(s^t\right)}{L+1} + \frac{p_F\left(s^t\right) L}{L+1} \right). \tag{10}$$

Since the bond is the only asset that is being traded, b^H coincides with the home country's net foreign asset (NFA) holdings in this period. The home country's current account is simply given by the change in NFAs

$$ca^H\left(s^t\right) = b^H\left(s^t\right) - b^H\left(s^{t-1}\right). \tag{11}$$

Analogous equations characterize the budget constraint of the household in the foreign country and the asset market clearing condition is given by

$$b^H\left(s^{t-1}\right) + b^F\left(s^{t-1}\right) = 0, \tag{12}$$

for all t.

Households choose consumption levels $\left\{c_{ij}\left(s^t\right), c_{ii}\left(s^t\right)\right\}$ and asset purchases for all s^t to maximize their expected lifetime utility, taking as given initial productivity shocks, initial asset holdings, and prices.

2.3 Definition and Characterization of Equilibrium

Definition 1. (*Competitive Equilibrium*)
A competitive equilibrium, for the economy with initial bond holdings $\left\{b_0^H, b_0^F\right\}$, is a collection of prices

$$\left\{p_H\left(s^t\right), p_F\left(s^t\right), w_H\left(s^t\right), w_F\left(s^t\right), r\left(s^t\right)\right\}_{s^t \in \Sigma}$$

and allocations

$$\left\{c_{ii}\left(s^t\right), c_{ji}\left(s^t\right), x_{ji}\left(s^t\right), x_{ii}\left(s^t\right), b^i\left(s^{t-1}\right)\right\}_{i,j \in \{H,F\}, s^t \in \Sigma}$$

such that households and firms, taking those prices as given, solve their respective maximization problems and markets clear.

To characterize the equilibrium, denote by p_i^M the price index for intermediate inputs in production in country i, which is given by

$$p_i^M = \left(\omega_i p_i^{\frac{\phi}{\phi-1}} + \left((1-\omega_i)\tau_i^{\frac{\phi}{1-\phi}}\right) p_j^{\frac{\phi}{\phi-1}}\right)^{\frac{\phi-1}{\phi}}. \tag{13}$$

The first-order conditions for the firm in country H are then given by

$$L_H = \alpha \left(\frac{p_H}{w_H} \right)^{\frac{1}{1-\eta}} x_H, \tag{14}$$

$$M_H = (1-\alpha) \left(\frac{p_H}{p_H^M} \right)^{\frac{1}{1-\eta}} x_H, \tag{15}$$

$$x_{HH} = \omega_H \left(\frac{p_H^M}{p_H} \right)^{\frac{1}{1-\phi}} M_H, \tag{16}$$

$$x_{FH} = (1-\omega_H) \tau_H^{\frac{\phi}{1-\phi}} \left(p_H^I \right)^{\frac{1}{1-\phi}} M_H. \tag{17}$$

An analogous set of equations characterizes the problem of the firm in country H.

The first-order conditions from the HH in the home country problem are given by

$$p_{H,t}^C U_c \left(c_t \right) Q \left(s^t \right) = \beta \mathbb{E}_t \left(U_c \left(c_{t+1} \right) p_{H,t+1}^C \right), \tag{18}$$

$$\frac{p_{H,t}}{p_{F,t}} = \left(\frac{\nu_H}{1-\nu_H} \right)^{1-\psi} \left(\frac{c_{HH}}{c_{FH}} \right)^{\psi-1}. \tag{19}$$

Whilst the first condition corresponds to a standard Euler equation, the second one governs the optimality trade-off between domestic and imported consumption goods.

2.4 Simple Measures of Global Value Chain Participation

In the model, firms experience temporary productivity shocks that alter the efficiency of foreign versus domestically sourced intermediate inputs. This in turn will change a country's position in global value chains through temporarily altering its demand for and supply of intermediate inputs on international input markets, whilst simultaneously changing its demand for savings on the international financial markets. To track changes in a country's position in global value chains, we start our analysis by looking at two simple measures of GVCP, summarizing a country's downstream and upstream position respectively. Backward participation (BP) is defined as the ratio of gross intermediate imports to gross total output, and forward participation is the ratio of gross intermediate exports to gross total output. Thus, for the home country, we have

$$BP_H = \frac{p_F x_{FH}}{p_H x_H}, \quad FP_H = \frac{p_H x_{HF}}{p_H x_H} = \frac{x_{HF}}{x_H}. \tag{20}$$

We choose to benchmark our analysis against these simple summary statistics as opposed to more sophisticated measures like Johnson and Noguera's (2012) VAX ratio for two reasons. Firstly, the VAX is primarily an inverse measure of a country's backward participation and does not straightforwardly generalize to capture a country's forward participation. However, we aim to track both aspects of a country's participation in global value chains. Secondly, we

account empirically for the importance of the VAX by confirming (i) its high correlation with our alternate measure of backward participation when computed based on the WIOD and (ii) including it as an alternative explanatory variable into our empirical specification.

2.5 Model Calibration and Results

In our baseline analysis, we calibrate the model to yearly data, implying a time discount-factor of $\beta = 0.96$. The elasticity of substitution across final goods from alternative source countries, governed by ψ, and the elasticity of substitution of inputs across inputs from alternative countries, governed by ϕ, jointly directly affect the overall elasticity of substitution between output from different sources. For our baseline analysis, we calibrate both parameters to be equal to 1/3, implying an overall trade elasticity of 1.5. There is considerable uncertainty regarding trade price elasticities and empirical researchers have found estimates that range from 0.1 to 2 (see a survey by (Hooper et al., 2000)) and estimates tend to vary, depending on the particular content of trade as well as the level of aggregation that is being considered. Our baseline parametrization is motivated by the fact that we consider a time horizon as well as a level of aggregation where the assumption of gross substitutes between inputs in production seems plausible.

The parametersα, ν_H, and ω_H are set to match the empirical averages in the WIOD, which we report in table A.1. Since we regard the foreign country as an aggregate of economies similar to the home economy of varying size, it can be shown that the size parameter L relates to the parameters governing home biases in production and preferences according to

$$1 - \omega_F = (1 - \omega_H)/L, \tag{21}$$

$$1 - \nu_F = (1 - \nu_H)/L. \tag{22}$$

From these two equations and the empirical averages for ω_F, ω_H, ν_F, and ν_H we get two values for L of which we take the average and obtain: $L = 67$. Thus, the home country in our model represents 1/68 of the world economy.

Finally, we choose the parameter η governing the elasticity of substitution across factors and inputs in production to be equal to 0.13, in line with the estimation of production functions by Koesler and Schymura (2012), who provide estimates based on the WIOD, our primary data source. Our parameter choices are summarized in the table below.

We now turn to the analysis of shocks to τ_H and τ_F, which we call home and foreign shock respectively. We consider shocks that increase the efficiency of using the respective intermediate inputs by 5 percent on impact. These shocks are transitory with a yearly persistence of 0.8.

The responses of key variables to these shocks are displayed in Figures 1 and 2 respectively. All responses are plotted as relative deviations from steady state, except for the current account,

Table 2.1: Baseline Calibration Parameters

Preferences	
β	0.96
ψ	1/3
σ (curvature)	1
ν_H	0.86
Production	
ϕ	1/3
α	0.5
η	0.13
ω_H	0.75
Other Parameters	
L	67
Shock size	0.05
Shock persistence	0.8

which is displayed in absolute deviations from the steady state in units of output.

As expected, both shocks raise output, the real wage, and the current account in the home country—these shocks thus generate higher income that is partly saved. As was to be expected, the domestic shock increases backward participation considerably and forward participation only moderately, while the foreign shock strongly increases forward participation and slightly reduces backward participation. Interpreted through the lens of our model, higher levels of participation in globalized production processes thus reflect temporary competitive improvements of a small economy in its role as a supplier of intermediate inputs or in its ability to integrate foreign inputs in its domestic production. As a result, higher levels of participation are accompanied by higher levels of income, which is partly saved for future consumption through increased accumulation of foreign assets.

Even though both shocks have similar qualitative effects on GVCP and foreign imbalances, concerning their impact on the bond price and the terms of trade, the two shocks strongly differ: Whilst the domestic shock reduces both, the foreign shock causes an increase in bond prices and the terms of trade. The relative price of the home good falls as it becomes easier to produce through the domestic shock, while it rises when the foreign good can be produced more efficiently after the foreign shock hits.

These price movements can explain the following puzzle: While the home shock increases the real wage much more than the foreign shock, it increases the current account by less. The reason is that with lower prices for the home good in case of the domestic shock, domestic consumers are tempted to consume a large part of their extra income today. The opposite is true for the foreign shock.

The model in its baseline parametrization thus predicts a positive comovement between a country's participation in global value chains on the one hand and its current account balance on the other hand. In what follows, we test this hypothesis empirically by constructing the empirical counterparts to our theoretical measures.

3 Empirical Evidence

3.1 The EBA model

On the one hand, some have built on structural models inspired by the New Open Economy Macroeconomics paradigm (Sachs, 1981; Glick and Rogoff, 1995; Obstfeld and Rogoff, 1995). Under this inter-temporal approach, current account imbalances are the outcome of decisions taken by forward-looking agents who maximise utility given expectations of future productivity, growth, fiscal policy as well as financial market conditions. While these models allow for a structural analysis of current account dynamics, their empirical fit tends to be relatively poor. On the other hand, others have studied the drivers of the current account from an empirical perspective that is not tied to a particular structural model (Calderon et al., 2002; Chinn and Prasad, 2003; Gruber and Kamin, 2005; Ca'Zorzi et al., 2012). Under this approach, current account balances are regressed on a large number of potential determinants using broad cross-country panel datasets. Such an approach has also been adopted by the IMF in its multilateral surveillance: the Consultative Group on Exchange Rate Issues (CGER) and, its successor, the External Balance Assessment (EBA) which is used in Article IV Reports and the External Sector Report (EBA; IMF, 2012, 2013a, 2014; Phillips et al., 2013). Despite some success in terms of empirical fit, a general finding of this literature is that the unexplained part of current account imbalances remains large, in particular for some surplus economies such as Germany. Thus, there remains considerable scope for advancing our understanding of the drivers of current account imbalances.

Several papers have considered reduced-form regressions for the determination of the current account (see, for example, Calderon et al., 2002; Chinn and Prasad, 2003; Gruber and Kamin, 2005; Ca'Zorzi et al., 2012). While the regression specifications are similar in spirit, there are some differences concerning the samples, the explanatory variables or the estimation method. In order to minimise the likelihood that the results in this paper concerning the impact of global value chain participation on the current account are driven by our own particular modelling choices, rather than putting forth yet another empirical model we adopt the IMF's current framework for the assessment of external imbalances: EBA. While it is widely recognised that EBA does have its weaknesses (for a discussion see Phillips et al., 2013), it is our preferred empirical framework given that it has become the main reference for the assessment of current account misalignments in the IMF's Article IV and External Sector Reports.

The backbone of EBA consists of the estimation of a reduced-form model for countries' current account balances given by

$$ca_{it} = \alpha + \boldsymbol{x}_{it} \cdot \boldsymbol{\beta} + u_{it}, \tag{23}$$

where ca_{it} denotes the current account balance relative to GDP for country i in period t, and $\boldsymbol{x}_{it}$ includes a set of variables that determine the current account.[3] Importantly, most of the explanatory variables are measured relative to rest-of-the-world averages; this is done because a change in, for example, the fiscal balance in country i can affect its current account balance only to the extent that other countries' fiscal balances do not change by the same amount. For the sake of brevity in the rest of the paper we refer to these relative explanatory variables simply as "the fiscal balance".[4] The explanatory variables in EBA *inter alia* include the net foreign asset position, the oil balance, output per worker, demographics, capital account openness, expected output growth, the terms of trade, the output gap and the fiscal balance; for a detailed discussion of the choice of the explanatory variables included in EBA we refer the reader to IMF (2013a) and Phillips et al. (2013).

The publicly available original IMF EBA dataset covers the time period from 1986 to 2010 for 49 economies. Unfortunately, it is not possible to simply expand the IMF dataset in its time and country dimension for various reasons. First, for some variables the IMF only provides the data as they enter the EBA regression; and as described above, most variables enter as difference relative to the rest of the world. Second, some variables are instrumented and enter as fitted values from a first stage instrumental variables regression. For this reason, we rebuild from scratch the entire EBA dataset to determine the rest-of-the-world averages as well as the instruments that result from a broader country sample and from an update to include 2011 data.

3.2 The WIOD

Over the past years different institutions have assembled various synthetic global input-output tables that describe the flow of intermediate goods across sectors and economies.[5] We follow Timmer et al. (2013), Baldwin and Lopez-Gonzalez (2013) and Costinot and Rodríguez-Clare (2014) and use the World Input-Output-Database (WIOD).[6] The WIOD provides global input-output tables at annual frequency for 40 countries and 35 sectors for the time period from 1995 to 2011. The broad cross-sectional coverage allows us to trace bilateral flows of intermediate inputs between countries and sectors at a fairly detailed level. Furthermore, the WIOD also provides

[3] One innovation in EBA relative to CGER is the explicit distinction between cyclical, structural and policy drivers of the current account. The latter are used to determine "policy gaps": the part of current account misalignments that stems from policies deviating from socially desirable values. This distinction is not relevant for the purposes of this paper.

[4] Some variables by their nature are already measured "relative" to the rest of the world, such as the net foreign asset position.

[5] Johnson (2014a) provides a list of existing public data sets on global input-output tables.

[6] Stehrer et al. (2014) provide a detailed description of the contents and construction of the WIOD.

information on both foreign and domestic final demand for each sector's output. Finally, the structure of the input-output tables in the WIOD involves quantitatively important self-loops, reflecting that sectors use part of their own output as intermediate inputs.

Figure 3 shows the evolution of our derived measures of backward and forward participation over the time period from 1995 to 2011 for our baseline specification of 29 economies. The country sample of our baseline specification corresponds to the intersection between the IMF's EBA and the OECD's WIOD dataset. The chart confirms the widely-documented rise in global value chain participation over the past 16 years (see, for example, Daudin et al., 2011; Johnson and Noguera, 2014). Both backward and forward participation increased gradually between 1995 and 2007, declined sharply during the financial crisis in 2008 and 2009, and recovered nearly to pre-crisis levels in 2010 and 2011.

The descriptive statistics shown in Table A.2 for 1995 and 2011 suggest that the mean of our measure of forward participation has increased much more than its dispersion (measured both by the standard deviation and the min-max range), suggesting that the rise of forward participation over this 16-year period has been spread relatively evenly across economies. For backward participation, the descriptive statistics suggest, conversely, a somewhat less evenly spread rise. In particular, the marked widening of the min-max range suggests that some countries have increased their participation disproportionately. Such a pattern of divergence in backward integration is also illustrated in Figure 5. For some smaller European economies, such as Hungary, Poland and the Czech Republic, the level of backward participation has further increased over the past 16 years, despite relatively high levels of backward participation in 1995. For forward participation, by contrast, there is less evidence of divergence. In fact, some emerging market economies with relatively limited forward participation relative to the rest of world in 1995, such as China and Turkey, increased their relative level of forward export links more than the cross-country average.

Finally, Figure 4 shows that high levels of backward participation are typically found for small economies, both in 1995 and 2011. This may largely reflect the limited degree of diversification of the production sector of small economies. This specialization warrants a high share of imported inputs in gross exports. Precisely the opposite holds true for forward participation. High levels of forward participation are found among large economies. This may partly reflect that many large economies are closer to the origin (upstream) of production chains and are hence more likely to have strong forward export links with subsequent production stages.

4 Results

The first column in Table A.5 replicates the results of the IMF's original EBA regression using the data provided by the IMF on its website (see Table 10 in IMF, 2013b).[7] The second column in Table A.5 reports the results from the estimation of the EBA regression model based on the replicated dataset for the smaller sample of countries and time periods for which we have data on backward and forward participation from the WIOD. Importantly, we estimate this regression *without* measures of backward and forward participation in order to ensure that the contraction of the sample does not affect the baseline results from the IMF's original EBA. The results suggest that the vast majority of coefficient estimates remains qualitatively unchanged compared to the original EBA regression and statistically significant in our baseline sample of 29 economies for the time period from 1995 to 2011.

The third column reports the results when our baseline measures of economies' backward and forward participation (relative to the rest of the world) are included. The relevant coefficient estimates are both positive and highly statistically significant, confirming the prediction from the theoretical model in Section 2 that countries which participate more in global value chains display larger current account balances, controlling for standard determinants of a country's current account. Importantly, this result holds for both dimensions of global value chain participation, backward and forward integration. This suggests that stronger forward participation is associated with higher current account balances beyond the impact of higher global value chain participation measured by stronger backward linkages.

Notably, the coefficient estimate on the backward participation measure is around four times as big as the estimated coefficient on forward participation. This suggests, per se, that a certain *level* of backward participation is associated with a higher current account, compared to the same level of forward participation. However, due to markable differences in the variables' means and standard deviations (see Table A.2), the numerical values of the point estimates of the regression coefficients cannot be easily compared to draw any conclusion on the relative importance of *changes* in backward and forward participation on the current account. To this end, we standardize our baseline measures of backward and forward participation by its means and standard deviations. We then replace the baseline measures by its standardized versions in our regression model. The results, reported column (4), show that the coefficient of the

[7] As in IMF (2013b), we perform pooled generalised least squares (GLS) estimation with a panel-wide AR(1) correction. Also as in the IMF's original EBA model, we do not include the lagged current account balance in the regression (see IMF, 2013b, pp. 9)

> "as in pooled data this would amount to adding a quasi-fixed effect to the estimates and open up a key interpretative issue related to having the current account in a given year being explained by the previous year's current account. With such a specification, the lagged current account balance might pick up the effects of sustained distortions that are otherwise not captured by the regression (in addition to serving its intended purpose of picking up dynamics and gradual adjustment). Therefore, we instead use pooled GLS with a panel-wide AR(1) correction to deal with autocorrelation."

standardized backward measure is twice as big as the coefficient of the standardized forward measure. This suggests that a rise in backward participation may have a markedly stronger impact on the current account than an equal rise in forward participation.

The theoretical model predicts that global value chain participation affects a country's current account mainly through the trade balance. In order to provide more evidence for this channel, we modify the empirical specification by replacing the current account as the dependent variable in Equation (23) by the trade balance. The results reported in the fifth column of Table A.5 suggest that backward and forward participation do indeed improve the current account through a positive impact on the trade balance. Interestingly, for the backward participation the impact on the trade balance is quantitatively more than three times as big as that on the current account.

A general finding in the various attempts to determine the current account in reduced-form regression models has been the failure to explain large current account imbalances, in particular of surplus economies. For a vivid illustration of this salient feature of current account models Figure 6 plots current account balances relative to GDP—in case the latter exceeds 3% in absolute values—for the year 2009, when global imbalances had still been at elevated levels. The residuals of the IMF's EBA model and of our baseline regression are plotted as additional bars. The figure illustrates that current balances of surplus economies have indeed been hardly explained by the standard regressors included in the EBA model. The residuals narrow considerably, however, upon the inclusion of our GVC measures. Figure 7 presents the reduction (in percent) of the residuals relative to those in the IMF's original EBA model for these countries. The results suggest that the variation in global value chain participation explains a substantial part of the unexplained current account balances. For example, for Germany about one third of the unexplained part of the current account surplus of 5.8% relative to GDP in 2009 is explained by its participation in global value chains. Importantly, this result is not confined to the year 2009. As illustrated in Figure 8, on average the unexplained part of Germany's current account surplus declined by 13% in each year over the sample period from 1995 to 2011. For all countries in our baseline sample, the residual declined by 3% on average upon the including the measures of backward and forward participation.

4.1 Robustness

In this section we examine the robustness of our results to different metrics of backward and forward participation, a sample that extends the country coverage relative to the IMF's EBA framework to include all countries covered in the WIOD, the inclusion of country fixed effects, and our baseline sample running only up to the start of the financial crisis in 2008.

4.1.1 Alternative measures of backward and forward participation

Various concepts and metrics have been proposed to measure trade in value added and global value chain participation (see, for instance, Hummels et al., 2001; Johnson and Noguera, 2012; Koopman et al., 2014; OECD, 2015). In this paper we use very simple and easy to calculate measures of backward and forward participation that can be directly mapped into the theoretical model described in Section 2. Notably, our measures of backward and forward participation are not based on value added trade, and may hence be subject to some overlap or double counting. A widely used measure of trade in value added is the VAX ratio proposed by Johnson and Noguera (2014) which is a generalization of the VS measure derived by Hummels et al. (2001). The VAX ratio can be interpreted as a metric of the domestic content of exports and should hence be inversely related to our measure of backward participation. Following Johnson and Noguera (2012), we calculate the VAX ratio as

$$VAX = \frac{va_{ij}}{x_{ij}}, \tag{24}$$

i.e. the ratio of domestically produced valued added to exports.[8]

Table A.3 shows the high correlation between the calculated VAX ratio and our baseline measure of backward participation, which is -0.97 for our baseline regression sample of 456 observations. In column (2) of Table A.6 we replace our baseline measure of backward participation with the VAX ratio calculated based on Equation (24). The regression coefficient of the VAX ratio is negative and highly statistically significant. Moreover, the coefficient estimate of the forward participation measure remains qualitatively unchanged.

In column (3) of Table A.6, we replace our baseline measure of backward participation by the original VAX indicator using the publicly available panel data on the VAX ratio (see Johnson, 2014a). Again, the coefficient of the VAX ratio is negative and statistically significant.[9] Moreover, Table A.3 confirms that the original VAX ratio is strongly negatively correlated (-0.92) with our baseline backward measure.

Another framework for the measurement of trade in value added has been developed and established by the OECD (OECD, 2012). In this framework, the OECD has put forth definitions of backward and forward participation, labeled as foreign and indirect value added, respectively (see OECD, 2015). The indicators are based on the WTO-OECD TiVA Database on trade in value added. We follow this methodology to derive measures of foreign and indirect value added

[8] Following Johnson and Noguera (2012), we define domestically produced valued added as $va_{ij} = r_i y_{ij}$, where r_i is the ratio of value added to output for each sector in each economy. Specifically, this ratio is measured as $r_i = 1 - \sum_j \sum_s A_{ji}$, where A is the bilateral input output matrix.

[9] The quantitative difference in the coefficient estimates of the calculated VAX ratio and the original VAX ratio may mainly reflect differences in the underlyting Input-Output Tables. While our measure is based on the WIOD Input-Output Tables, the data source of the original VAX ratio is the Global Trade Analysis Project Database (GTAP) (see Johnson and Noguera, 2012).

based on the WIOD database. The correlation between our baseline backward measure and the measure on foreign value added based on the OECD definition is 0.94 (Table A.3). For the respective forward measures the correlation is 0.35 (see Table A.4). The regression results based on these alternative measures of backward and forward participation are shown in column (4) of Table A.6. Again, both indicators have the expected sign are are statistically significant.

Overall, these results corroborate our finding that higher global value chain participation, defined as stronger backward import and forward export linkages, is associated with higher current account imbalances. And in particular it suggests that this result is not confined to our simple measures of backward and forward participation but also holds for more conventional and widely used measures of trade in value added and global value chain participation, including the VAX or the OECD's measures of foreign and indirect value added.

4.1.2 WIOD Sample

The country sample of the baseline specification corresponds to the intersection between the IMF's EBA and the OECD's WIOD dataset. In addition to the countries covered by the IMF in its EBA framework, the WIOD database includes some small European countries.[10] In order to exploit these additional WIOD data, we extend the EBA dataset to cover 38 rather than only 29 of the countries covered in the WIOD. The fifth column in Table A.6 reports the results for the sample of 38 WIOD countries.[11] The coefficient estimate for backward and forward participation again remain positive and statistically significantly different from zero.

4.1.3 Inclusion of Country Fixed Effects

The IMF's original EBA model does not control for country fixed effects. The IMF argues that fixed effects do not provide an *economic* explanation of observed current account balances (see IMF, 2013b). However, from an econometric point of view controlling for unobserved heterogeneity might be important to obtain consistent estimates of the coefficients of the explanatory variables, in particular if the latter are correlated with the unobserved country characteristics that affect the current account. The sixth column in Table A.6 reports the estimation results from our baseline model in Equation (23) when we include country fixed effects; the coefficient estimates of backward and forward participation remain positive and statistically significantly different from zero.

[10] The country selection in the IMF's EBA dataset is partly determined by institutional considerations rather than by data availability.

[11] Estonia and Taiwan are excluded from our empirical analysis due to restricted data availability on some of the EBA regressors.

4.1.4 Pre-2008 Sample

The global financial crisis was followed by a noticeable reduction in global imbalances which was, however, to a large extent driven by cyclical factors (see IMF, 2012). To ensure that our results are not driven by the crisis years, we restrict the estimation to the time period before 2008. The seventh column in Table A.6 presents the results from this robustness check, which suggest that discarding the time period after the financial crisis does not affect our results concerning the impact of global value chain participation on the current account.

5 Conclusion

This paper examines the impact of economies' participation in global value chains on their current account balances. In line with theoretical predictions, our empirical analysis suggests that global value chain participation raises economies' current account balances. Apart from fostering growth, magnifying cross-country spillovers and changing an economy's income distribution global value chain participation may thus improve external positions in particular in deficit economies.

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A Tables

Table A.1: Summary statistics for gross input shares, value added shares and input shares

	mean	min	max	sd
a_FH	0.13190	0.02226	0.40756	0.07040
$1-\omega_H$	0.25181	0.04750	0.61961	0.11928
$1-\nu_H$	0.13799	0.02688	0.32294	0.06406
α_H	0.48443	0.32622	0.62497	0.05791
a_HF	0.00173	0.00002	0.01587	0.00255
$1-\omega_F$	0.00348	0.00003	0.03179	0.00509
$1-\nu_F$	0.00221	0.00002	0.01519	0.00315
α_F	0.50660	0.46271	0.52885	0.01536

Table A.2: Descriptive Statistics for Backward and Forward Participation

	count	mean	sd	min	max
Backward participation	456	0.107	0.053	0.022	0.276
Backward partcipation in 1995	27	0.086	0.040	0.022	0.205
Backward partcipation in 2011	29	0.122	0.062	0.042	0.276
Forward participation	456	0.149	0.160	0.014	0.760
Forward partcipation in 1995	27	0.122	0.151	0.015	0.632
Forward partcipation in 2011	29	0.156	0.159	0.014	0.627

Table A.3: Correlation between Baseline Measure of Backward Participation and Alternative Measures of Backward Participation

	count	b
VAX	456	-0.970
VAX (Johnson, 2014)	398	-0.916
Foreign value added (OECD)	456	0.937

Table A.4: Correlation between Baseline Measure of Forward Participation and Alternative Measure of Forward Participation

	count	b
Indirect value added (OECD)	456	0.347

Table A.5: The Impact of Backward and Forward Participation on the Current Account: Baseline Regression Results

	(1) IMF EBA	(2) GVC sample	(3) Baseline	(4) Standardized	(5) Trade Balance
Lagged Net Foreign Assets	0.02**	0.04***	0.03***	0.03***	0.01
Lagged NFA*1(NFA<-0.6)	-0.01	-0.04**	-0.04**	-0.04**	-0.01
Financial Center	0.03***	0.03*	0.03*	0.03*	0.00
Lagged Output/Worker rel. to Top-3 economies	0.01	0.03+	0.01	0.01	0.06**
Lagged Output/Worker*Capital Openess	0.07***	0.04*	0.06***	0.06***	0.05**
Oil Balance*Ressource Temporariness Dummy	0.61***	1.43***	1.59***	1.59***	2.60***
Old-Age Dependency Ratio	-0.03	-0.03	-0.02	-0.02	-0.09**
Population Growth	-0.63+	-0.34	0.04	0.04	0.59+
Aging	0.16***	0.09*	0.16***	0.16***	0.19***
Expected GDP Growth	-0.47***	-0.53***	-0.60***	-0.60***	-0.41**
Lagged Public Health Spending to GDP	-0.55***	-0.10	-0.22	-0.22	-0.20
Lagged VOX*Capital Openess	0.07***	-0.03+	-0.03	-0.03	0.01
Lagged VOX*Capital Openess*COFER share	-0.14*	0.14+	0.11	0.11	0.03
Share of currency in world reserves	-0.05***	-0.01	-0.01	-0.01	-0.01
Output Gap	-0.40***	-0.28***	-0.29***	-0.29***	-0.33***
Commodity ToT*Trade Openess	0.23***	0.08***	0.08***	0.08***	0.09***
Strength of Institutions	-0.11***	-0.04**	-0.05***	-0.05***	-0.07***
Demeaned Credit to GDP	-0.03***	-0.03***	-0.03***	-0.03***	-0.02**
Fiscal Balance (instr)	0.32***	0.57***	0.49***	0.49***	0.37*
Chg in FX reserves*Capital Openess(instr)	0.35**	0.35***	0.33***	0.33***	0.28**
Backward Participation			0.17***		0.57***
Forward Participation			0.04**		0.05***
Backward Part. (standardized)				0.12***	
Forward Part. (standardized)				0.06**	
Constant	-0.01***	0.04***	0.03***	0.03***	0.06***
Observations	1080	456	456	456	456
R^2	0.34	0.38	0.40	0.40	0.44
Number of countries	49	29	29	29	29

Robust standard errors.
$^{+}$ $p < 0.2$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: The Impact of Backward and Forward Participation on the Current Account: Robustness Checks

	(1) Baseline	(2) VAX	(3) VAX (Johnson)	(4) FVA/IVA (OECD)	(5) WIOD sample	(6) Fixed Effects	(7) Pre-2008
Lagged Net Foreign Assets	0.03***	0.03***	0.03***	0.04***	0.01	0.03***	0.03***
Lagged NFA*1(NFA<-0.6)	-0.04**	-0.04**	-0.03+	-0.04***	-0.02	-0.06***	-0.04+
Financial Center	0.03*	0.03*	0.03*	0.02+	0.05***	0.04***	0.02+
Lagged Output/Worker rel. to Top-3 economies	0.01	0.01	0.02	0.02	-0.01	-0.12***	0.01
Lagged Output/Worker*Capital Openess	0.06***	0.06**	0.05**	0.05**	0.05***	0.05***	0.07***
Oil Balance*Ressource Temporariness Dummy	1.59***	1.64***	1.74***	1.30***	1.46***	-0.13	1.83***
Old-Age Dependency Ratio	-0.02	-0.02	-0.03	-0.03	-0.04	-0.05	-0.04
Population Growth	0.04	0.04	0.10	-0.05	-0.61+	-0.38	0.27
Aging	0.16***	0.14***	0.17***	0.11**	0.18***	-0.05	0.22***
Expected GDP Growth	-0.60***	-0.63***	-0.61***	-0.57***	-0.46***	-0.60***	-0.76***
Lagged Public Health Spending to GDP	-0.22	-0.18	-0.27	-0.14	0.01	-0.56**	-0.33+
Lagged VOX*Capital Openess	-0.03	-0.03+	-0.02	-0.03+	0.08***	0.02	-0.06*
Lagged VOX*Capital Openess*COFER share	0.11	0.12+	0.11	0.15*	-0.29***	-0.06	0.20+
Share of currency in world reserves	-0.01	-0.01	-0.01	-0.00	-0.03**	-0.02+	0.01
Output Gap	-0.29***	-0.29***	-0.29***	-0.29***	-0.39***	-0.25***	-0.31***
Commodity ToT*Trade Openess	0.08***	0.08***	0.09***	0.08***	0.05**	0.11***	0.10***
Strength of Institutions	-0.05***	-0.05***	-0.06***	-0.05***	-0.06***	-0.06***	-0.06***
Demeaned Credit to GDP	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.05***
Fiscal Balance (instr)	0.49***	0.54***	0.61***	0.55***	0.04	-0.04	0.59***
Chg in FX reserves*Capital Openess(instr)	0.33***	0.32***	0.35***	0.35***	0.31***	0.50***	0.39***
Backward Participation	0.17***				0.11*	0.25***	0.18***
Forward Participation	0.04**	0.03**	0.03**		0.05***	0.13***	0.04**
VAX		-0.12***					
VAX (Johnson, 2014)			-0.06**				
Foreign value added (OECD)				0.07**			
Indirect value added (OECD)				0.08*			
Eastern Europe					-0.04***		
Constant	0.03***	0.03***	0.04***	0.03***	0.03**	-0.04***	0.03***
Observations	456	456	398	456	553	456	340
R^2	0.40	0.41	0.43	0.39	0.42	0.42	0.47
Number of countries	29	29	29	29	38	29	29

Robust standard errors.
$^{+}$ $p < 0.2$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

B Figures

Figure 1: Impulse Responses for a Domestic Shock

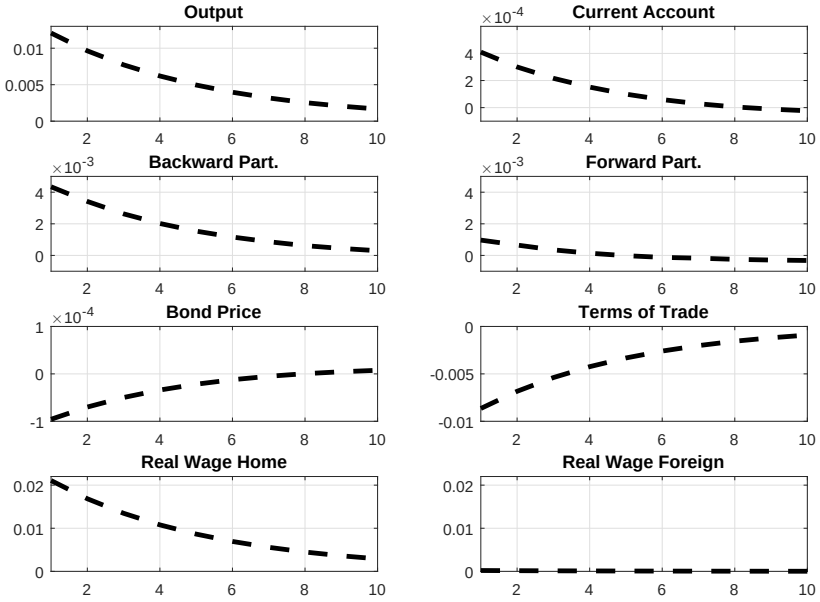


Figure 2: Impulse Responses for a Foreign Shock

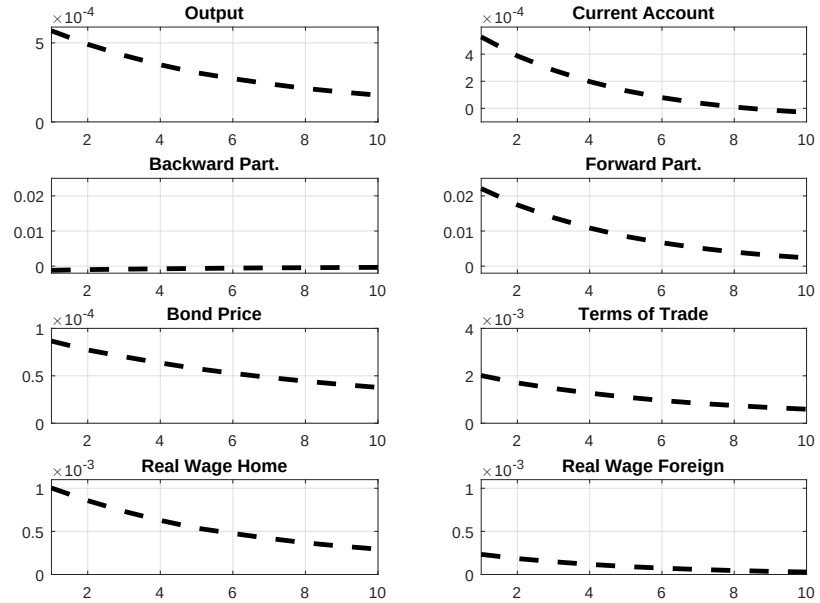
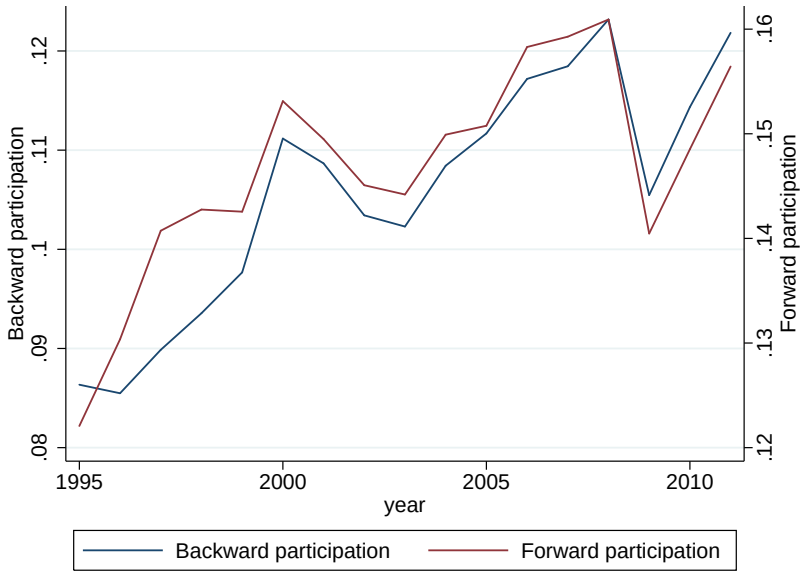
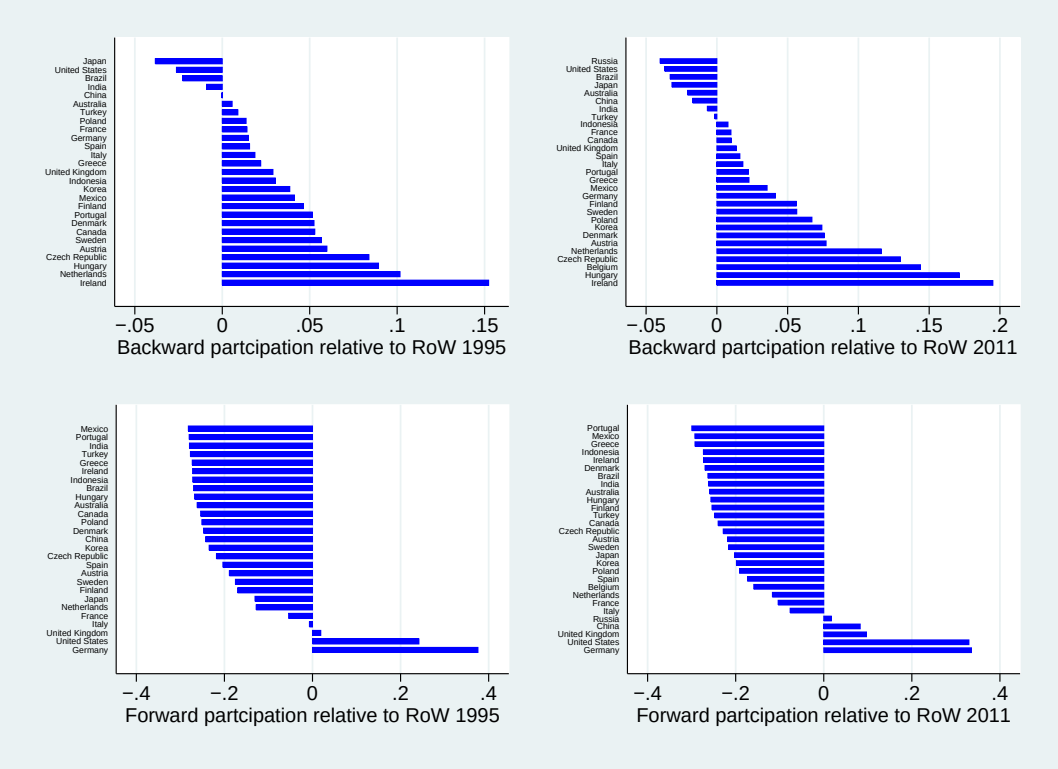


Figure 3: Evolution of the Cross-Country Average of Backward and Forward Participation from 1995 to 2011



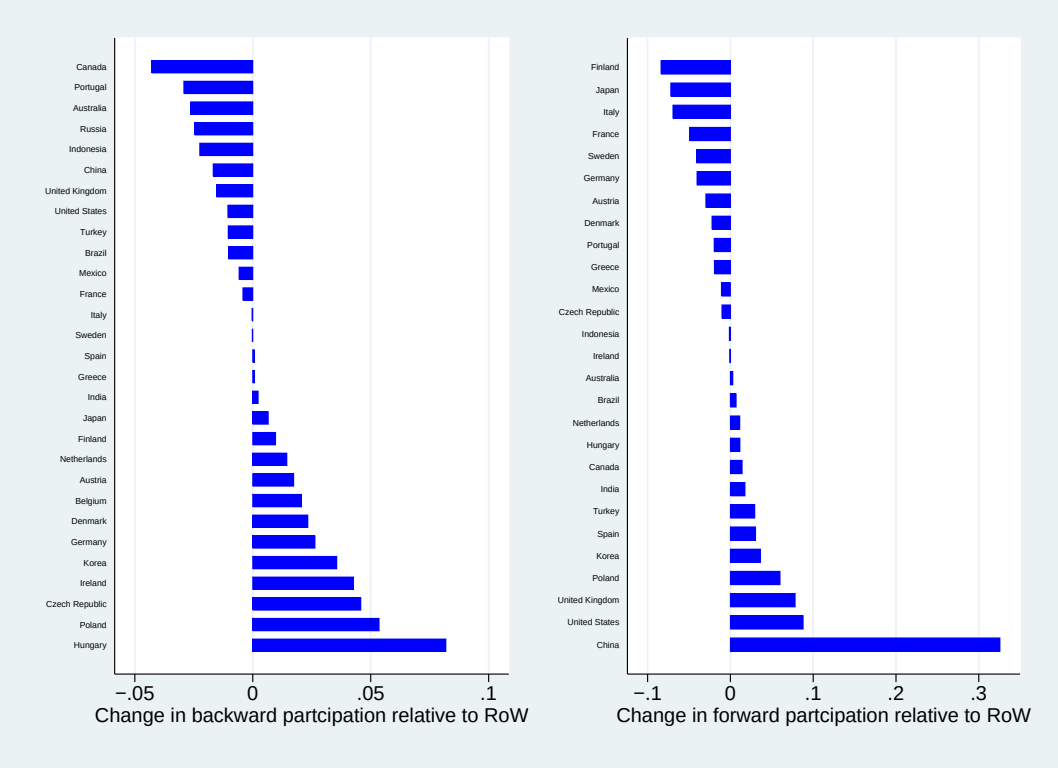
Note: The figure presents the evolution of the cross-country average of the measure of backward and forward participation as defined in Equation (**??**) for all countries that enter our regression analysis.

Figure 4: Rankings of Backward and Forward Participation in 1995 and 2011



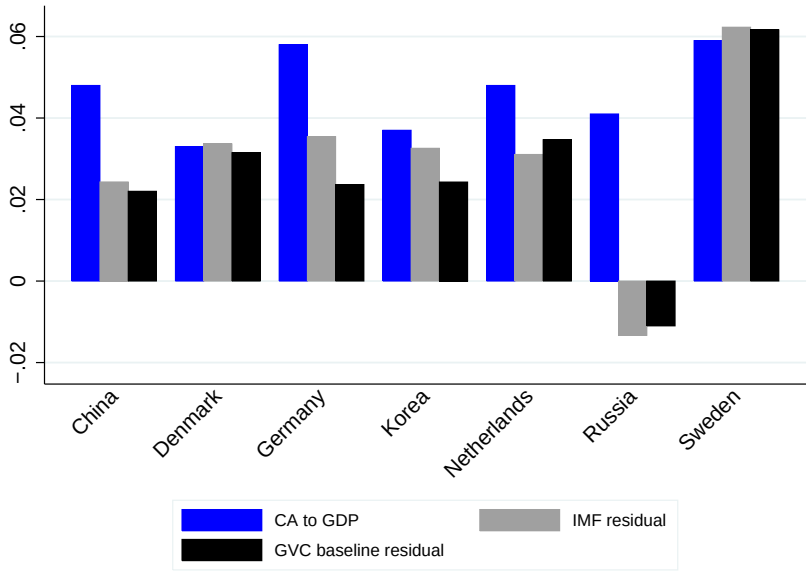
Note: The panels display the rankings of global value chain participation calculated based on Equation (**??**) and using the WIOD for the years 1995 and 2011. The rankings are shown for all countries which enter our regressions at least in one year during 1995 to 2011. The measure of global value chain participation is calculated as difference to the rest of the world.

Figure 5: Change in Backward and Forward Participation (year of first observation to 2011)



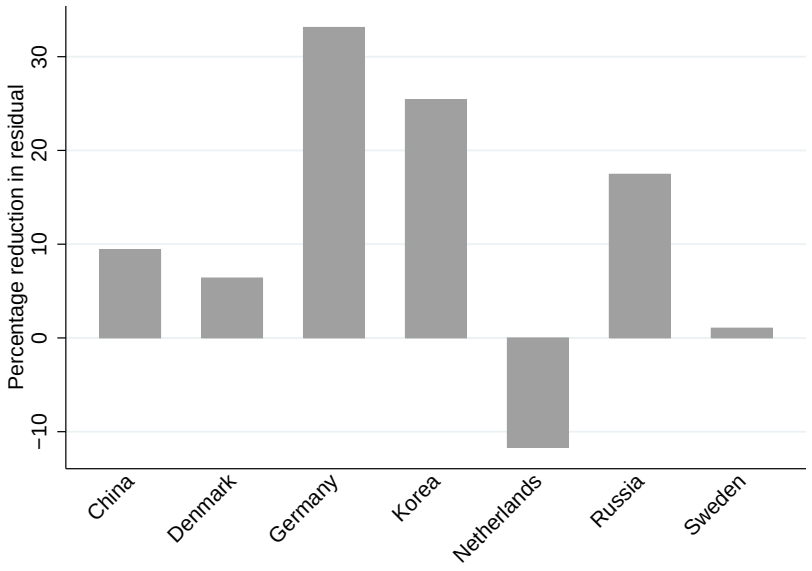
Note: Percentage change of backward and forward participation (measured relative to the rest of the world) from year of first observation to 2011.

Figure 6: Selected Current Account Balances and Residuals for 2009



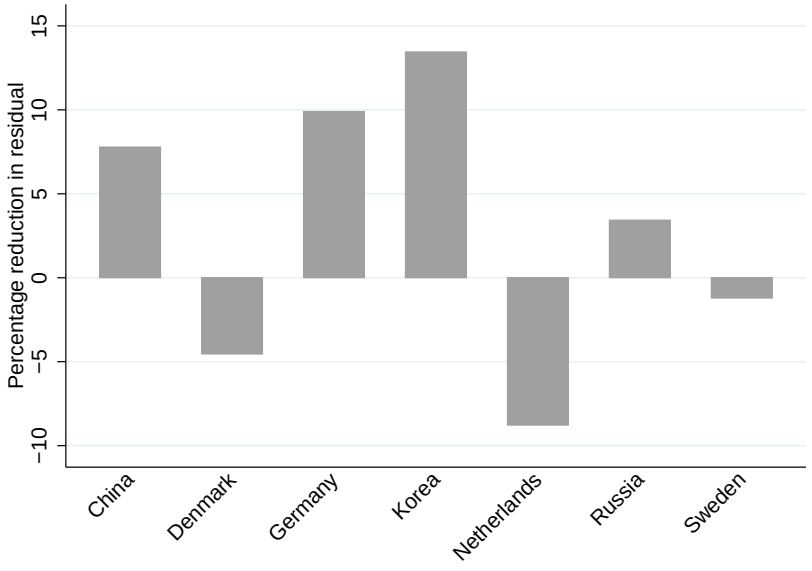
Note: The figure presents the value of the current account balance relative to GDP (blue) and the residual for the IMF's EBA regression (grey) as well as for our baseline regression including our measures of backward and forward participation for the year 2009.

Figure 7: Reduction of Unexplained Current Account Balance of Surplus Economies Upon Inclusion of Backward and Forward Participation for 2009



Note: The figure displays the percentage reduction of the 2009 residuals from the IMF's EBA regressions that result from the inclusion of backward and forward participation in the EBA model. The countries shown are the same as in Figure 6.

Figure 8: Reduction of Unexplained Current Account Balance of Surplus Economies Upon Inclusion of Backward and Forward Participation between 1995 and 2011



Note: The figure displays the percentage reduction of the time average of the absolute residuals from the IMF's EBA regressions that result from the inclusion of backward and forward participation in the EBA model. The countries shown are the same as in Figure 6.