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The Economic Consequences of U.S. Border Closure in Response to a Security Threat: A Dynamic CGE Assessment

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THE ECONOMIC CONSEQUENCES OF U.S. BORDER CLOSURE IN RESPONSE TO A SECURITY THREAT: A DYNAMIC CGE ASSESSMENT

P.B. Dixon¹, J.A. Giesecke^{1*}, M.T. Rimmer¹ and A. Rose²

Abstract

We investigate the economic consequences of a twelve-month closure of U.S. borders in the form of cessation of trade, tourism and immigration flows. The federal government might contemplate such action in the face of an extreme terrorism or public health threat. Using a computable general equilibrium model, we find that border closure would cause substantial economic loss. However this damage is significantly reduced when critical imports (such as energy) are either exempted from the policy, or made available through use of domestic stockpiles (such as the Strategic Petroleum Reserve). Economic damage is reduced further if workers accept lower real wages for the duration of the security crisis. We argue that if border closure were ever to be contemplated as a response to a security or public health threat, it would be prudent to keep its scope to a minimum, to make its duration as short as possible, to allow market responses to run their course, and to enact countervailing policies that can help minimize the economic losses.

JEL classification: F52, C68

Key words: border closure, strategic reserves, bottleneck imports, dynamic CGE

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1. INTRODUCTION

Several threats to the United States may raise the consideration of a partial or complete shutdown of borders to people and goods. Such threats would include a coordinated terrorist attack or an influenza outbreak, and could last anywhere from just a few days to several months. The motivation for the research we report in this paper was a request by the U.S. Department of Homeland Security and the Treasury Department to analyze the economic impacts of shutdown of U.S. borders in response to the threat of an Avian Influenza or other serious communicable disease epidemic. Given that the U.S. economy is highly dependent on international mobility of goods and people, the economic impacts of a partial or total border closure are likely to be significant.

Only a limited number of studies have expressly analyzed the effects of major shut downs of U.S. borders to goods and/or people. The most comprehensive of these are Rose et al. (2009) and Gordon et al. (2009). Rose et al. use a macroeconometric model to assess the effects of a twelve month closure of U.S. borders. Gordon et al. (2009) use an input-output approach to assess border closure impacts at the national and state levels. Few other studies of border shutdown have been undertaken. The major exception is the case of oil embargoes and related supply dislocations, which do provide insights to the more general considerations modeled in this paper. The first contemporary oil price shock was instigated by the Arab country members of the Organization of Petroleum Exporting Countries (OPEC) in the form of an embargo that lasted from September to December 1973, during which these members reduced their production by 4.2 million barrels per day. Greene et al. (1998) use consumer and producer surplus analysis to estimate the impacts of a hypothetical 2-year reduction in oil output similar to the prior oil shock.

In this paper we use a dynamic computable general equilibrium (CGE) model of the U.S. economy (USAGE)ⁱ to investigate the effects of a twelve month closure of U.S. borders. We find that complete border closure over such a lengthy period imposes substantial economic cost on the U.S. economy. This scenario serves a useful purpose as an upper bound on the possible impacts. However it is an unlikely policy prescription, not only because of the large impacts, but also because it is unnecessary. Oil, natural gas,

ⁱ We describe USAGE in Section 2 of this paper.

communications services and several other sectors are not likely to transmit any infectious diseases or be the basis of terrorist entrance to the U.S. We show that the economic cost from border closure is significantly reduced when critical imports (such as energy) are either exempted from the policy, or made available through use of domestic stockpiles (such as the Strategic Petroleum Reserve). The economic disruption caused by border closure is reduced further if workers accept lower real wages for the duration of the security crisis. We argue that if border closure were to ever be contemplated as a response to a security or public health threat, it would be prudent to keep its scope to a minimum, to make its duration as short as possible, to allow market responses to run their course, and to enact countervailing policies that can help minimize the economic losses.

2. THE USAGE MODEL OF THE U.S. ECONOMY

USAGE is a detailed, dynamic CGE model of the U.S. It has been developed at the Centre of Policy Studies, Monash University, in collaboration with the U.S. International Trade Commission.ⁱⁱ The theoretical structure of USAGE is similar to that of the MONASH model of Australia (Dixon and Rimmer, 2002).

The model has one representative household and one central government. Optimising behaviour governs decision-making by firms and households. Each industry minimises unit costs subject to given input prices and a constant-returns-to-scale output function. Household demands are modelled via a representative utility-maximising household. Units of new industry-specific capital are cost minimising combinations of U.S. and foreign commodities. Imperfect substitutability between imported and domestic varieties of each commodity is modelled using the Armington constant elasticity of supply (CES) assumption. The export demand for any given U.S. commodity is inversely related to its foreign-currency price. The model recognises consumption of commodities by government, and a variety of direct and indirect taxation instruments. It is assumed that all sectors are competitive and all markets clear. Purchasers' prices differ from producer prices by the value of indirect taxes and trade and transport margins.

ⁱⁱ Prominent applications of USAGE by the U.S. International Trade Commission include USITC (2004 and 2007).

USAGE includes three types of dynamic mechanisms: capital accumulation; liability accumulation; and lagged adjustment processes. Capital accumulation is specified separately for each industry. An industry's capital stock at the start of year $t+1$ is its capital at the start of year t plus its investment during year t minus depreciation. Investment during year t is determined as a positive function of the expected rate of return on the industry's capital. Expected rates of return can be determined by rational expectations (forward-looking) or static expectations in which only information from year t and earlier years is used.ⁱⁱⁱ Liability accumulation is specified for the public sector and for the foreign accounts. Public sector liability at the start of year $t+1$ is public sector liability at the start of year t plus the public sector deficit incurred during year t . Net foreign liabilities at the start of year $t+1$ are specified as net foreign liabilities at the start of year t plus the current account deficit in year t plus the effects of revaluations of assets and liabilities caused by changes in price levels and the exchange rate. Lagged adjustment processes are specified for the response of wage rates to gaps between the demand for and the supply of labor. There are also lagged adjustment processes in USAGE for the response of foreign demand for U.S. exports to changes in their foreign-currency prices.

In a USAGE simulation of the effects of policy and other shocks, we need two runs of the model: a basecase or business-as-usual run and a policy run. The basecase is intended to be a plausible forecast, while the policy run generates deviations away from the basecase caused by the policy under consideration. The basecase incorporates trends in industry technologies, household preferences and trade and demographic variables. These trends are estimated largely on the basis of results from historical runs in which USAGE is forced to track a piece of history. Most macro variables are exogenous in the basecase so that their paths can be set in accordance with forecasts made by expert macro forecasting groups such as the Congressional Budget Office. This requires endogenization of various macro propensities, e.g. the average propensity to consume. These propensities must be allowed to adjust in the basecase run to accommodate the exogenous paths for the macro variables.

ⁱⁱⁱ The investment specification for the MONASH model, adopted in USAGE, is discussed in detail in Dixon *et al.* (2005).

The policy run in a USAGE study is normally conducted with a different closure (choice of exogenous variables) from that used in the basecase. In the policy run, macro variables must be endogenous: we want to know how they are affected by the policy. Correspondingly, macro propensities are exogenized and given the values they had in the basecase. More generally, all exogenous variables in the policy run have the values they had in the basecase, either endogenously or exogenously, with the exception of the policy variables of interest. Comparison of results from the policy and basecase runs then gives the effects of moving the policy variables of interest away from their basecase values. We discuss in Section 3.1 the manner in which the policy run differs from the basecase.

3. SIMULATION DESIGN

3.1 Modelling border closure in USAGE

In Section 4 we present results of USAGE simulations in which U.S. borders are closed for twelve months^{iv}. We present results for eight years (2008 – 2015). This period can be divided into three phases: the border closure year (2008), the border reopening year (2009) and the post-reopening period (2010-2015). The policy run is distinguished from the basecase in that we add exogenous shocks representing border closure in 2008, then reverse these shocks in 2009. Thereafter, exogenous economic forces in the policy-run are the same as those in the basecase. We examine five scenarios, the most restrictive of which is Scenario 2. This scenario has the following characteristics:

- (A) We force import volumes to contract by 95 per cent relative to basecase.^v This is achieved through endogenous "phantom" import taxes.^{vi} These phantom import taxes are removed in 2009.

^{iv} We have simulated a one-year shutdown of the borders, but this lengthy time period, while again aiding in establishing an upper bound on impacts, is likely to be more than would be required to protect against a public health or terrorist threat. Readers may be tempted to scale results for our border closure year to reflect closure periods of less than twelve months. However the presence of domestic stockpiles, inventories and reserves of imported commodities are likely to significantly mitigate the economic cost of short-duration border closures. This is apparent in our results for Scenarios (1) and (3) in which mining reserves are used.

^v We choose 95 per cent for two reasons. First, with imports modelled via the CES assumption of Armington, import volume contraction can be pushed close to, but not equal to, -100 per cent. Second,

- (B) In the basecase, U.S. exports represent about 10 per cent of GDP, and imports represent about 17 per cent of GDP. Hence a 95 per cent reduction in the volume of trade requires the balance of trade deficit to fall to 0.35 per cent of GDP. This requires real gross national expenditure (GNE) to fall relative to real GDP. We allow consumption (private and public) to be a fixed proportion of gross national product (GNP) in the policy case^{vii}. This leaves the GNE adjustment to be borne by investment. In 2008, we allow required rates of return on investment to move upwards by an amount sufficient to generate an investment deviation consistent with a 95 per cent reduction in the balance of trade deficit. In 2009, we return policy-run required rates of return back to their basecase levels.
- (C) The macroeconomic closure summarised in (B) ensures that a -95 per cent import volume deviation will be approximately matched by a -95 per cent export volume deviation. Normally, a negative export deviation will generate a positive deviation in the terms of trade. We prevent a deviation in the terms of trade during the border closure year via a downward shift in foreign willingness to pay for U.S. exports. Without this assumption, the U.S. terms of trade would improve significantly during the border closure year. With the domestic price level the numeraire, this involves substantial depreciation of foreign currencies against the U.S. dollar. We assume that foreign countries will not accept this exchange rate movement, and thus take action against U.S. imports to keep their terms of trade with the U.S. unchanged from basecase. This action can be interpreted as retaliatory tariffs or quotas on U.S. exports. In 2009, this retaliation is lifted, effectively putting U.S. export demand schedules back in their basecase positions.
- (D) In 2008, we allow households to adjust their preferences for import-intensive commodities. That is, we make provision for household adaptation to import restrictions. For example, purchases of durable goods might be deferred to the

with import volumes heavily restricted, the returns from evading border closure are high. We can interpret the residual 5 per cent of imports as successful evasion of border security measures.

^{vi} “Phantom” in the sense that the government collects no revenue from the tax.

^{vii} In the absence of movements in the terms of trade, this is very close to fixing private and public consumption relative to GDP.

border reopening year. Figure 1 describes the mechanism implementing household adaptation. The x-axis describes the policy-run CPI-deflated price of commodity i ($(P_i^{(3)} / \text{CPI})$) relative to its basecase value ($(P_i^{(3)} / \text{CPI})_{(F)}$). The y-axis describes the ratio of the basecase household preference for i ($A_{(F)i}^{(3)}$) to the policy-run household preference for i ($A_i^{(3)}$). With the relationship in Figure 1 activated for a particular commodity, positive deviations from basecase in the price of i generate negative deviations from basecase in the household preference for i . In the border closure year, we activate the Figure 1 relationship for the most import-intensive household commodity--footwear. In 2009 we return the household preference for footwear to its 2009 basecase level.

- (E) There is no net immigration during the border closure year. In 2008, this reduces the labor force by 0.4 per cent relative to basecase. We assume this labor force loss is permanent.
- (F) Real consumer wages are sticky in the short-run. As such, short-run labor market pressures arising from border closure are expressed as a fall in employment. In the long run, real wage flexibility ensures employment returns to its basecase level minus those potential workers lost due to immigration restriction in 2008.

Scenario 2 is an extreme case of border closure, since all imports are restricted and real wages are rigid. We conjecture that the economic impact of border closure can be mitigated in three ways:

- (G) In investigating Scenario 2, we learned that some imported commodities, produced in low quantities in the U.S., contribute disproportionately to the economic costs of border closure. In Section 3.2 we present a back-of-the-envelope model that expands on the role of these critical imports. In USAGE, the most important of these is mining. This commodity includes energy imports. By exempting mining (energy) imports from the shocks outlined in (A) above, we substantially reduce the costs of border closure. We do this in Scenarios 4 and 5.

- (H) The U.S. has domestic stockpiles of certain critical imports. The most prominent of these stockpiles is the Strategic Petroleum Reserve. This reserve is worth approximately two month's worth of oil imports. In Scenarios 1 and 2 we examine the effect of allowing a draw down of mining inventories equivalent to two month's worth of mining imports. In 2009, this stockpile is rebuilt to its basecase level.
- (I) Our scenarios represent extreme border closure. Such closure would be contemplated only in a time of significant security threat. As such, workers might be convinced to accept a lower real wage during the border closure year as part of the price of security promotion. In Scenarios 3 and 4 we investigate the effect of keeping employment unchanged from basecase via real wage reduction.

Panel A of Table 1 describes our five scenarios, distinguishing the three dimensions in which they vary: whether mining imports are restricted, whether strategic reserves are allowed, and whether employment is flexible (with real wages sticky) or fixed on its basecase level (with real wages flexible). A measure of the welfare cost of border closure is the 2008 deviation in real GNE. Panel B describes two sets of real GNE results. The first is from USAGE. The second is from a specific-purpose back-of-the-envelope (BOTE) model designed to capture the main USAGE mechanisms at work in these simulations. We describe BOTE below.

3.2 A back-of-the-envelope model with bottleneck imports

In this section we describe a model of a model. This is a simple, transparent system that can be represented diagrammatically and explains what is going on in our full-blown CGE model when imports are restricted by border closure.

In the simple model, we assume that the economy produces and consumes two goods: a domestic good and an import good. By the production of a unit of import good we mean the production of sufficient exports to pay for that good. We assume that the economy is constrained in its production of the two goods by a transformation frontier specified by:

$$(1) \quad Z = CET(X_1, X_2)$$

where

X_1 is production of the domestic good;

X_2 is production of the import good; and

Z is the economy's overall capacity to produce, determining the distance of the transformation frontier (Figure 2) from the origin.

We assume that Z is determined according to:

$$(2) \quad Z = X_0 g(X_3 / X_0)$$

In (2), X_0 is a composite of inputs of capital and labor. It can be thought of as an ordinary production function. X_3 is the input of "bottleneck" imports. Scarcity of these imports inhibits the economy's ability to use capital and labor (X_0) to generate capacity to produce (Z). The most obvious example of X_3 imports are mineral products that are not readily producible in the U.S. in sufficient quantities to satisfy the economy's requirements. In the simple model, the particular specification we use for g is:

$$(3a) \quad g(X_3 / X_0) = \alpha_0 + \alpha_1 \left(\frac{X_3}{X_0} \right) + \alpha_2 \left(\frac{X_3}{X_0} \right)^2 \quad \text{for } \frac{X_3}{X_0} \leq \left(\frac{X_3}{X_0} \right)_I$$

and

$$(3b) \quad g(X_3 / X_0) = 1 \quad \text{for } \frac{X_3}{X_0} > \left(\frac{X_3}{X_0} \right)_I$$

where

$\left(\frac{X_3}{X_0}\right)_I$ is the initial (that is before border closure) ratio of bottleneck imports

to use of primary factors; and

α_0 , α_1 and α_2 are parameters specified so that $\alpha_0 + \alpha_1 \left(\frac{X_3}{X_0}\right)_I + \alpha_2 \left(\frac{X_3}{X_0}\right)_I^2 = 1$.

Figure 3 illustrates the g function adopted in our computations with the simple model.

We assume that the economy's output is inhibited by:

- 20 per cent when bottleneck imports are unavailable (that is $g(0)=0.8$); and
- 5 per cent when the ratio of bottleneck imports to primary factor inputs is reduced by 50 per cent (that is $g(0.5(X_3 / X_0)_I) = 0.95$)

On the demand side we assume in this simple economy that consumer welfare is given by a CES combination of consumption of goods 1 and 2:

$$(4) \quad U = CES(C_1, C_2)$$

Consumption of good 1 is the production of good 1, that is:

$$(5) \quad X_1 = C_1$$

Consumption of good 2 is given by:

$$(6) \quad C_2 = X_2 + (D - X_3)$$

where D is the trade deficit.

In (6) we assume that all products have a price of 1.

In parameterising the simple model, we set the initial values for the variables at: $C_1 = X_1 = 0.9$; $X_2 = 0.1$; $C_2 = 0.153$; $X_3 = 0.017$; $D = 0.07$. In choosing these values we were guided by the USAGE database for 2005 in which exports are 10 per cent of GDP, imports are 17 per cent of GDP, leaving the balance of trade deficit as 7 per cent of GDP. We assume that bottleneck imports are 1.7 per cent of GDP: Mining imports are about 10 per cent of total imports. For convenience we choose units so that the initial value for X_0 is 0.017, implying that the initial value for X_3/X_0 is 1. Thus the initial value for Z , determined in (2) is also 0.017. The only other information required to complete the numerical specification of the simple model is the transformation elasticity (τ) in the CET function, (1), and the substitution elasticity (σ) in the CES function, (4). In carrying out computations with the simple model, we vary τ between -0.5 and $-\infty$, and σ between 1.1 and 8. We find $\tau = 2$ and $\sigma = 2$ allows the simple model to closely reproduce the USAGE results under all five scenarios.

The operation of the simple model is illustrated in Figure 4. Initially, consumption is at point 1a and production at point 1b. In our central USAGE simulations, we reduce all imports by 95 per cent and assume that the balance of trade moves to 95 per cent of its initial level. In terms of the simple model, this means that C_2 moves from 0.153 to 0.00765, X_3 moves from 0.017 to 0.00085, and D moves to 0.0035. The balance of trade constraint, (6), implies that X_2 must move to 0.005. Via the g function the border closure causes a bottleneck contraction in the economy's capacity to produce. There may be a further contraction through unemployment (a reduction in X_0). The contraction in capacity to produce is illustrated in Figure 4 by the inward movement in the transformation frontier with Z declining from Z_I to Z_F . Consumption and production in the new situation are at points 2a and 2b. The border closure causes utility or real consumption to decline from U_I to U_F .

3.3 Results from BOTE and USAGE compared

We provide a discussion of detailed USAGE results in Section 4. Here, we compare the real absorption outcomes of the simple model with those of USAGE (Table

1). This allows us to test BOTE's representation of the role of bottleneck imports in USAGE.

As the first four columns of Table 1 describe, we examine five scenarios. The five scenarios are distinguished in three ways. First, mining imports may be either restricted (along with all other imports), or exempted from the general import restriction. In USAGE mining imports correspond to the bottleneck import of the BOTE model. Second, domestic strategic reserves of the mining commodity can be used, or not used. Third, national employment can be fixed (that is, held at basecase) or flexible under a sticky wage regime.

The BOTE results are very close to those of USAGE. The economic costs of border closure are largest under Scenario (2). This is the most restrictive scenario. All imports (including the bottleneck import) are restricted, and strategic domestic reserves are untapped. At the same time, real consumer wages are sticky. Complete import restriction causes a sharp decline in the value of the marginal product of labor at the initial level of employment. With no relief via use of reserves, and little downward adjustment of real wages, Scenario (2) produces a steep negative deviation in real GNE. Like Scenario (2), Scenario (1) also involves restriction of all imports and sticky real consumer wages. However unlike (2), Scenario (1) provides for use of strategic reserves equivalent to two month's worth of mining imports. Relative to (2), this reduces the potential contraction in real GNE by 8 percentage points. The economic damage from border closure can be reduced further if workers accept lower real wages. Scenario (3) differs from (1) in that it assumes real wages fall sufficiently to keep employment at its basecase level. Relative to Scenario (1), full downward flexibility in real wages reduces the potential contraction in real GNE by 16.9 percentage points. Nevertheless, the contraction in economic activity remains substantial, with real GNE 25 per cent below its basecase level. Like Scenario (3), Scenario (5) also assumes workers are willing to accept lower real wages during the year of border closure. However mining imports are exempted from the otherwise general import restriction. This is the least costly of the five scenarios. With the bottleneck import (mining) exempted and workers accepting real wage reductions sufficient to keep employment at its basecase level, the real GNE loss is 14.4 per cent. Scenario (4) presents the same border closure case as (5), but assumes

workers resist real wage reduction. Like Scenarios (1) and (2), this generates substantial employment losses, producing a sharp contraction in real GNE.

4. RESULTS

4.1 Full border closure under sticky wages (Scenario 2)

As outlined in Section 3, we investigate five border closure scenarios distinguishing varying degrees of trade restriction. Our most restrictive scenario is (2). In Scenario (2), we restrict all imports (including mining) by 95 per cent, and do not use strategic reserves. Net immigration is reduced by 95 per cent relative to basecase. In the remainder of this section, we discuss Scenario (2) in detail. In Section 4.2, we investigate the effects of selective relaxation of certain aspects of Scenario (2).

As described in section 3.1, we implement import restriction by forcing import users to behave as if they face a much higher price for imports. This is achieved through an endogenous “phantom” import tax. The phantom tax is manifested in a steep increase in the tax-inclusive import price deflator relative to the basic price import deflator (Figure 5). The increase in the price of imports, aided by the resulting sharp contraction in economic activity, drives down import volumes (Figure 6). As discussed in Section 3.1, our macroeconomic closure in the policy-run links movements in private and public consumption spending with movements in GNP. Since we hold the terms of trade on basecase during the border closure year, linking consumption to GNP is quite close to linking consumption to GDP. This explains why the real consumption deviation is very similar to the real GDP deviation in the year of border closure (Figure 7). With C and G approximately moving with GDP, and with I (in the first instance) also approximately moving with GDP, the export volume deviation follows the import volume deviation. However the U.S. balance of trade is initially in deficit. Hence part of the reduction in the volume of trade must be achieved through a reduction in domestic absorption. We assume that the absorption adjustment is borne by investment. This explains why the investment deviation lies below the real GDP deviation (Figure 7).

The export volume deviation is negative throughout the simulation period (Figure 8). Naturally, the deepest point of the negative export deviation is the year of border

closure. Typically, negative export deviations are associated with positive deviations in the terms of trade. However we prevent a deviation in the terms of trade during the border closure year via a shift in foreign willingness to pay for U.S. exports. Without this assumption, the U.S. terms of trade would improve significantly during the border closure year. With the domestic price level the numeraire, this would involve substantial depreciation of foreign currencies against the U.S. dollar. We assume that foreign countries will not accept this exchange rate movement, and thus take action against U.S. imports to keep their terms of trade with the U.S. unchanged from basecase. This action can be interpreted as retaliatory tariffs or quotas on U.S. exports. In the year following border closure, this retaliation is lifted, effectively putting U.S. export demand schedules back in their basecase positions. In Figure 8 we see a persistent negative deviation in export volumes in the post-reopening period. With export demand schedules back in their basecase positions, this negative export deviation produces a persistent positive deviation in the terms of trade.

Export volumes are below basecase by an average of around 8.5 per cent in the post-reopening period (Figure 8). This is the largest of the enduring macroeconomic consequences of border closure. We can understand the permanent negative export deviation with the aid of equations (7) – (10).

Equation (7) is the percentage change in real GDP:

$$(7) \quad y = S_{\text{GNE}} gne + S_{\text{X}} x - S_{\text{M}} m$$

where y , gne , x and m are the percentage deviations in real GDP, real GNE, export volumes and import volumes respectively; and S_{GNE} , S_{X} and S_{M} are the shares of GNE, exports and imports in real GDP at market prices.

We define the difference between the deviation in GDP, and the deviations of real GNE and import volumes, as follows:

$$(8) \quad gne_{\text{DIFF}} = gne - y$$

$$(9) \quad m_{DIFF} = m - y$$

Substitute (8) and (9) into (7) for gne and m :

$$(10) \quad x = y + [S_M / S_X] m_{DIFF} - [S_{GNE} / S_X] gne_{DIFF}$$

Equation (10) says that a negative export deviation can be due to:

- (i) a negative real GDP deviation;
- (ii) the import volume deviation being less than the real GDP deviation; and/or
- (iii) the real GNE deviation exceeding the real GDP deviation.

All three factors are relevant in explaining the post-reopening negative deviation in export volumes, as we explain below.

Figure 9 reports employment and the real consumer wage. In Scenario (2) we are assuming that the real consumer wage is sticky. Forcing firms to curtail their import use by 95 per cent sharply reduces the value of the marginal product of labor at the initial level of employment. Since real wages adjust downwards only slightly in the border closure year, this causes a steep fall in employment (Figure 9). In the year following the border closure year, all policy settings associated with border closure are reversed. That is, phantom import taxes, foreign willingness to pay for U.S. exports, required rates of return on investment, and household tastes are returned to their basecase levels. With real wages now lower, but economic structural variables back on their basecase values, employment initially overshoots its basecase level. Thereafter, employment gradually returns towards basecase. It falls below basecase in 2012, and ends the simulation 0.36 per cent below basecase. This reflects our assumption that the net immigrant flow foregone during the border closure year is never recouped.

With employment below basecase, so too is real GDP (Figure 10). The real GDP deviation exceeds that which might be predicted by the employment loss alone. This is so for two reasons: an allocative efficiency loss attributable to import restriction, and impairment of the economy's productive capacity due to bottleneck import restriction. Borders are reopened in 2009. Employment and real GDP return close to their basecase

levels. However the capital stock is below basecase in 2009. This reflects the steep negative deviation in investment during the border closure year. With the capital / labor ratio below basecase in 2009, the rate of return on capital is above basecase. This accounts for the positive deviation in 2009 investment (Figure 7). The real investment deviation exceeds the real GDP deviation throughout the post-2009 period. This accounts for the gradual return of the capital stock towards basecase (Figure 10). However, with the capital stock below basecase from 2009-2015, and with employment below basecase from 2012, the real GDP deviation is negative throughout the post-reopening period. The average real GDP deviation over this period (2010-2015) is approximately -1 per cent. Via Equation (10), this accounts for one percentage point of the persistent post-reopening negative deviation in export volumes.

With export volumes below basecase in the post-reopening period, the terms of trade is above basecase. In the policy-run we assume that real consumption (private and public) is a fixed share of GNP. The positive terms of trade deviation causes the deviation in real (consumption-price-deflated) GNP to exceed the deviation in real GDP. This explains why the post-reopening positive deviation in real consumption exceeds the deviation in real GDP (Figure 7). With the post-reopening real investment deviation also exceeding the real GDP deviation, the deviation in real GNE must exceed the deviation in real GDP. The gap between the real GNE and real GDP deviations is gne_{DIFF} in equation (10). The average value of gne_{DIFF} in the post-reopening period is 0.68. The ratio of GNE to exports (S_{GNE} / S_X in equation 10) averages approximately 8.9 in the post-reopening period. Hence the strong positive deviation in post-reopening real GNE contributes approximately 6.2 percentage points (8.9×0.68) to the post-reopening negative deviation in real export volumes (Figure 8).

The final contributor to the persistent negative deviation in export volumes is the negative import volume deviation (Figure 6). The import deviation lies below the real GDP deviation by an average 0.13 per cent in the post-reopening period (that is, $m_{DIFF} = -0.13$). The import/export ratio (S_M / S_X in equation 10) is approximately 1.6 in the post-closure period. Hence the damped outcome for imports relative to GDP

contributes 0.2 percentage points ($=-1.6*0.13$) to the persistent negative deviation in real export volumes over 2010-2015 (Figure 8).

4.2 Macroeconomic outcomes under alternative border closure assumptions

Figures 11 and 12 compare import and export volume deviations under each of the five scenarios. Under Scenarios (1) – (3), all trade is restricted. This accounts for the 95 per cent import and export volume reductions under scenarios (1) – (3). In Scenarios (3) and (4), imports of the USAGE bottleneck import, mining, are not restricted. This accounts for the lower import volume reductions under these two scenarios. The import volume reduction under Scenario (5) (-82.1 per cent) is slightly less than that under Scenario (4) (-84.0 per cent). This is due to differences in labor market closure. Employment is fixed under Scenario (5), but flexible under Scenario (4). Hence the negative real GDP deviation is deeper under Scenario (4) than Scenario (5). With mining imports endogenous in both scenarios, they decline less under Scenario (5) (fixed employment) than Scenario (4) (flexible employment).

Under Scenarios (1)–(3), the 95 per cent contraction in the volume of trade requires the balance of trade to move towards surplus. That is, the size of the balance of trade deficit must fall by 95 per cent. As discussed in Section 3.1, this requires a negative deviation in domestic absorption relative to real GDP. In Scenarios (4) and (5), import volumes contract by less than Scenarios (1) and (3). Since we are simulating the effects of border closure, one option would be to continue to require export volumes to contract by 95 per cent in Scenarios 4 and 5. However this would mean that, relative to Scenarios (1)–(3), Scenarios (4) and (5) would involve a movement towards balance of trade deficit. This would hinder comparability of GNE results across simulations. To facilitate comparability of GNE results, we exogenously impose on Scenarios (4) and (5) the same balance of trade outcome as Scenarios (1) – (3). Like Scenarios (1) – (3), this is achieved through adjustment to aggregate investment. The requirement that the decline in the balance of trade deficit be same as that in Scenarios (1) – (3) means that the export deviation must be greater than the import deviation in both Scenarios (4) and (5). This is apparent in Figure 12, where we see the Scenario (4) and (5) export volume deviations

are approximately -75 per cent, compared with import volume deviations around -83 per cent^{viii}.

Figure 13 compares employment outcomes under the five scenarios. All five scenarios end the simulation period with employment deviations in the order of -0.4 per cent. This reflects the permanent loss of the immigrant workers who would otherwise have joined the workforce during the border closure year. Under Scenarios (3) and (5), employment is held on its basecase path, less the foregone immigrant labor. Here, we assume that workers are willing to absorb a real wage reduction for the duration of the crisis motivating border closure. The wage reduction is sufficient to keep employment of the incumbent workforce at its basecase 2008 level. The required real wage cut is highest for Scenario (3), since this scenario involves full import restriction (Figure 14). The reduction in real wages required to keep employment unchanged is substantially less when mining imports are allowed (Scenario 5). Under Scenarios (1), (2) and (4), real consumer wages are sticky. They fall slightly during the border closure year, in response to the negative employment deviations in that year. However, with real wages sticky, labor market pressure under Scenarios (1), (2) and (4) is expressed mainly as a change in employment (Figure 13). The employment loss is deepest under Scenario (2). This is our most restrictive case, in that all imports are restricted and strategic reserves are untapped. With the employment loss deepest under Scenario (2), so too is the real GDP loss (Figure 15). Like Scenario (2), all imports are also restricted under Scenario (1). However use is made of strategic reserves of the mining commodity. This attenuates the cost of restricting mining imports. This accounts for the lower employment and real GDP losses under Scenario (1) relative to Scenario (2). The economic damage caused by restricting mining imports, which represent only 10 per cent of all imports, can be seen by comparing the employment and real GDP deviations of Scenarios (4) and (2) (Figures 13 and 14). Scenario (4) is like Scenario (2) in all respects other than restriction of mining

^{viii} In Section 3.1, we noted that exports and imports are initially 0.10 and 0.17 of GDP, implying an initial balance of trade of -0.07 of GDP. Under Scenarios (1)–(3), import and export volumes are reduced by 95 per cent. This implies a movement in the balance of trade from -0.07 to -0.0035 of GDP. In Scenarios (4) and (5), with mining imports unrestricted, the average import reduction across the two scenarios is 83 per cent. Hence the new level of imports as a share of GDP is around 0.0288. In Scenarios (4) and (5) we require the balance of trade outcome be the same as that of Scenarios (1) – (3). Hence the new level of exports, expressed as a share of GDP, must be approximately 0.0253 ($= -0.0035 + 0.0288$). This is a reduction of 75 per cent ($= 100 * [0.0253 / 0.10 - 1]$) on the initial level of exports.

imports. Lifting this restriction alone reduces the real GDP deviation from -49 per cent (Scenario 2) to -19 per cent (Scenario 4). The economic disruption caused by border closure can be reduced further if workers accept real wage reduction during the closure year. Scenario (5) is like Scenario (4) in all respects other than real wage rigidity. In Scenario (5), workers accept an 11 per cent reduction in the real consumer wage (Figure 14). This is sufficient to keep employment on basecase, limiting the 2008 real GDP loss to -11 per cent (Figure 15).

Figure 16 reports real consumption deviations under the five border closure scenarios. In the policy case, nominal consumption (private plus public) is a fixed proportion of nominal GNP. Since we hold the terms of trade on basecase during the border closure year, the real consumption and real GDP deviations in this year are very similar (compare Figures 15 and 16). In the years following border reopening (that is, 2010 – 2015) the average real consumption loss is -0.7 per cent across all scenarios and years. This is slightly less than the average real GDP loss over the same period (-0.9 per cent). As discussed in Section 4.1, border closure generates a persistent post-closure negative deviation in export volumes (Figure 12). This causes a persistent post-closure positive terms of trade deviation. This produces a positive deviation in real (consumption price deflated) GNP relative to GDP. This explains why the real consumption deviation is slightly higher than the real GDP deviation in the post-closure period.

5. CONCLUSIONS

In this paper we investigated five alternative border closure scenarios. Our most restrictive scenario involved limiting imports of all commodities, under a labor market regime characterised by sticky real wages. Under such circumstances, a twelve-month closure of U.S. borders generates a reduction in real GDP of 48 per cent. We find that restrictions on the importation of certain commodities contribute disproportionately to this dramatic result. These commodities, which we label “bottleneck imports”, are characterised by the absence of readily available domestic alternatives. The most prominent example is energy. In our simulations with USAGE, we found that the mining commodity possessed the characteristics of a bottleneck import. Allowing a draw-down

in domestic inventories of the mining import, of which coal, oil and natural gas are part, calibrated to equal two-month's worth of imports, alleviated the GDP impact of full border closure by 8 percentage points. Exempting mining imports from the policy altogether alleviated the GDP impact of border closure by 30 percentage points. The real GDP contraction can be further reduced if workers accept real wage reduction for the duration of the security threat motivating border closure. Together with exemption of mining imports, an 11.4 per cent reduction in the real consumer wage limits the real GDP impact of border closure to -11.3 per cent.

The benefits of border closure must be assessed by public health and security experts in the context of specific threats. Results of the type we present in this paper can be input to the "cost" side of a border closure cost-benefit calculation. Given the great cost of general border closure, our results highlight the importance of targeted border closure. An important element of targeting will be ensuring that the border activities that are restricted match the nature of the threat. However, our results also suggest that an important element of targeting should include an awareness of the disproportionate economic damage caused by restricting bottleneck imports. The importance of these commodities also highlights the value of strategic reserves. Just as we have done for the mining commodity in this paper, a model like USAGE can be used to calculate the value of strategic reserves of other commodities in an environment of general border closure.

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Figure 1. Endogenous household taste adjustment

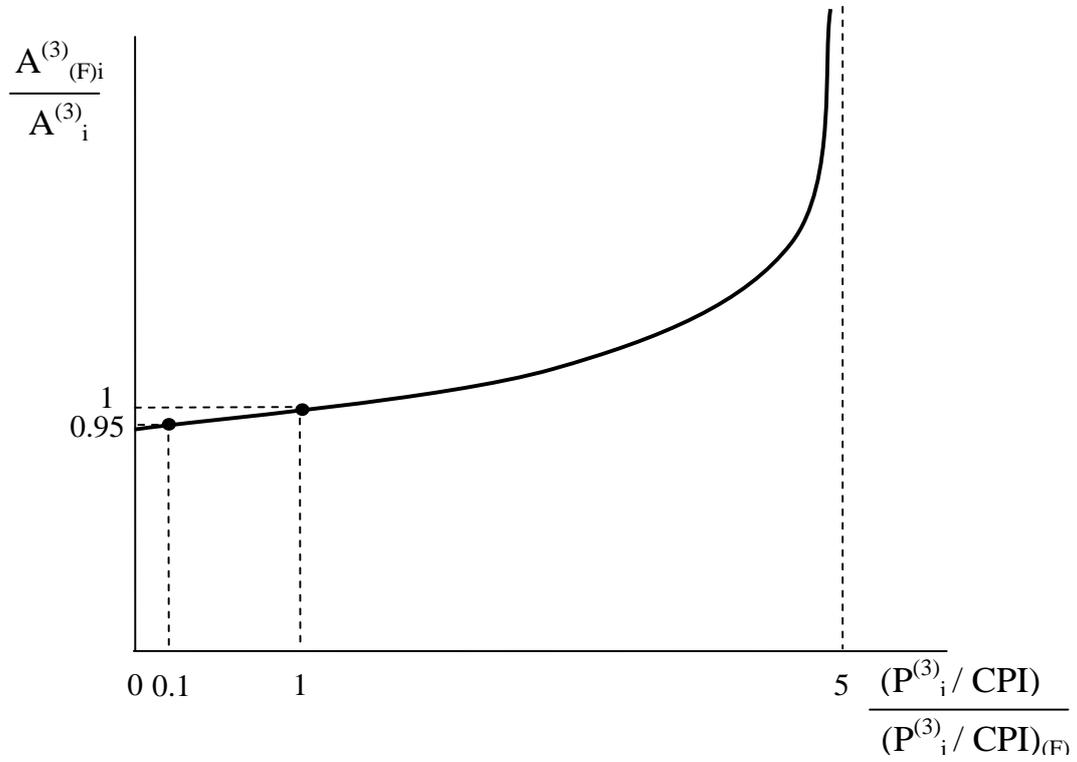


Figure 2. CET transformation frontier

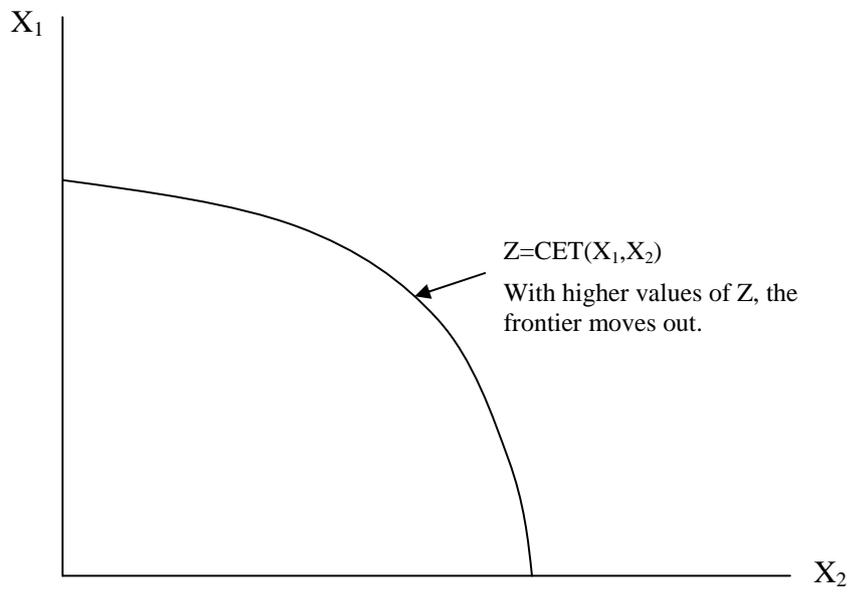


Figure 3. Bottleneck in the economy's ability to produce

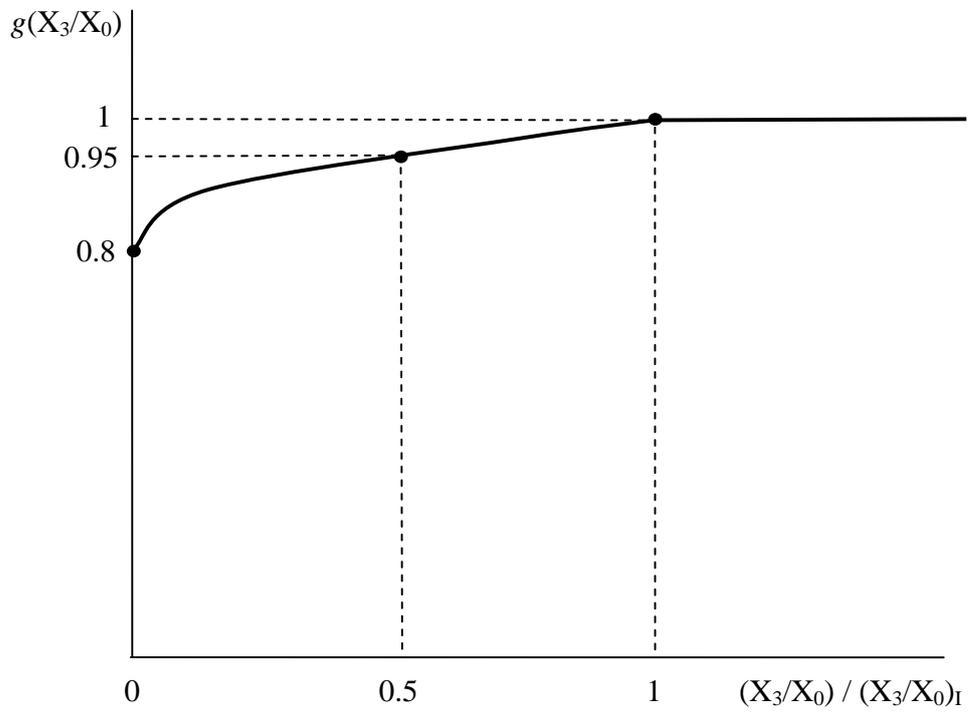


Figure 4. The effects of 95 per cent port closure in the simple model

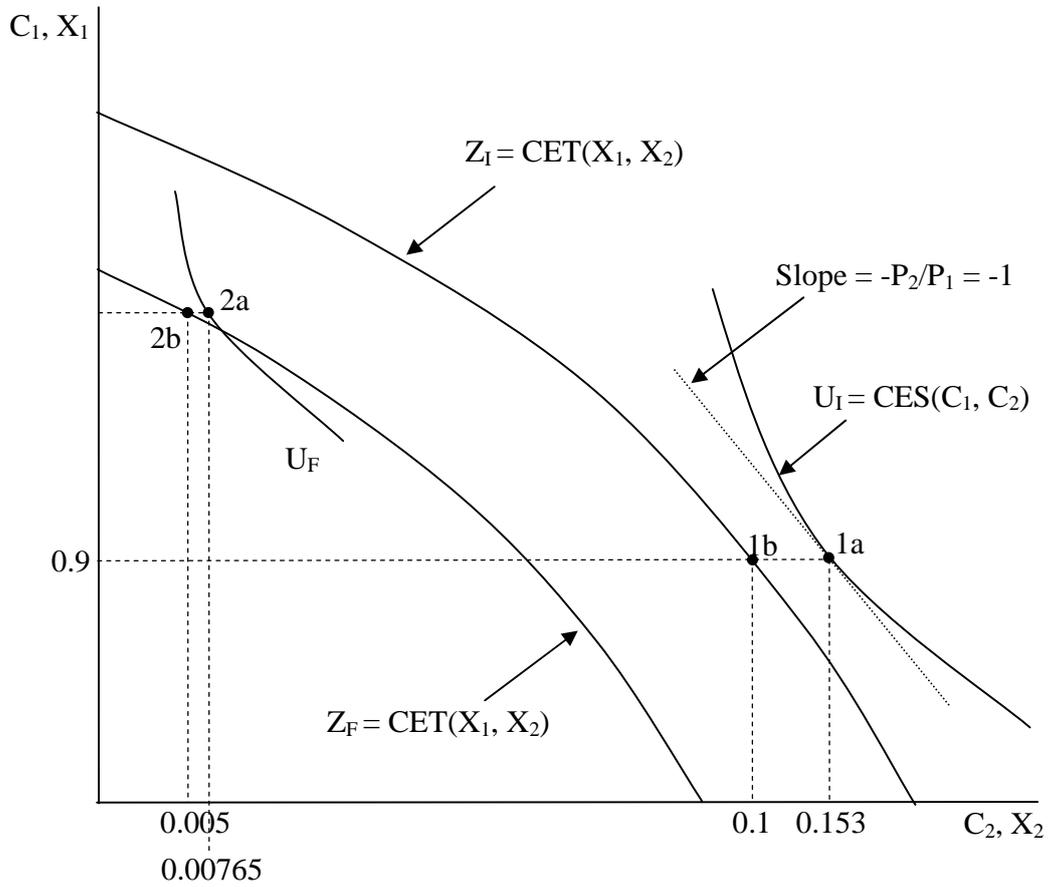


Figure 5: Import price deflators, c.i.f and phantom-tax-inclusive, Scenario 2. (% deviation from basecase)

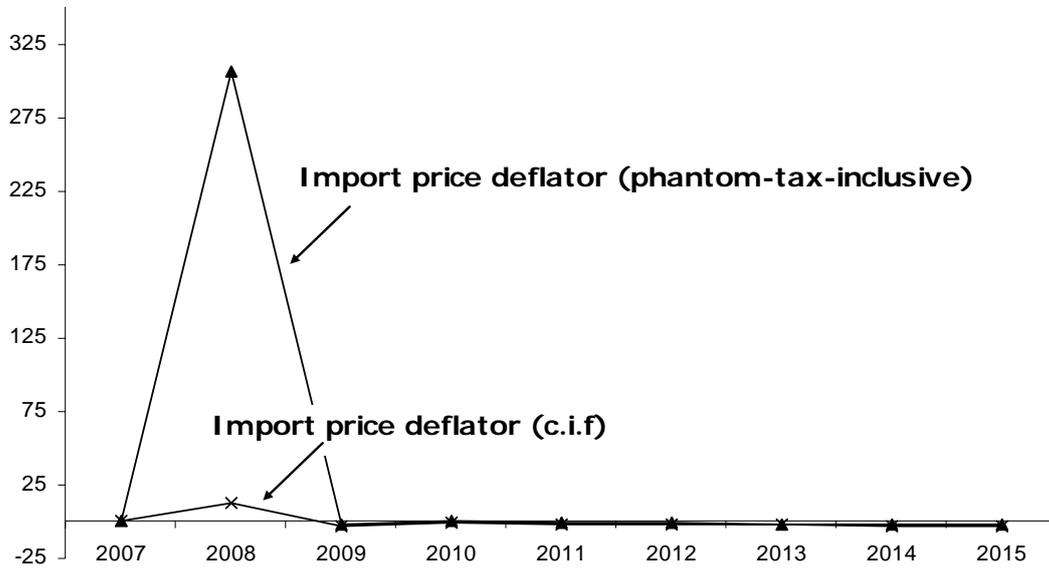


Figure 6: Import and export volumes, Scenario 2 (% deviation from basecase)

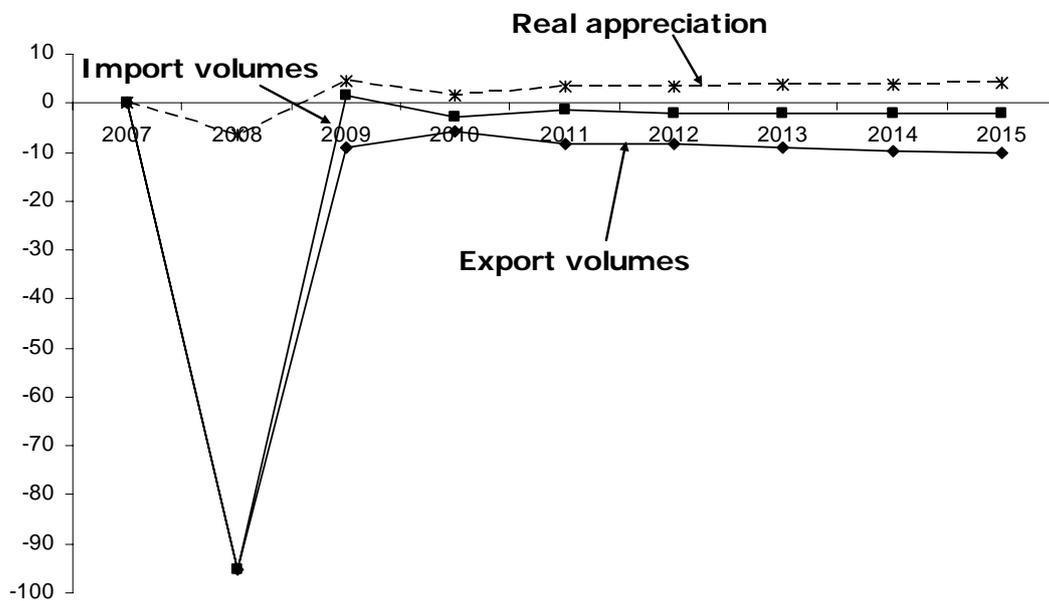


Figure 7: Real consumption, real investment and real GDP, Scenario 2 (% deviation from basecase)

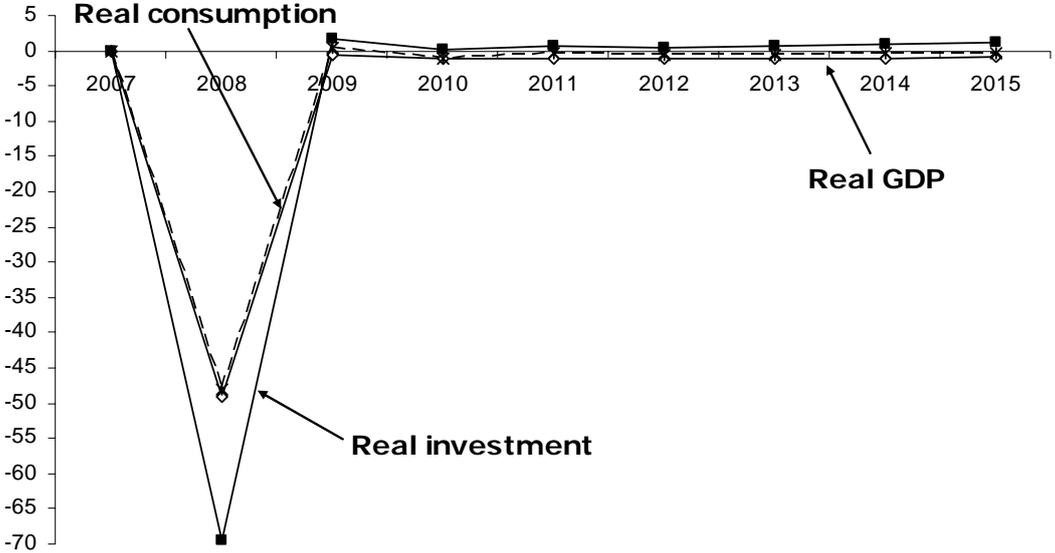


Figure 8: Export volumes and the terms of trade, Scenario 2 (% deviation from basecase)

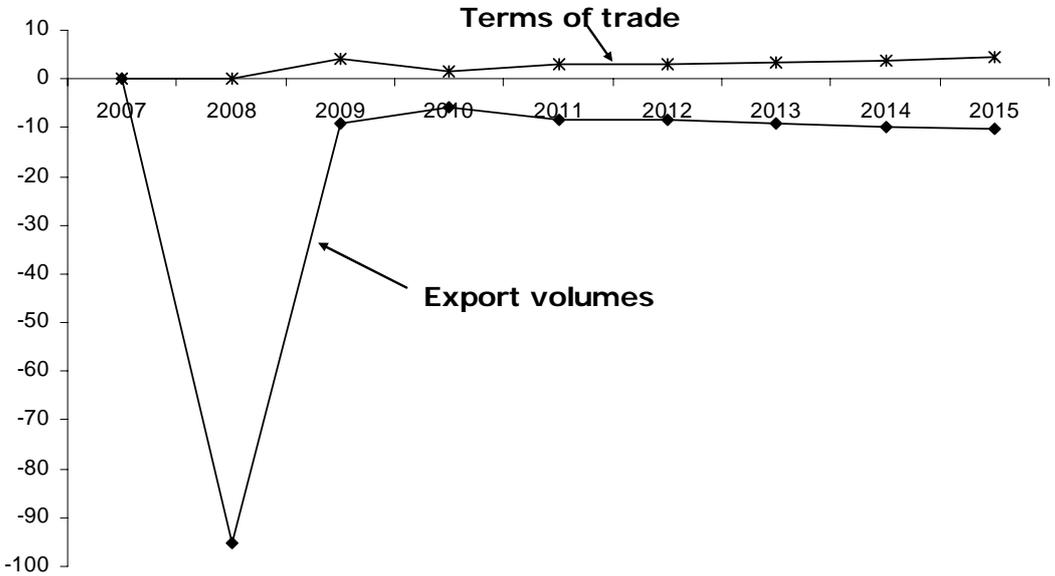


Figure 9: Employment and the real consumer wage, Scenario 2 (% deviation from basecase)

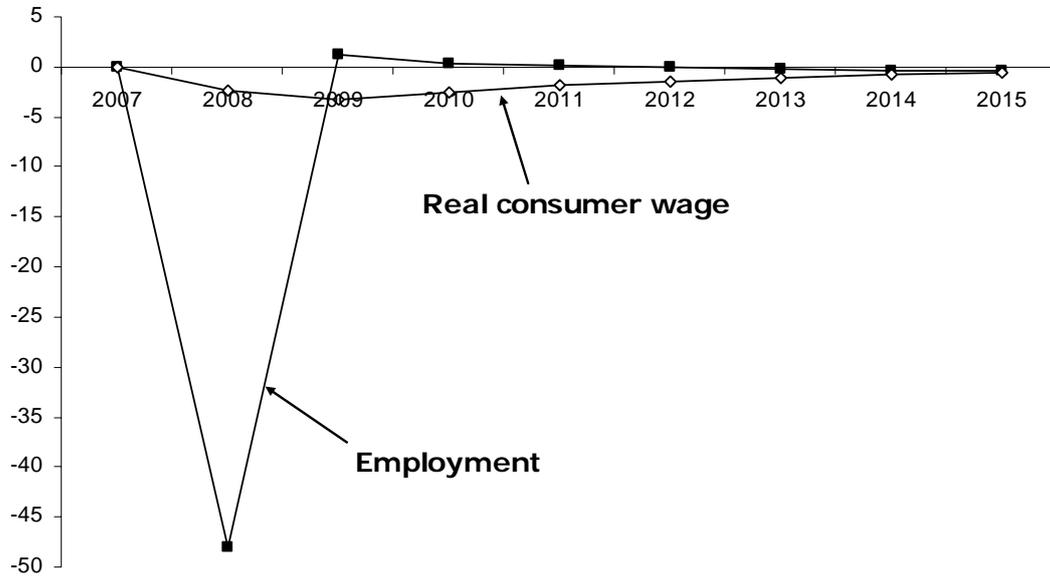


Figure 10: Employment, capital and real GDP, Scenario 2 (% deviation from basecase)

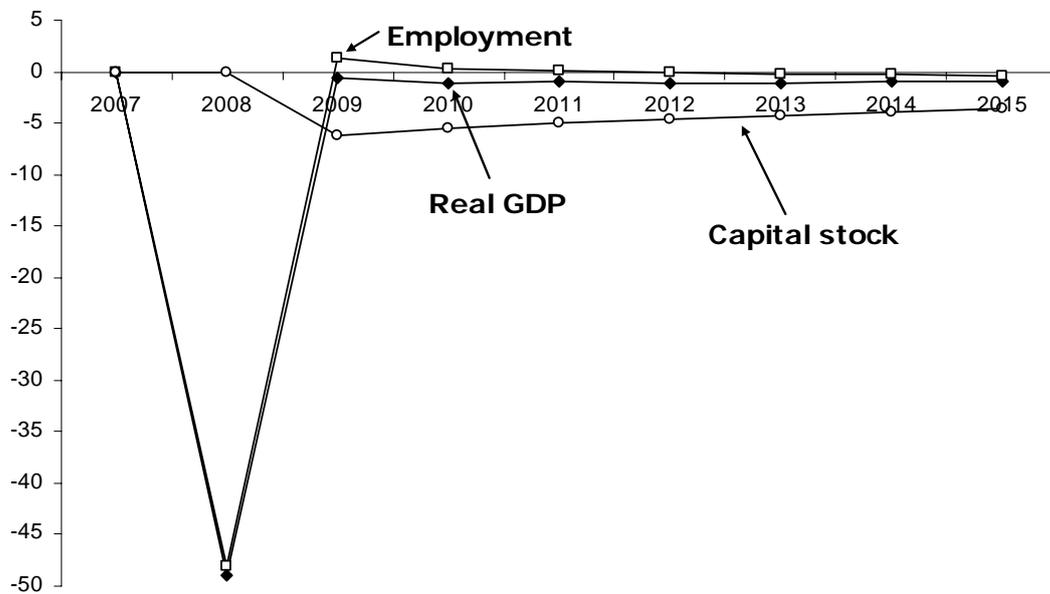


Figure 11: Import volumes – Scenarios 1-5 compared (% deviation from basecase)

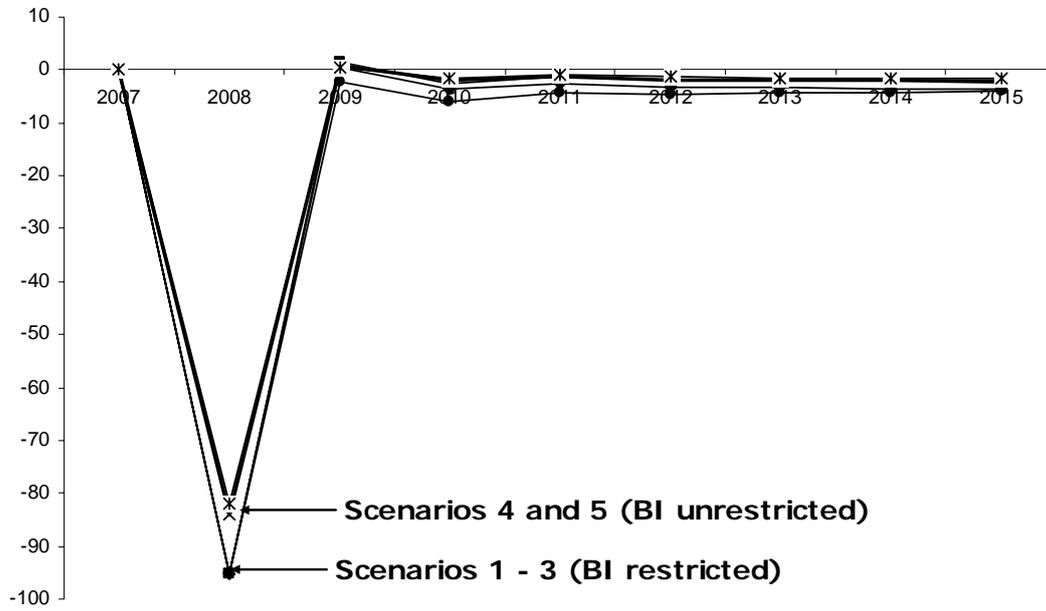


Figure 12: Export volumes – Scenarios 1-5 compared (% deviation from basecase)

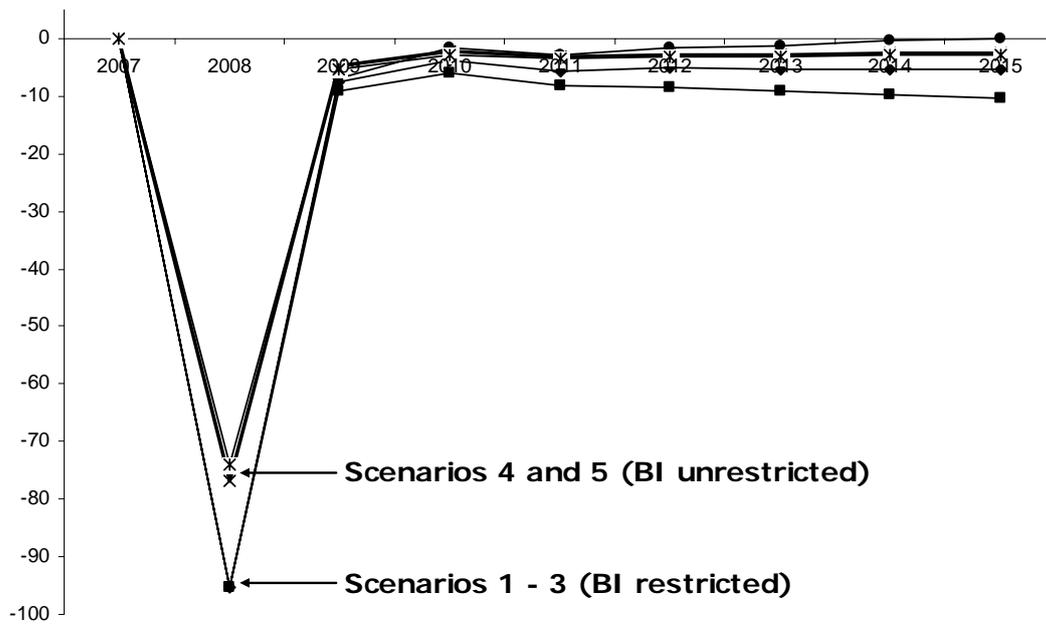


Figure 13: Employment – Scenarios 1-5 compared (% deviation from basecase)

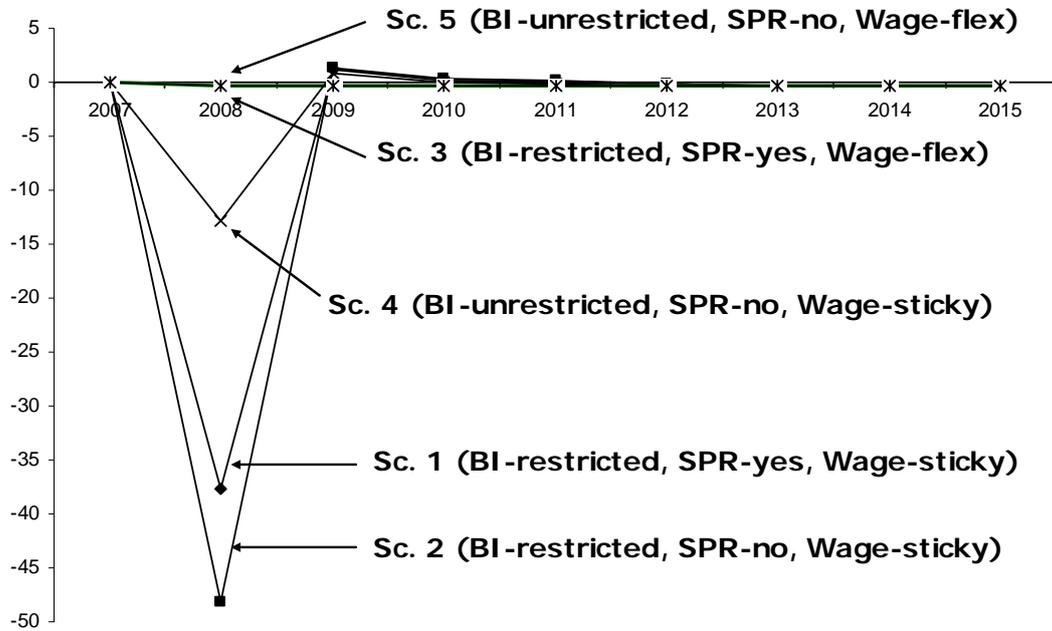


Figure 14: Real consumer wage – Scenarios 1-5 compared (% deviation from basecase)

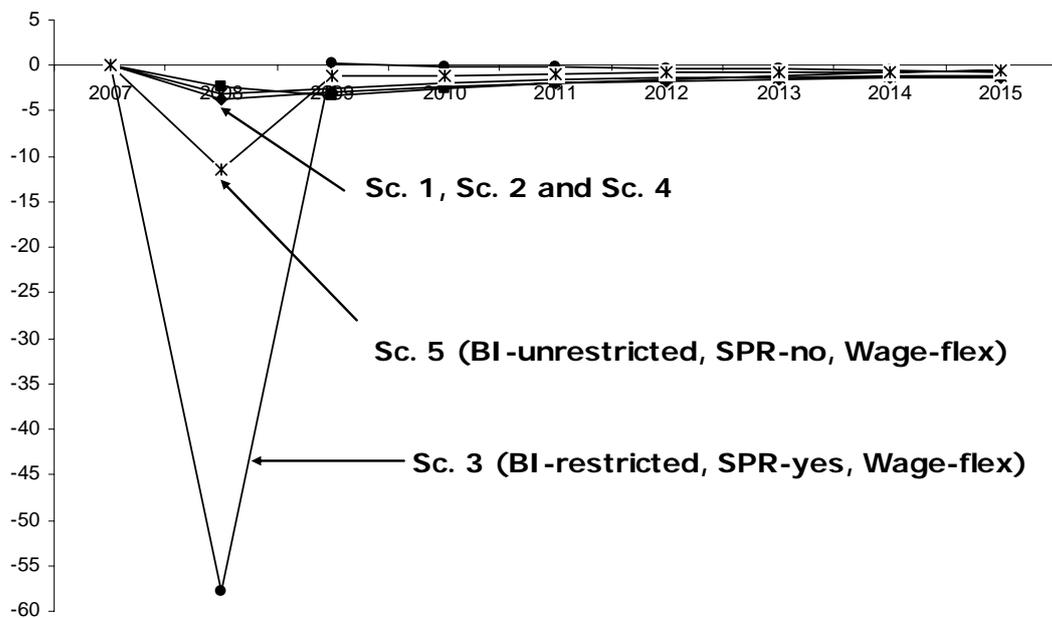


Figure 15: Real GDP – Scenarios 1-5 compared (% deviation from basecase)

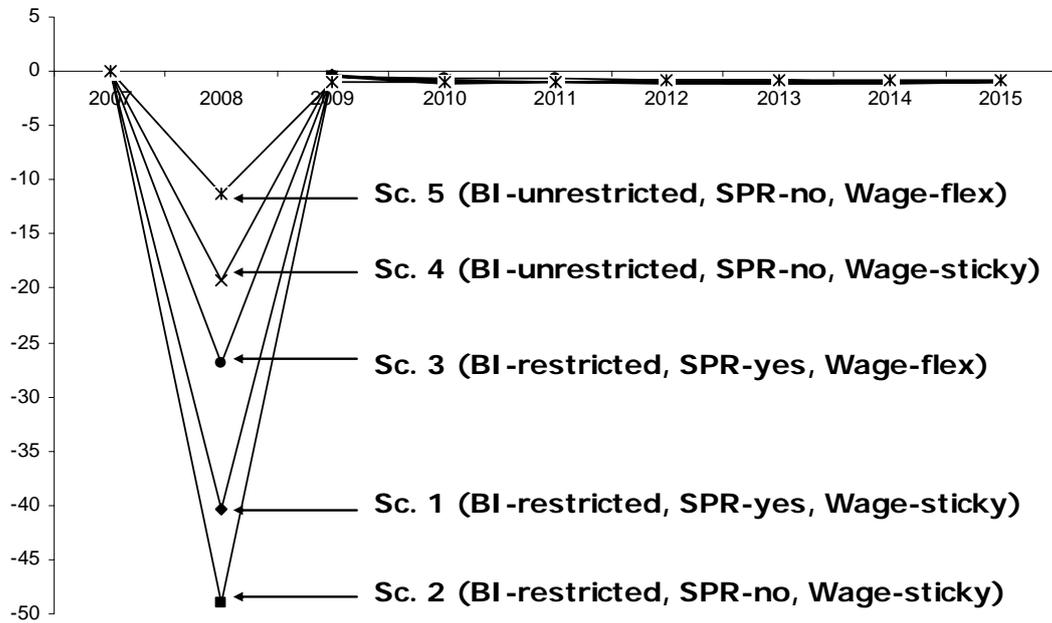


Figure 16: Real consumption – Scenarios 1-5 compared (% deviation from basecase)

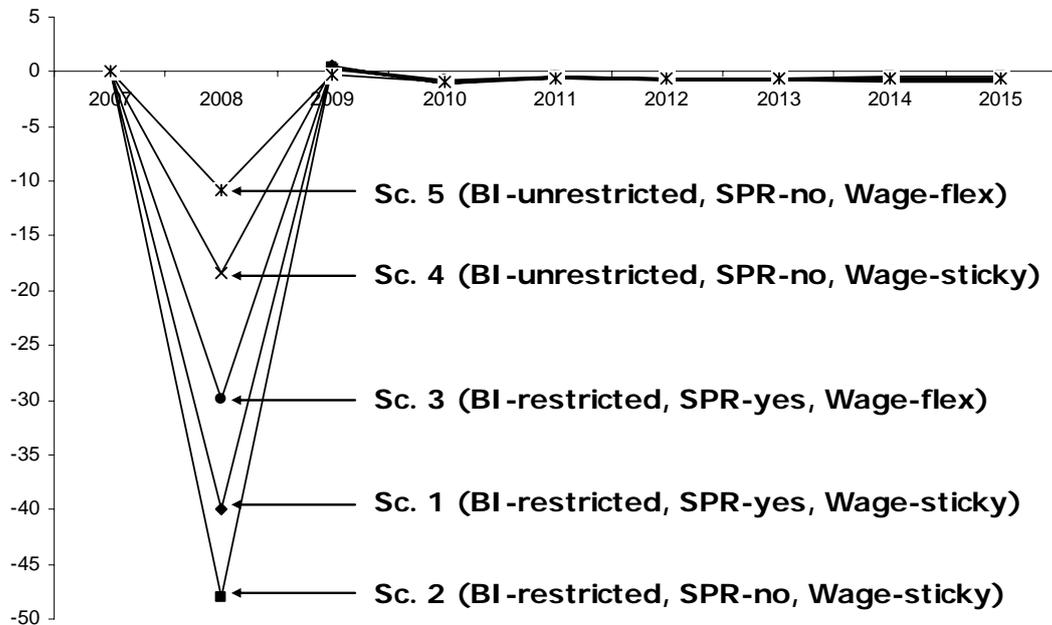


Table 1: Real absorption under alternative border closure scenarios: USAGE and BOTE compared

A. Scenario Description				B. Real GNE (%)	
Scenario	Mining Imports	Strategic Reserves	Employment	USAGE	BOTE*
(1)	Restricted	Used	Flexible	-42.0	-42.6
(2)	Restricted	Not used	Flexible	-50.0	-52.5
(3)	Restricted	Used	Fixed	-25.1	-23.8
(4)	Allowed	Not used	Flexible	-22.2	-21.0
(5)	Allowed	Not used	Fixed	-14.4	-13.4

* For transformation elasticity (τ) = 2 and substitution elasticity (σ) = 2. See Section 3.2 for details