Economic growth and balance of payments constraint in Vietnam

A. Bagnai[a], A. Rieber[b], T.A.D. Tran[c]

[a] *Department of Economics, 'Gabriele D'Annunzio' University, Pescara, Italy*
[b] *Department of Economics, University of Rouen, France*
[c] *DIAL, Institute of Research for Development, Vietnam*

Our paper examines the long-run relation between economic growth and current account equilibrium in Vietnam, using a multi-country BoP-constrained growth model. We find that in the whole sample (1985-2010) Vietnam grew less than the rate predicted by the model. We also find that the BoP-constrained growth rate shifted after the 1997 Asian crisis. Since the relative price effect is neutral, the volume effects dominate in setting the BoP constraint. On the one side, owing to the high income elasticities of exports, growth in advanced countries has a strong multiplier effect on the Vietnamese economy. On the other side, this effect is hindered by a high 'appetite' for imports coming from Asia. Finally, we assess the impact of the current crisis on Vietnam's growth for the period 2011 to 2017.

Keywords: Economic growth, BoP constrained growth model, Multi country model, Asia, Vietnam.

JEL Classification: E12, F43, O11, O53

I. Introduction

The transition process from central planning to a market economy, launched in 1986 with *Doi Moi* ('renovation' in Vietnamese), enabled Vietnam to shift in less than 20 years from one of the poorest countries in the world (with per capita income of 98 USD in 1990) to a Lower Middle Income (LMI) country (with per capita income of 1130 USD in 2010). Vietnam's economy has grown at an annual average rate of 7.3% from 1990 through 2010, outpacing other countries in the Asian region. The ratio of population in absolute poverty has fallen from 58% in 1993 to 14.5% in 2008, while most indicators of welfare have improved (World Bank, 2011).

Behind the story, integration in the world economy has been the key driver of Vietnam's economic and social development. The country has gone through a far reaching transformation from an inward looking planned economy to one that is globalized and market-based. The country formally completed World Trade Organization (WTO) accession in late 2006, culminating a long process of efforts to integrate the national economy into global markets (Abbott *et al.*, 2009). These changes have had dramatic implications for trade and investment flows: exports and imports as a share of Gross Domestic Product (GDP) increased tenfold from 1988 to 2008, reaching respectively 77.5% and 87.8% of GDP in 2010. Over the last two decades, average growth rates of exports and imports were 16.4% and 18% respectively, compared with 7.3% for GDP.

(Insert Figure 1 here)

However, owing to rapid growth and massive capital inflows, the country has experienced growing macroeconomic turbulence in recent years. Between 2005 and 2007, the current account deficit increased from 0.9% to 9.8% of GDP (Figure 1) while the capital account surplus increased even faster, from 4.8% to 24.6% of GDP (World Bank, 2008). Net positive capital inflows have led to demand pressures and subsequent changes in relative prices. Inflation rates averaged 16% a year between 2008 and 2011, and asset price bubbles emerged, while the country was coping with persistent pressures on its currency, loss of international reserves, and capital flight.

According to the World Bank (2011), the government addressed these macroeconomic imbalances by relying almost exclusively on tight monetary policy, but it has yet to tackle their root causes. From our point of view, the analysis of macroeconomic instability in Vietnam cannot be dissociated from the country's Balance of Payments (BoP) position. Substantial current account deficits and the rising capital inflows to finance them played a significant role in perturbing macroeconomic stability. Based on these stylised facts, the question naturally arises as to whether the country is growing faster than the rate allowed by its BoP equilibrium.

To this purpose, our paper examines the long run relationship between economic growth and the current account balance equilibrium using the BoP constrained growth model, originally developed by Thirlwall (1979). While neoclassical theories explain growth through supply side elements such as factor accumulation, technological progress or the contribution of productivity growth, this alternative approach emphasises demand driven mechanisms, by postulating that in the long run BoP equilibrium is the primary constraint on a country's economic growth.

Our study aims at filling a number of gaps in the literature. From a theoretical point of view, the analytical framework proposed here improves over previous attempts to extend Thirlwall's law to a multi-country setting (e.g., Nell, 2003), by allowing for a more rigorous disaggregation of the BoP constraint among different partner areas (Bagnai *et al.*, 2012). More precisely, our extended model allows us to assess the relative importance of the different channels of transmission (real growth, changes in relative prices and import/export market shares) in the different partner areas. From an empirical point of view, the paper provides fresh evidence on growth performance in Vietnam since *Doi Moi*, using annual data from 1985 to 2010. There have been several studies applying the BoP constrained growth model to individual countries and groups of countries (Thirlwall, 2012), but to our knowledge, no empirical study has yet tested the model for Vietnam; neither has there been an analysis of long-run growth since the country's accession to the WTO.

The paper is structured as follows. Section 2 presents the BoP-constrained growth model and the extensions proposed in our study. Section 3 describes the estimation procedure. Section 4 presents

and interprets our empirical results. Considering the recent global slowdown, Section 5 presents some simulation exercises aimed at forecasting the impact of external shocks on Vietnam's future growth. Section 6 summarizes our main results.

II. The theoretical background

Thirlwall's Law and the developing countries

According to Thirlwall (1979), the need to satisfy the external constraint in the long run sets *an upper limit* to growth. Thirlwall's Law is expressed in these terms: *'In the long run, no country can grow faster than the rate consistent with its balance of payments equilibrium on the current account, unless it can finance an ever growing external deficit, which, in general, it cannot'*. In other words, there is a growth rate that a country cannot exceed for prolonged periods, because if it does, it will quickly incur into BoP difficulties. This is the 'BoP-constrained growth rate'. Exports play a major role in the definition of the BoP-constrained growth rate, because, in contrast to the other components of aggregate demand, they are the only component whose expansion provides the foreign exchange needed to pay for the import requirements associated with the following expansion of output (Hussain, 1999).

Assuming constancy of relative prices, Thirlwall's Law postulates that the rate of growth of an open economy which is consistent with BoP equilibrium (denoted here $\dot{Y}_{BP}$) is determined by the growth rate of its volume of exports ($\dot{X}$) divided by the income elasticity of imports (π). To put it differently, the BoP equilibrium growth rate depends on the growth of world income ($\dot{Z}$) and on the relative size of the income elasticities of demand for exports (ε) and imports. This relation can be formulated as follows:[1]

$$\dot{Y}_{BP} = \frac{\varepsilon \dot{Z}}{\pi} = \frac{\dot{X}}{\pi} \qquad (1)$$

[1] Alternatively, Equation (1) can be obtained by assuming that the Marshall-Lerner condition is satisfied with equality (Thirlwall, 1979). Since this appears to be an extremely unlikely event, we will not discuss it any further.

If a country's growth rate is lower than $\dot{Y}_{BP}$, the country will accumulate trade surpluses and become a net capital exporter. Conversely, if its actual growth exceeds $\dot{Y}_{BP}$, the current account worsens and the country will become a net capital importer, but this cannot continue indefinitely. An economy is 'BoP-constrained' whenever its growth rate must adjust downwards to maintain the BoP equilibrium.

Two remarks are worth emphasising at this stage. Firstly, the model assumes that developing countries operate at less than full capacity, as a result of the lack of foreign exchange and other structural bottlenecks. However, although it stresses the role of growth in aggregate demand to raise capacity utilisation, the model does not imply that supply factors are unimportant. Rather, any production bottleneck that restricts export growth will be detrimental for growth (Felipe et al., 2009).

Secondly, this approach provides a rationale for an export-led growth model, because exports are the only one component of demand whose growth simultaneously relaxes the BoP constraint. Therefore, policies designed to increase the income elasticity of export (ε), such as changing composition of exports, or other measures that improve the performance of exports, may have positive effects on long-run growth. But these efforts could be hindered by the country's 'appetite' for imports (π), that is by its degree of dependence on foreign goods and services. This implies that the same rates of export growth in different countries do not produce the same rates of economic growth, because of the existence of different income elasticities of imports.

Our study extends the original BoP-constrained growth model in two ways. First, we relax the hypothesis of relative price constancy in Equation (1), which is contradicted by the evidence that in developing countries the terms of trade are trending, as implied by the Prebisch-Singer hypothesis (Sapsford and Chen, 1998). Such relative price changes appear to be relevant in a transition economy like Vietnam, where the abolition of price and exchange rate controls in 1987, followed by international integration, caused substantial adjustments in relative prices. Therefore, we decided to include the role of relative price changes in the analytical framework.

Our second extension deals with the geographical structure of trade flows. In the original model, the long–run economic growth of an open economy is determined by the rate of growth of aggregate exports, which is, in turn, determined by the exogenously given growth of 'world income'. In practice however, an individual country trades goods and services with a number of partner countries, and each bilateral trade relations may have different outcomes. Since the economic growth of a country depends on the growth rate of other countries through the BoP constraint, this mutual interdependence should be captured in a model with multilateral trade relations between the individual country and blocks of countries. By the same token, the import behaviour should be differentiated among the selling countries to assess how geography can be a determinant of trade relations. In view of this, we extend the original Thirlwall's law by applying it in a multi-country setting. This allows us to identify the role of structural parameters such as the imports and exports market shares and the bilateral trade elasticities in determining the BoP-constrained rate.

A multi country version of Thirlwall's Law

Our analytical extension assumes that a given country i has n trading partners. In our empirical analysis, we set $n = 5$ by considering five main partner areas: j = A, B, C, D, E (see Appendix A for country grouping). The current account equilibrium becomes: [2]

$$P_i \sum_{j=A,B,C,D,E} X_{ij} = \sum_{j=A,B,C,D,E} E_{ij} P_j M_{ij}$$

where P_i are country i export prices, X_{ij} is the real demand of partner j for country i exports, E_{ij} is the bilateral nominal exchange rate, P_j are export prices in j, and M_{ij} are country i imports from partner j. As a matter of fact, $X_{ij} = M_{ji}$ (namely, the exports from country i to partner j must equal the imports of the latter from the former). This 'mirror flows' identity, routinely exploited as a convenient simplification in a number of multi-country models, offers some practical advantages in terms of data collection and of the specification of the demand functions. Notably, it enables us to work only with import functions.

[2] To keep things simple, we ignore net incomes from abroad.

As a consequence, we formulate the model as follows:

$$M_{ij} = \left(\frac{P_i}{E_{ij} P_j} \right)^{\psi_{ij}} Y_i^{\pi_{ij}} \tag{2}$$

$$M_{ji} = \left(\frac{E_{ij} P_j}{P_i} \right)^{\psi_{ji}} Y_j^{\pi_{ji}} \tag{3}$$

$$P_i \sum_j M_{ji} = \sum_j E_{ij} P_j M_{ij} \tag{4}$$

Where, in addition to the previous variables, ψ_{ij} and π_{ij} are respectively the price and income elasticities of country *i* imports from partner *j*, M_{ji} is the real demand of partner *j* for imports from country *i* (namely, exports from country *i* to partner *j*), ψ_{ji} and π_{ji} are the corresponding price and income elasticities, and Y_j is partner *j* real GDP.

Taking the growth rates in (4) we obtain:

$$\dot{P}_i + \sum_j \nu_{ji} \dot{M}_{ji} = \sum_j \mu_{ij} \left(\dot{E}_{ij} + \dot{P}_j + \dot{M}_{ij} \right) \tag{5}$$

Where: $\nu_{ji} = \frac{M_{ji}}{\sum_j M_{ji}} = \frac{X_{ij}}{X_i}$ $\mu_{ij} = \frac{E_{ij} P_j M_{ij}}{\sum_j E_{ij} P_j M_{ij}}$ (j = A,B,C,D,E)

ν_{ji} and μ_{ij} are respectively the market shares of partner *j* in country *i* total exports (in volume) and in country *i* total imports (in value).[3]

Solving for the growth rate of country *i* as before, and denoting $R_{ij} = P_i/(E_{ij}P_j)$ the bilateral relative prices (namely, the ratio of domestic to foreign prices expressed in domestic currency), we obtain a multi-country version of Thirlwall's Law:

$$\dot{Y}_{i,BP} = \frac{\sum_{j=A,B,C,D,E} \dot{R}_{ij} \left[\mu_{ij} \left(1 - \psi_{ij} \right) - \nu_{ji} \psi_{ji} \right] + \sum_{j=A,B,C,D,E} \nu_{ji} \pi_{ji} \dot{Y}_j}{\sum_{j=A,B,C,D,E} \mu_{ij} \pi_{ij}} \tag{6}$$

[3] This asymmetric treatment of the market shares is a mathematical consequence of the fact that the summation in the left-hand side of the constraint (4) involves terms in volume, while the summation in the right-hand side involves terms in value.

The multi-country specification allows us to separately assess the contribution of each group of countries to country *i* growth rate predicted by the model. We can observe that the numerator of the multi country law features both a relative price effect (whose sign depends on the market shares weighted bilateral price elasticities), and a volume effect (a weighted sum of real export growth). The denominator instead features a sum of bilateral income elasticities of imports, weighted by the corresponding market shares, that expresses country's *i* aggregate 'appetite for imports' $\pi = \sum_j \mu_{ij}\pi_{ij}$. In other words, the aggregate income elasticity, that plays a crucial role in the single country version of Thirlwall's law, is nothing but a 'black box' summarising behavioural parameters that are likely be subject to changes.

Another important feature of the multi-country law is that it cannot be decomposed in bilateral terms. In fact, any bilateral deficit is not constrained *per se*, since in principle it could be financed by another bilateral surplus; as a consequence, the aggregate BoP constraint cannot be expressed as an additive function of bilateral balances. However, the extended law allows one to measure the contribution of partner *j*'s variables (either in country *i* export market or import demand) to *changes* in the aggregate BoP constraint of country *i* (see Bagnai *et al.*, 2012).

III. Data and estimation issues

In a first step, the long-run elasticities featuring the BoP constraint are estimated through the following ten loglinear bilateral trade equations:

$$m_{j,t} = \alpha_j + \psi_{i,j}\, r_{j,t} + \pi_{i,j}\, y_{i,t} + u_{j,t} \qquad (j = A,B,C,D,E)$$

$$x_{j,t} = \beta_j - \psi_{j,i}\, r_{j,t} + \pi_{j,i}\, y_{j,t} + e_{j,t} \qquad (j = A,B,C,D,E)$$

Where lower case letters indicate natural logs of the corresponding variables (therefore, $r_{j,t} = p_{i,t} - e_{i,j,t} - p_{j,t}$), and $u_{j,t}$ and $e_{j,t}$ are error terms.

Appendix B provides the sources and definitions of the data used in the estimation. In order to estimate the long-run elasticities by cointegration, we first need to ascertain whether the Data

Generating Process (DGP) of each series features a stochastic trend. The relevant tests were performed following the procedure suggested by Elder and Kennedy (2001). The rationale of this procedure is reported in Appendix C, along with its results. Summing up, all the time series involved in the estimation of the trade equations for Vietnam turn out to possess a unit root.

Having established the presence of stochastic trends in the DGP of our time series, we tested for the existence of a long-run relation between the relevant variables by the usual Engle and Granger (1987) cointegrating residual *ADF* (*CRADF*) test. When this test rejected the null of non cointegration, we took the estimated elasticities as the relevant long-run parameters. If instead the ordinary cointegration test failed to reject the null of non cointegration, we hypothesised that the non rejection could depend on the presence of a structural break in the long-run parameters. In order to cope with this, we applied the cointegration estimator proposed by Gregory and Hansen (1996), which tests the null of non cointegration against the alternative of cointegration in the presence of a structural break of unknown date. The breaks are modelled using the dummy variable $\varphi_{\tau t} = I(t > [T\tau])$, where I is the indicator function, T is the sample size (T=24, except for the exports to the US) [4], τ the relative timing of the change point, and [.] the integer part function. The Gregory and Hansen procedure takes into account several possible alternative models, featuring a break in the intercept only (the 'level' shift), or in the intercept and in the slopes (the 'regime' shift). Moreover, some alternative modes include a time trend, which in turn can be modelled with or without a break. Owing to the relatively limited dimension of our sample, we decided to test the null of non cointegration against the simplest alternative, that of level shift, where only the intercept is affected by the structural break.[5]

Taking the import equation as an example, the level shift is modelled as follows:

$$m_{j,t} = \alpha_{j0} + \mu_{j0}\varphi_{\tau t} + \psi_{i,j}\, r_{j,t} + \pi_{i,j}\, y_{i,t} + u_{j,t} \qquad (j = A, B, C, D, E)$$

[4] Since bilateral trade data with the US were subject to embargo until 1994 and only started thereafter, we were not able to apply the Gregory and Hansen procedure to these equations.

[5] Testing the null of non cointegration against other alternatives led to non rejection, or rejection with larger *p*-values, or models with imprecisely estimated elasticities. It is worth noting that in our case, the so called regime shift alternative entails the loss of three (instead of one) degrees of freedom (corresponding to the three shift parameters).

Where α_{j0} is the intercept in the first regime, $\varphi_{\tau t}$ is the shift dummy variable defined before, μ_{j0} is the intercept shift, so that the value taken by the intercept in the second subsample is $\alpha_{j1} = \alpha_{j0} + \mu_{j0}$. It is worth noting that in the level shift case the income and price elasticities are unaffected, which implies that a structural break of this kind has no impact on the BoP constraint (as the relevant elasticities remain constant throughout the sample).

The test statistic is evaluated as $ADF^* = \inf_{\tau} ADF_r(\tau)$, where $ADF(\tau)$ is the cointegrating ADF statistic corresponding to the shift occurring in $[T\tau]$. In other words, ADF^* is the smallest among all the ADF statistics that can be evaluated across all possible dates of structural breaks. The reported break date $T_1 = [\tau T]$ refers to the last year of the first regime (that is, the change in the parameter occurs between T_1 and T_1+1).

Finally, in order to take into account the possible endogeneity bias in the income elasticity of imports (whose importance has been pointed out by Soukiazis and Antunes, 2011-12), the import functions were re-estimated using Phillips and Hansen (1990) fully-modified OLS (FMOLS) estimator.

IV. Results

The estimates of the long-run elasticities

Tables 1 to 4 report the estimation results, starting from the import equations. The Engle-Granger CRADF (reported in Table 1), was unable to reject the null of non cointegration, with the limited exception of the imports from the US, where the null is rejected at the 10% significance level. In most cases, the relative price term is small and statistically insignificant. The Gregory-Hansen procedure confirms that bilateral import flows are rather inelastic to changes in relative prices (Table 2). The structural breaks in the bilateral import equations are all upward level shifts, with the only exception of the Rest of the World (RoW) case, which features a downward level shift after 1990. This structural break with level shifts makes sense from an economic point of view. The year

1991 corresponds to the collapse of the Soviet bloc countries, forcing Vietnam to reform its trade relations. The country adjusted by shifting its bilateral trade flows from former socialist countries towards Western countries and the Asian neighbours.

(Insert Tables 1 to 4 here)

As far as the bilateral export equations are concerned, the results are similar, with two differences: the equations appear to be more stable (non cointegration is strongly rejected against a stable alternative in two cases, the Rest of Asia and the US), and the relative price elasticity is statistically significant in a number of cases (while it was never found to be significant in the bilateral import equations). As shown in Table 3, the Engle-Granger procedure rejects the null of non cointegration in the cases of the Rest of Asia (RoA), USA, and RoW (in the last case only at the 10% level). In the latter two cases the price elasticity, although correctly signed, is found to be statistically insignificant (although marginally in the RoW case). In the remaining cases, the Gregory-Hansen procedure rejects the null of non cointegration against the alternative of cointegration with an upward level shift (Table 4).

Despite using a relatively short sample in terms of number of observations, all the relevant elasticities are estimated very precisely, with Student's *t* typically ranging from about 5 to about 20. This result is consistent with the fact that as far as the statistical properties of cointegration estimates are concerned, the sample length (in calendar terms) is more important than the number of observations (Otero and Smith, 2000).

Table 5 presents the FMOLS estimates of the import equations income and relative price elasticities, performed conditional on the structure of the deterministic component selected in the previous stages of the estimation procedure.[6] In three out of five cases the conventional estimates of the income elasticities appear to be downward biased, as suggested by Soukiazis and Antunes (2011-12).

[6] In other words, the deterministic component of the estimated equation (k_t in Phillips and Hansen's notation) consists of a segmented intercept (with the only exception of the equation of imports from the United States), where the appropriate intercept shift results from the Gregory and Hansen's procedure. The conventional goodness of fit measures are omitted from Table 5 as they make no sense in the context of instrumental variable estimation.

(Insert Table 5 here)

Finally, Table 6 summarizes the long-run elasticities that will be used to calculate the predicted growth rate for Vietnam. In brief, all the income elasticities are statistically significant and correctly signed. The largest export income elasticities are those of the developed partners (the US, the RoA and the EU), which, in addition, feature smaller import income elasticities. This implies that any favourable change in the Northern partners' income (especially in the US, where the export elasticity reaches 11.7) has a major role in relaxing Vietnam's BoP constraint, through the export demand. The asymmetry in the income elasticities implies that with unchanged relative prices and market shares, if Vietnam grows at the same rate than its trading partners, the corresponding bilateral balance will improve. The opposite applies to Developing Asia, whose imports income elasticity is both the largest, and it is larger than the corresponding bilateral exports elasticity (2.9 and 1.9 respectively). This stylized fact is consistent with a triangular trade relation, where Vietnam imports raw materials and semi-finished goods for the neighbouring developing countries, and exports finished goods in developed countries.

(Insert Table 6 here)

Another picture that emerges is one where variations in the relative prices do not matter in Vietnam's imports, neither in the country's exports to the US and the RoW. This means that in the long run, a large part of foreign goods and services are imported regardless of changes in their prices. This is explained by the structure of Vietnam's imports, where a large part is dominated by production goods (semi final products, intermediate and capital goods) that are not produced domestically. On the other hand, any competitive devaluation that decreases domestic prices relative to foreign ones will only boost exports to the Developing Asia, and to a much lesser extent to the RoA and the EU.

The BoP equilibrium growth rate

A second step consists in comparing the average growth rates predicted by the BoP constrained growth model ($\dot{Y}_{BP}$) with the actual rates ($\dot{Y}$): the purpose is to test whether or not the country's growth was BoP-constrained over the period from 1985 to 2010. Moreover, since most Asian countries were affected by the economic recession that hit the region after 1997, we examined separately the two subperiods *before* (1985-1997) and *after* (1998-2010) the East Asian crisis.

(Insert Table 7 here)

Table 7 reports the elements needed for the evaluation of the BoP-constrained growth rate following Equation (6). Broadly speaking, Vietnam's actual growth rate was below the constrained one during the entire period considered: 6.9% compared to 8.5% on average. This indicates that Vietnam was respecting its BoP constraint. Equation (6) gives us further insights on the meaning of this result. The estimation results showed that the coefficients of the relative price term are statistically insignificant in all import equations as well as in the equations of exports to the US and the RoW. As a consequence, the relative price effect in the numerator of Equation (6) is very small, and income changes dominate the BoP constraint. The export volume effect (namely, the second term in the numerator) contributes to the BoP-constrained rate by 0.153/1.805=8.5 percentage points in aggregate, a result unaffected by the adverse but negligible relative price effect. A closer look at Equation (6) shows that the volume effect at the numerator depends on partner countries' growth as well as on the interaction between the bilateral income elasticities and the market shares of exports. In particular, since the RoA has the largest export market, equal to 33.2% in the whole sample, its contribution dominates the sum. As far as the denominator is concerned, the sum is dominated again by the RoA, owing to its large import market shares (equal to 0.357), followed by developing Asia, whose market share is smaller (0.194), but whose import elasticity is larger (2.9 instead of 2.0 for RoA, see Table 6). With a contribution of 0.567 and 0.701 respectively, DA and RoA explain 70% of the aggregate import elasticity of Vietnam.

Substantial differences emerge however when we analyse separately the two subperiods before and after the Asian crisis. While the actual growth rate displays a surprising stability, the constraint shifts between the first and the second subsample. Before the East Asian crisis, Vietnam grew at a rate *below* the BoP-constrained one, with a spread of 4.1 percentage points. The large part of trade that occurred with the former Soviet bloc countries may partially explain the much higher growth rate predicted by the model for this subperiod. Still, the sustained rapid growth achieved by the country after *Doi Moi* illustrates a situation where productive capacity was underutilised within the planned economy and the transition reforms brought resources into production. Thus, Vietnam between 1985 and 1997 may be described as capacity constrained, with the country growing at its capacity growth rate without encountering BoP difficulties.

The reverse occurs in the second subperiod, where Vietnam's actual growth rate marginally exceeded the BoP-constrained one (6.9% compared to 6.7%), resulting in capital inflows to bridge the financing gap. The spread between the BoP equilibrium and the actual averages, which decreased from 4.1 to about -0.2 percentage point, can be taken as evidence of an increased demand constraint on Vietnam's growth. As a matter of fact, the constrained growth rate fell from 10.6% to 6.7% after the Asian crisis, while the country actually kept growing at 6.9%. As a consequence, the question arises as to why was Vietnam's BoP-equilibrium growth rate falling? Which partners were responsible for this and through which channel of transmission?

(Insert Figure 2 here)

Table 7 allows us to answer these questions by separately reporting the terms of the summations at the numerator and the denominator of Eq. (6). We should remark at the outset that since the estimated elasticities are constant and the relative price effects are negligible over the whole sample, any change between the first and the second subsample must come from either the evolution of the market shares, or a change in a partner's growth rate, or both. At an aggregate level, we observe that the evolution of the constraint was determined by both a decrease in the numerator (from 0.165 to 0.137) and an increase in the denominator (from 1.591 to 2.033), where

the former was smaller (in percentage terms) than the latter (the numerator decreased by 18.6% and the denominator increased by 27.7%). As for the numerator, the strongest effect which contributed to tightening Vietnam's BoP came from the volume of exports destined to the RoA. With the heaviest weight in the bilateral income elasticity of exports, the RoA (namely, the developed Asia) sustained Vietnam's export growth over the whole period considered (Figure 2). However, its GDP growth rate declined by 2 percentage points in the second subperiod, eroding Vietnam's export performance. A Bilateral Trade Agreement (BTA) signed in 2000 between Vietnam and the US evidently boosted Vietnamese exports. But this only partially compensated the former negative effect In fact, the US contribution in the first subsample was negligible, therefore, although it increased tenfold (from 0.3 percentage point to 3.8), its contribution was unable to offset the fall of the RoA export volume effect to one third (from 9.6 to 3.2).

As for the denominator of Equation (6), its increase from 1.59 to 2.03 between the two subperiods is explained mainly by the evolution of the trade relations with the other Asian countries. While Vietnam was mainly dependent on imports from the Rest of Asia over the whole period considered, the most relevant change came from the share of the Developing Asia in Vietnam's total imports. Since this market share climbed from 10.1% before the Asian crisis to 29.6% in the last subperiod, the corresponding weighted bilateral elasticity rose sharply from 0.31 to 0.9. This indicates a strong asymmetry in bilateral trade relations between Vietnam and its developing neighbours: the country exports mainly to the advanced countries (with the highest export sensitivity to income changes for the US), but any rise in domestic activity will imply a sustained growth of imports from the Developing Asia.

Figure 2 depicts the evolution of Vietnam's trade market shares over the period considered: as bilateral flows grew at different rates, the market shares evolved accordingly. Even if the bilateral income elasticities remained constant, the denominator changed over time and impacted negatively on the country's BoP position. Our study finds evidence in support of Sepheri and Akram-Lodhi

(2005), whose estimates for import behaviour demonstrated that Vietnam's growth is highly dependent on imported capital and intermediate goods. After the regional crisis in 1997, its appetite for imports coming from Asia reached 1.62 out of 2.03 in the denominator. Thus, the greater the rate of capacity utilisation through exports, the greater the extent of necessary imports to keep production moving.

V. Impact of the current global crisis

Filtering

A last step of our study assesses the impact of the current global crisis on Vietnam's economic growth. More precisely, the over reliance on the high income markets for exports has been questioned since 2008. In order to address this issue, we look at the evolution over time of the BoP constrained rate. Since the BoP constraint is in its nature a long-run constraint, we evaluate it using the long-run components of the relevant variables, and compare it with an estimate of the long-run growth rate.

The long-run component of each series was extracted using the Hodrick and Prescott (1997) filter. The filter computes the smoothed (long run) component s_t of a series y_t by minimising the variance of the deviation of y_t from s_t, subject to a penalty that constrains the second differences of the smoothed series. The long-run component s_t thus minimizes the following expression:

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda \sum_{t=2}^{T-1}[(s_{t+1} - s_t) - (s_t - s_{t-1})]^2$$

The λ parameter equals 100, namely the value suggested by Hodrick and Prescott (1997) when dealing with annual data.

(Insert Figure 3 here)

The filtered series were then inputted in Equation (6), providing us with a time varying estimate of the BoP constraint. The estimate allows us to confirm the previous results (Figure 3). After successful transition reforms through *Doi Moi*, Vietnam grew at an impressive rate. From a capacity

constrained growth before 1993, the country grew almost at the same rate as the one predicted by the model until 2005, started to violate its BoP constraint. This outcome was not caused by an acceleration in growth, as the historical rates remained almost stable, but because of a tightening of the BoP constraint since 2005, determined by the evolution of the bilateral market shares and partners' growth rates. Export growth made a significant contribution to GDP growth, but the shift to a more import intensive pattern of growth contributed to deteriorating the BoP position of Vietnam, whose export growth was affected by economic slowdown in the RoA, while the import growth was simultaneously accelerated by the process of regional integration (notably towards Developing Asia).

Growth targets and the global economic turmoil

Vietnam's Socio Economic Development Strategy (SEDS) for the period 2011 to 2020 identifies the country's key priorities over the current decade. The overall goal is for Vietnam to lay the foundations for a modern, industrialised society by 2020. Accordingly, the government aspires to achieve by that year a *per capita* income level of 3000 current USD. This translates into a nearly 10% annual growth in *per capita* nominal GDP over the decade (World Bank, 2011). To meet this ambitious target, the Vietnamese National Assembly set a target for real GDP growth of around 6.5-7% annually under the five year Socio Economic Development Plan 2011-2015 (SEDP), . The total export receipts are expected to increase by 13%. Gross capital accumulation would occupy 33.5–35% of GDP in this period, while the trade deficit rate would be gradually reduced from 2012 onwards and is expected to be 10% of total export turnover by 2015.

The question addressed here is whether the government's medium-run growth target is achievable in the context of a weaker global economic environment, and how the foreign exchange requirements will be filled to meet this target. To this purpose, we depart from the last assessment of GDP growth edited by the International Monetary Fund (IMF, 2012). We constructed our baseline scenario by using the IMF's medium term projections for the period 2011 to 2017, along

with the filtered series for import and export market shares.[7] The corresponding BoP equilibrium growth rate is calculated by substituting our estimates of the long-run income and price elasticities.

(Insert Table 8 here)

According to IMF projections, growth prospects differ across the partner areas: while the Developing Asia is expected to maintain a high growth rate (7.8% per year on average), activity in the Northern partners (the RoA, the EU and the US) will remain rather low. The relatively high growth rate in the RoW is attributable to the recent dynamic expansion of South–South trade, providing developing countries with a favourable external economic climate for export expansion (Bagnai *et al.*, 2012). Vietnam is expected by the IMF to keep growing at a rate of 6.7% per year, which is consistent with the government's target (Table 7).

Our baseline scenario shows that, provided that all the partner areas confirm the growth rates projected by the IMF for the period from 2011 to 2017, Vietnam's BoP constraint would be relaxed in comparison with the 1998-2010 subperiod, because of high demand growth in the RoA, the US and the RoW. The growth rate predicted by the model lifts up (8.2%), enabling the country to achieve its growth target without encountering BoP problems.

However, in case the current crisis in the euro area does not lead to visible improvement in the external environment, this relevant change could be reversed. In this perspective, three scenarios are compared here. *Scenario 1* assumes a sharp recession in the world economy, with a decrease in all partners' GDP growth by one percentage point with respect to the baseline. Under *scenario 2*, the same slowdown in GDP growth affects only the Northern partners (the RoA, the US and the EU). Finally, *scenario 3* hypothesizes that the Asian area is able to avoid the economic turmoil.

Under *scenario 1*, recession in all partner areas, with the associated slowdown in the demand for Vietnam's exports, will tighten the BoP constraint to 5.2%. As a result, the government growth target could be achieved only through a heavier reliance on capital inflows. Under *scenario 2*, when

[7] Due to the low relative price effect, we neglect it in our simulations.

only the Northern partners are affected by the economic turmoil, Vietnam's BoP constraint is less binding; but the corresponding growth rate (5.5%) remains lower than the government's target and far lower than the growth rate estimated in the baseline. In other words, a demand led expansion in South–South trade may be a weak alternative engine of export expansion. Whatever the scenario undertaken, the ongoing recession reveals the vulnerability of Vietnam's growth to the external economic climate, as the production networks built in the Asian area work to its disadvantage. To illustrate this argument, *scenario 3* results in more optimistic projections by assuming that the Asian area is sheltered from the global crisis. In this case Vietnam's BoP–constrained growth rate is close to the target (6.2% against 6.5%), allowing the government to achieve the medium-run growth rate without further increases in capital inflows to bridge the financing gap. In other words, continued robust economic expansion in the Asian region would attenuate the negative impact on Vietnam of what would otherwise be a global economic downturn.

VI. Conclusion

Vietnam has made important progress in achieving economic and social development over the past two decades. The country's accession to the WTO paved the way to greater market liberalisation and foreign investment inflows. However, recent developments in Vietnam's economic conditions suggest that the country's BoP problems come from its integration into global and regional economies. In the face of rapid growth with structural change in trade partnerships, the connection between BoP and growth cannot be ignored.

In view of this, our paper examines the long-run relationship between economic growth and the current account balance equilibrium using a multi-country BoP constrained growth model. This model allows us to assess whether the country growth was compatible with its BoP equilibrium, and what are the international factors that could prevent any attempt to achieve a sustained growth of rate. The model specified was estimated using annual data for the period between 1985 and 2010,

and we analysed separately the two subsamples before and after the 1997 Asian crisis, looking at the possible role of the different trading partners in the evolution of the BoP constraint.

Our results show that over the whole sample Vietnam respected its BoP constraint. However, our decomposition allows us to identify the international mechanisms through which Vietnam's BoP position worsened, related to the nature of the country's trade partnership before and after the Asian crisis. While before the crisis (1985-1997) the Vietnamese economy was well inside its BoP constraint, after the crisis the constraint tightened quickly. The estimation results show that this outcome does not depend on the evolution of relative prices, whose effect is neutral. The evolution of the BoP constraint is dominated by changes in the market shares and in the partners' growth rate. In particular, Vietnam has partially benefited from a change in bilateral or multilateral trade policies with advanced countries (for instance, through the US-VN bilateral trade agreement). However, Vietnamese growth is hindered by the 'appetite' for imports coming from the whole of Asia. This feature is consistent with a production oriented trade structure which has proliferated in the region, often as a part of triangular (South–South–North) trading networks. Finally, the study addressed the issue of the impact of global recession on Vietnam's growth for the period 2011 to 2017. The scenario analyses show that slower growth in the partner areas will result in a BoP constraint well below the government medium-run growth target. However, the capital inflows needed to fill the foreign exchange gap are relatively limited in case the Asian partners keep growing and remain unaffected by the global economic turmoil.

Since exports represent a source of foreign exchange, the analysis developed here provides a rationale for an export-led growth strategy. However, our results suggest that this strategy is highly vulnerable to the external economic environment, notably through the constraint imposed by the pace of growth of high income countries' demand for exports.

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Appendix A. Countries

Group A (Developing Asia, DA): Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand.

Group B (Rest Of Asia, RoA): Australia, Brunei, French Polynesia, Hong Kong, Japan, Macao, New Caledonia, New Zealand, North. Mariana Islands, Singapore, South Korea.

Group C (EU15): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

Group D: USA

Group E: Rest of the World (RoW)

Appendix B. Data sources and definitions

The bilateral trade flows of Vietnam to and from each partner region were reconstructed using the Comtrade database. The sample runs from 1985 through 2010. Missing data in the bilateral trade series were reconstructed as follows: if either of the two flows is missing, we use its 'mirror'. If instead they are both reported but with different values, the bilateral series are reconstructed as a weighted average of the import and the export ones (where imports receive a 2/3 weight). The data on the bilateral trade relations between Vietnam and the RoW are missing from the beginning of the sample through 1997. The two series were reconstructed taking for each the difference between the total flow, extracted from the World Development Indicators (WDI) database, and the sum of the other bilateral flows. Then we calculated the RoW flows by subtracting from the total the other four bilateral trade series.

Since the Comtrade series are in USD at current prices, in order to get their real counterparts, the import series M_j were deflated using country j aggregate export deflator (evaluated as the ratio of nominal to real exports in USD), while the export series X_j were deflated using Vietnam export deflator (evaluated accordingly). Vietnam export deflator was missing from 1985 to 1988. The missing data were retropolated using the GDP deflator growth rate. The data on nominal and real

aggregate exports and GDP come from the 2012 edition of the WDI database. All real variables are measured in USD at 2000 prices.

Relative prices were constructed as the ratio of domestic prices (measured by Vietnam export deflator) to foreign prices (measured by partner *j* GDP deflator). The estimation was also performed using a terms of trade variable constructed as the ratio of Vietnam export deflator to the partner export deflator (that is, to Vietnam import deflator). The empirical results (available upon request) did not compare favourably with the one presented in the paper.

Appendix C. Unit root tests

As is well known, the results of unit root tests are strongly dependent on the correct specification of the deterministic component (drift and trend) of the underlying Data Generating Process (DGP). Misspecification of the deterministic component may entail a loss of power (see Campbell and Perron, 1991). In order to cope with this issue, we adopted the testing strategy proposed by Elder and Kennedy (2001). In short, this strategy uses the *a priori* information, provided by the pattern of the time series, in order to rule out those alternative hypotheses that are inconsistent with the observed behaviour of the data. This allows the researcher to decide on *both* the correct specification of the deterministic component *and* the presence of a unit root using a single test, thus reducing the multiple hypotheses testing issues presented by other testing strategies (such as the one proposed by Dolado *et al.*, 1990).

First, the plot of the series is inspected, in order to verify whether it exhibits a trending behaviour. If the series is trending, we perform an *F* test for the null hypothesis H_0: $\rho=1$, $\beta=0$ in the model:

$$y_t = \alpha + \beta t + \rho\, y_{t-1} + \varepsilon_t$$

This *F* statistic has a non standard distribution under the null and is compared with the critical values of the Φ_3 statistic provided by Dickey and Fuller (1979). Failure to reject the null implies that the series is *I*(1) with drift, while rejection implies that it is *I*(0) around a deterministic trend

(namely, $\rho<1$, $\beta\neq0$). The other possible alternatives are ruled out, being inconsistent with the observed data behaviour (see Elder and Kennedy, 2001).

If instead the series does not display a regular trending behaviour, we test the null hypothesis H_0:$\rho=1$, $\alpha=0$ in the model:

$$y_t = \alpha + \rho\, y_{t-1} + \varepsilon_t$$

In this case the F statistics follows the Φ_1 distribution by Dickey and Fuller (1979). Failure to reject implies that the series is $I(1)$ without drift, while rejection implies that the series was generated by an $I(0)$ process with unconditional mean different from zero. In both cases, lags of the differenced dependent variable were added to the equation in order to whiten its residuals. The lag length was determined by reduction, starting from a maximum order of lags equal to 2, which was deemed appropriate considering the sample length and the fact that we are using annual data.

The results of the tests are summarized in Table A1. All the variables, except relative prices, display a clear trending behaviour, that could be compatible with either a $I(1)$ with drift process, or with a $I(0)$ process with deterministic trend. The relative price series, instead, display a pronounced reversal occurring at the beginning of the 1990s, which is incompatible with the presence of a deterministic trend. The results show that in all cases we were unable to reject the unit root null.

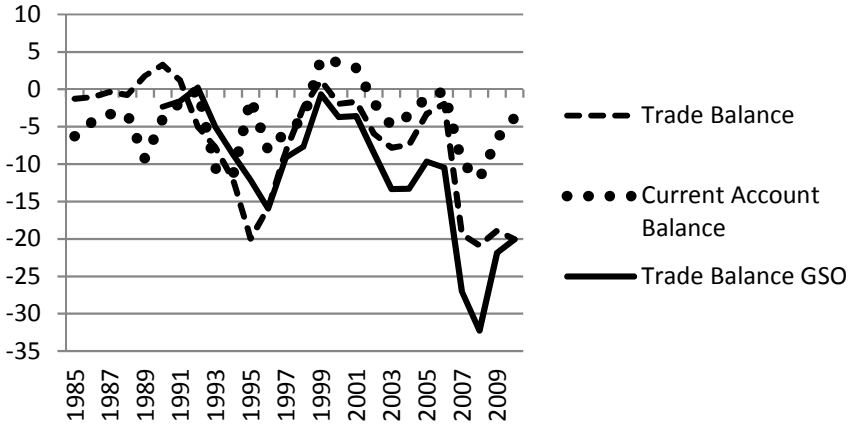
Table A1. Unit root tests

variable	behaviour	statistic	lags	variable	behaviour	statistic	lags
$m_{A,t}$	trending	3.17	0	$x_{A,t}$	trending	2.20	0
$m_{B,t}$	trending	2.46	1	$x_{B,t}$	trending	1.53	0
$m_{C,t}$	trending	3.63	0	$x_{C,t}$	trending	1.76	0
$m_{D,t}$	trending	2.27	0	$x_{D,t}$	trending	5.33	0
$m_{E,t}$	trending	0.77	0	$x_{E,t}$	trending	5.60	1
$y_{A,t}$	trending	2.20	1	$r_{A,t}$	non trending	2.31	0
$y_{B,t}$	trending	3.84	0	$r_{B,t}$	non trending	2.73	0
$y_{C,t}$	trending	3.25	1	$r_{C,t}$	non trending	2.75	0
$y_{D,t}$	trending	4.59	2	$r_{D,t}$	non trending	2.17	0
$y_{E,t}$	trending	2.79	0	$r_{E,t}$	non trending	2.15	0
y_t	trending	5.77	1				

For trending series we applied the Φ_3 test and for non trending series the Φ_1 test by Dickey and Fuller (1981). The 5% critical values are 7.24 and 5.18 respectively. The unit root null is never rejected by the data.

Figures and tables

Figure 1. Vietnam's external balance



Sources: Trade balance, UN Comtrade and General Statistics Office of Vietnam (GSO); Current account balance, IMF World Economic Outlook.

Figure 2. Export and import market shares (respectively in volume and in value)

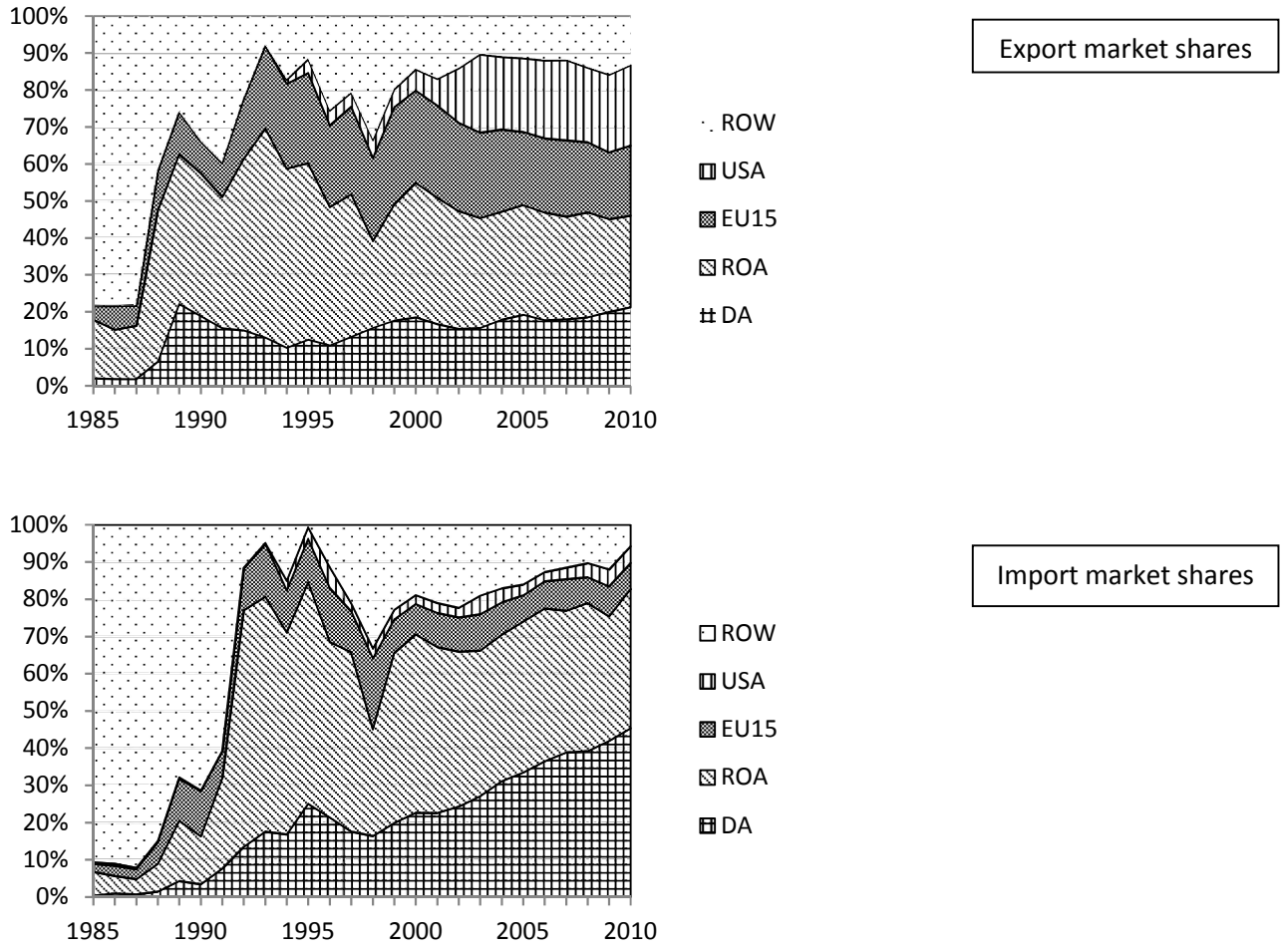


Figure 3. The HP series of BoP equilibrium and actual growth rates

Table 1. Bilateral imports equations, Engle and Granger estimation

	sample	α_j	$\psi_{i,j}$	$\pi_{i,j}$	$\overline{R}^2$	DW	CRADF	
DA	1985-2010	-29.54	-0.42	3.63	0.96	0.69	-1.81	
		-15.48	*-1.94*	*19.49*				
RoA	1985-2010	-18.53	-0.39	2.63	0.94	0.622	-2.28	
		-11.60	*-2.62*	*16.98*				
EU15	1985-2010	-12.28	-0.12	1.87	0.93	1.119	-3.05	
		-9.80	*-1.01*	*15.22*				
EU15	1985-2010	-12.97		1.94	0.93	1.049	-2.94	
		-12.28		*18.69*				
USA	1994-2010	-18.14	0.52	2.35	0.87	1.763	-3.44	
		-7.66	*1.12*	*10.41*				
USA	1994-2010	-18.22		2.36	0.87	1.653	-3.24	*
		-7.64		*10.39*				
RoW	1985-2010	-4.16	0.61	0.73	0.42	1.268	-3.48	
		-8.25	*-1.76*	*12.09*				

The *t*-statistics are reported in italic under the coefficient estimates. DW is the statistic of the Durbin-Watson test, CRADF is the cointegrating residual augmented Dickey-Fuller test. An asterisk indicates rejection at the 10% level.

Table 2. Bilateral imports equations, Gregory and Hansen estimation

	α_{j0}	μ_{j0}	$\psi_{i,j}$	$\pi_{i,j}$	$\overline{R}^2$	DW	ADF*	Break
DA	-23.99	1.15	-0.17	3.00	0.985	1.99	-7.49 ***	1991
	-16.20	*6.19*	*-1.24*	*19.51*				
DA	-24.44	1.22		3.03	0.984	1.84	-6.63 ***	1991
	-16.84	*6.75*		*19.93*				
RoA	-12.77	1.27	-0.02	1.97	0.984	1.76	-5.55 ***	1991
	-11.82	*8.13*	*-0.26*	*17.25*				
RoA	-12.76	1.29		1.96	0.985	1.78	-5.54 ***	1991
	-12.08	*9.81*		*17.71*				
EU15	-7.89	0.64	-0.10	1.40	0.959	2.29	-5.72 ***	1993
	-5.28	*3.91*	*-1.12*	*9.03*				
EU15	-8.20	0.73		1.42	0.97	2.25	-5.60 ***	1992
	-7.28	*5.46*		*12.04*				
RoW	16.44	-16.99	0.25	-1.38	0.68	3.00	-4.53	1991
	3.58	*-2.88*	*1.60*	*-2.95*				
RoW	-5.27	-0.99		0.92	0.44	1.82	-4.57 *	1990
	-2.77	*-3.96*		*4.63*				

α_{j0} is the intercept, μ_{j0} the shift in the intercept, $\psi_{i,j}$ the relative prices elasticity, $\pi_{i,j}$ the income elasticity. The *t*-statistics are reported in italic under the coefficient estimates. DW is the statistic of the Durbin-Watson test, ADF* is the statistic of the Gregory and Hansen test for the null of non cointegration. One (two, three) asterisk indicates a 10% (5%, 1%) significant statistic.

Table 3. Bilateral exports equations, Engle and Granger estimation

	sample	β_j	$\psi_{j,i}$	$\pi_{j,i}$	$\overline{R}^2$	DW	CRADF	
DA	1985-2010	-28.0	-2.2	2.4	0.98	0.645	-3.15	
		-13.6	*-12.6*	*17.2*				
RoA	1985-2010	-112.2	-0.8	7.7	0.98	0.998	-5.58	***
		-20.8	*-7.2*	*22.3*				
EU15	1985-2010	-138.5	-1.0	9.2	0.95	0.335	-2.34	
		-13.1	*-5.0*	*13.8*				
USA	1994-2010	-178.7	-0.6	11.5	0.95	1.124	-3.75	*
		-15.7	*-1.0*	*16.4*				
USA	1994-2010	-180.2		11.6	0.95	1.153	-3.85	**
		-16.0		*16.7*				
RoW	1985-2010	-50.6	-0.3	3.7	0.80	1.322	-3.81	*
		-6.3	*-1.7*	*7.2*				
RoW	1985-2010	-58.2		4.2	0.78	1.314	-3.63	*
		-8.4		*9.5*				

The *t*-statistics are reported in italic under the coefficient estimates. DW is the statistic of the Durbin-Watson test, CRADF is the cointegrating residual augmented Dickey-Fuller test. An asterisk indicates rejection at the 10% level.

Table 4. Bilateral exports functions, Gregory and Hansen estimation

	sample	β_{j0}	μ_{j0}	$\psi_{j,i}$	$\pi_{j,i}$	$\overline{R}^2$	DW	ADF*		Break
DA	85-10	-21.35	0.61	-2.23	1.93	0.981	1.01	-5.0	**	1995
		-7.13	*2.78*	*-14.54*	*9.06*					
EU15	86-09	-93.74	1.31	-0.91	6.32	0.987	1.78	-4.6	*	1992
		-12.53	*8.78*	*-9.55*	*13.23*					
RoW	85-10	-42.07	0.64		3.15	0.813	1.44	-5.8	***	1993
		-4.37	*2.25*		*5.02*					

β_{j0} is the intercept, μ_{j0} the shift in the intercept, $\psi_{j,i,}$ the relative prices elasticity, $\pi_{j,i,}$ the income elasticity. The *t*-statistics are reported in italic under the coefficient estimates. DW is the statistic of the Durbin-Watson test, *ADF** is the statistic of the Gregory and Hansen test for the null of non cointegration against the alternative of a level shift. One (two, three) asterisk indicates a 10% (5%, 1%) significant statistic.

Table 5. Bilateral imports functions, FMOLS estimation

	sample	$\pi_{j,i}$	DW
DA	1985-2010	2.92	2.11
		25.12	
RoA	1985-2010	1.96	1.95
		21.46	
EU15	1985-2010	1.34	2.28
		13.07	
USA	1994-2010	2.41	1.63
		9.68	
RoW	1985-2010	1.07	1.91
		5.76	

The *t*-statistics are reported in italic under the coefficient estimates. DW is the statistic of the Durbin-Watson test.

Table 6. A summary of the estimated elasticities

	bilateral imports		bilateral exports	
	income	prices	income	prices
DA	2.9	/	1.9	-2.2
RoA	2.0	/	7.7	-0.8
EU15	1.3	/	6.3	-0.9
USA	2.4	/	11.6	/
RoW	1.1	/	3.1	/

Table 7. Comparison between the BoP equilibrium and the actual growth rates

			Full sample 1985-2010	Subsample 1985-1997	Subsample 1998-2010
Numerator: Relative price effect	DA		-0.003	-0.010	0.001
	RoA		0.000	0.000	0.002
	EU15		0.000	0.000	0.000
	USA		0.001	0.001	0.000
	RoW		0.001	0.013	-0.003
		Subtotal	-0.001	0.004	0.000
Numerator: Volume effect	DA		0.021	0.016	0.026
	RoA		0.060	0.096	0.032
	EU15		0.023	0.021	0.024
	USA		0.024	0.003	0.038
	RoW		0.025	0.029	0.017
		Subtotal	0.153	0.165	0.137
Denominator	DA		0.567	0.297	0.865
	RoA		0.701	0.632	0.761
	EU15		0.123	0.126	0.119
	USA		0.053	0.031	0.077
	RoW		0.361	0.505	0.211
		Subtotal	1.805	1.591	2.033
		$\dot{Y}_{BP}$	**0.085**	**0.106**	**0.067**
		$\dot{Y}$	**0.069**	**0.069**	**0.069**

Table 8. Some projections on Vietnam's economic growth (2011-2017)

	Baseline: IMF projections	Scenario 1	Scenario 2	Scenario 3
Partner's growth				
DA	0.078	**0.068**	0.078	0.078
RoA	0.021	**0.011**	**0.011**	0.021
EU15	0.016	**0.006**	**0.006**	**0.006**
USA	0.028	**0.018**	**0.018**	**0.018**
RoW	0.040	**0.030**	0.040	**0.030**
$\dot{Y}_{BP}$	**0.082**	**0.052**	**0.055**	**0.062**
$\dot{Y}^{target}$	**0.065**	**0.065**	**0.065**	**0.065**