Macro, industry and state effects in the U.S. of removing major tariffs and quotas*

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Abstract

We use a 500-industry CGE model of the U.S. to simulate the macro, industry and state effects of removing major U.S. tariffs and quotas. We find that this would generate a welfare gain of 0.07 per cent. For most industries, the output change would be negligible but for sugar, butter and several textile industries output contractions would be large. The state employment changes are all between -0.5 and 0.2 per cent. We explain the results by elementary mechanisms, in a way that does not require prior knowledge of the underlying CGE model.

1 Introduction and assumptions

This paper has two objectives. The first is to make a contribution to the understanding of the effects of U.S. import restraints (tariffs and quotas) on the U.S. economy. There has been increased interest in this topic in recent years because of participation by the U.S. in both multilateral (Uruguay and Doha) and bilateral trade negotiations (with Canada, Mexico, Israel, Korea, Australia and other countries). As in previous studies, our analysis of U.S. import restraints depends on a computable general equilibrium (CGE) model. However, relative to earlier studies the model applied here contains far greater detail. Whereas earlier studies have used national models identifying between 10 and 70 industries[1], our model distinguishes over 500 industries and provides not only national results but also results for the 50 states and the District of Columbia.

Our second objective is to demonstrate that results from a detailed CGE model can be explained in terms of elementary mechanisms. Rather than merely listing modeling assumptions we show, via back-of-the-envelope calculations, how the assumptions influence our results. This is important because in assessing CGE results policy makers and their advisors typically have neither the time nor the inclination to master voluminous technical documentation.

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[1] See for example De Melo and Tarr (1990) and U.S. International Trade Commission (1999, 2002 and 2004).

To achieve our objectives we apply USAGE-ITC[2] to simulate the effects on U.S. industries and states of removing major U.S.-imposed tariffs and quotas. The model was developed for the U.S. International Trade Commission (ITC) to assist in its analytical work (see for example U.S. International Trade Commission, 2004). The theoretical structure of USAGE-ITC is similar to that of the MONASH model of Australia (Dixon and Rimmer, 2002). However, as we demonstrate, no prior knowledge of MONASH or USAGE-ITC is required to follow our results.

For the particular application of USAGE-ITC described here, the ITC have calculated for the 500 USAGE-ITC commodities the percentage by which tariffs and quotas raise landed-duty-paid prices.[3] These percentages, which we refer to as wedges, are divided into two parts. The first part is the tariff paid by importers. The second part is the increase in the price levied by foreign suppliers made possible by U.S.-imposed quotas. This is equivalent to an export tax imposed by foreigners on their exports to the U.S. In this paper we focus on the 45 USAGE-ITC commodities listed in Table 1, those with the highest wedges. We use USAGE-ITC to simulate the long-run effects of removing these 45 wedges.

The main assumptions underlying our simulation are as follows.

1. The removal of the 45 wedges (which we refer to as the policy) has no effect on real national savings, defined as household savings plus the public sector surplus divided by the price deflator for investment. Thus we assume that U.S. residents own the same quantity of capital with the policy change as they would have owned without the

[2] USAGE-ITC stands for U.S. applied general equilibrium-International Trade Commission.

[3] The authors thank colleagues at the USITC for these calculations. For details of the calculations see USITC (2004, chapters 2-4).

policy change. This assumption enables us to interpret movements in real private and government consumption (C+G) as movements in economic welfare.

2. The ratio of real public consumption to real private consumption is unaffected by the policy.
3. Real private consumption is related to real disposable income. The government adjusts the tax rate on labor income to ensure that the policy-induced movement in real private consumption (together with that in real public consumption) is consistent with maintenance of real national savings.
4. The ratio of investment to capital (I/K) in each industry is held constant. Because I/K in any year is a reflection of business confidence, this assumption means that the policy has no long run effect on business confidence. Nevertheless, aggregate investment can move relative to aggregate capital because of variations between industries in their I/K ratios.
5. The average rate of return on capital across industries is assumed to be unaffected by the policy. This is consistent with the idea that capital stocks adjust to bring rates of return into line with interest rates adjusted by risk premia and that interest rates and risk premia are independent of the policy. However, we allow for increases in rates of return on capital in industries favored by the policy and decreases in industries that are harmed. The rate-of-return assumptions mean that our simulation depicts long-run effects.
6. Real wage rates adjust so that the policy has no effect on aggregate employment.
7. The policy has no effect on technology or consumer preferences.
8. The policy has no effect on the price deflator for private consumption, that is we treat this price deflator as the numeraire.

In the next section we explain the macro results from the simulation. Then in sections 3 and 4 we explain the results for output by commodity and for employment by state. Throughout these sections we make extensive use of back-of-the-envelope calculations that draw on relevant parts of the USAGE-ITC theory and database. Concluding remarks are section 5.

2 Macro effects

(a) Import stimulation

The most obvious macro effect of removing the 45 wedges is to stimulate imports. Thus we find a positive entry (0.732 per cent) in row 10 of Table 2. For understanding the size of the import effect it is useful to begin with a stylized version of the import-demand equation of a typical agent (industry, capital creator, household, government) in USAGE-ITC:

$$x_m = z - \theta \times S_d \times (1 - S_{marg}) \times (p_m - p_d) \ , \qquad (1)$$

where

x_m is the percentage change in the agent's demand for the imported variety of a commodity;

p_m and p_d are the percentage changes in the basic prices of the imported and domestically produced varieties of the commodity (basic prices of imports are landed-duty-paid prices and those of domestic products are prices at the factory door or farm gate);

z is the percentage change in the agent's activity level (industry output, level of capital creation, aggregate real consumption);

θ is the agent's substitution elasticity (Armington elasticity[4]) between the imported and the domestically produced varieties;

S_d is the share of the agent's expenditure on the commodity that is accounted for by the domestic variety; and

S_{marg} is the margin share in purchasers' prices, i.e. the combined share of wholesale, retail and transport costs.

In using (1), we start by noting from Table 1 that the wedges removed in our simulation have implied tariff revenue[5] of $20,240 b. With imports in 2002 being $1460.390 b. (column 4, Table 1), the impact effect of removing these wedges is to reduce landed-duty-paid import prices by 1.367 per cent [= 100×20.240/(1460.390 + 20.039)].[6] This is partially offset by real devaluation[7] of 0.373 per cent (row 1, Table 2) leaving a net reduction in landed-duty-paid import prices relative to basic prices of domestic commodities of about 0.99 per cent (i.e., $p_m - p_d = -0.99$). Margin costs represent about 25 per cent of purchasers' costs of imports and their domestic competitor products ($S_{marg} = 0.25$). As indicated by the GDP result in row 7 of Table 2, the tariff cuts generate practically no change in real GDP, implying an average value for z of zero. An import-weighted average of the Armington elasticities is 2.4 ($\theta = 2.4$) and an import-weighted average of the domestic shares (S_d) in the USAGE-ITC database is 0.63.[8] Putting all these numbers into equation (1) gives the percentage change in imports as 1.12 per cent

[4] See Armington (1969 and 1970).

[5] Implied tariff revenue is what would be collected if the wedges were entirely tariffs.

[6] The c.i.f. value of imports includes the export-tax wedge. Therefore the landed-duty-paid value of imports is the c.i.f. value plus the tariff collection.

[7] The movement in the real exchange rate is the movement in the nominal exchange rate adjusted for changes in the U.S. price level (measured by the GDP deflator) relative to changes in the price levels of U.S. trading partners. As explained later in this section, removal of import restraints causes real devaluation.

[8] This may seem low. However, when we use import weights we give heavy weight to low domestic shares.

[$x_m = 0.000 - 2.4\times0.63\times0.75\times(-0.99)$]. This is about one and a half times the result (0.732) in row 10 of Table 2.

On investigation we found that the use of averages in (1) is too crude. Commodities for which our simulation gives a large negative value for p_m - p_d happen to have small values for $\theta\times S_d\times(1-S_{marg})$. For example, Apparel, which suffers a sharp reduction in p_m - p_d, has a low Armington elasticity ($\theta = 1.6$), a low domestic share ($S_d = 0.59$) and a very high margin share ($S_{marg} = 0.53$). With a strong negative correlation between $\theta\times S_d\times(1-S_{marg})$ and the absolute values of p_m - p_d, the use of averages in (1) leads to an overestimate of the simulated increase in imports.

(b) Contraction of capital stocks and investment

The removal of the 45 wedges has a negative effect on capital stocks (row 4 of Table 2) for two reasons. First, the industries that are harmed have, on average, high capital intensities relative to those that benefit. For example, the capital share of primary-factor input in Sugar crops (an industry that suffers a sharp reduction in output from the removal of the wedge on manufactured sugar, commodity 78 in Table 1) is over 80 per cent, whereas for the whole economy it is only 27 per cent. Second, the policy causes a change in the cost of using capital relative to the cost of using labor. The increase in nominal before-tax wages is 0.286 per cent (rows 2 and 13 in Table 2). With rates of return fixed, rental rates on capital move in line with asset prices, implying that the increase in the nominal cost of using a unit of capital is 0.336 per cent (row 14 in Table 2). Thus there is a small increase in the cost of using capital relative to the cost of using labor, which induces substitution of labor for capital. With aggregate employment fixed, this must reduce aggregate capital.

The reason for the increase in the cost of using capital relative to labor is that U.S. tariffs and quotas are concentrated mainly on consumption goods. Their removal causes an increase in the price of investment goods relative to the price of consumption goods. With consumption goods being a dominant component of the GDP deflator, the removal of import restraints causes an increase in the price of investment goods relative to the price of GDP (compare rows 14 and 15, Table 2). This induces an increase in the rental rate of capital relative to the GDP deflator, which in turn causes a reduction in wages relative to rentals.

The result for investment in row 5 of Table 2 is close to that of capital reflecting assumption 4.

(c) Reduction in net foreign liabilities

Under assumption 1, the policy has no effect on the volume of capital owned by U.S. residents. The reduction in capital is entirely a reduction in the quantity of U.S. capital owned by foreigners. Consequently, in row 17 of Table 2 there is a reduction in U.S. foreign liabilities.

(d) GDP and efficiency triangles

Despite the reduction in capital and our assumptions of no changes in technology or aggregate employment (assumptions 6 and 7), the removal of import restraints does not reduce real GDP (row 7 of Table 2). On the basis of the capital result, we would expect a reduction in GDP of about 0.017 per cent (the capital share of GDP times the percentage reduction in capital, 0.27×0.062). The offsetting positive effect on GDP is provided by the efficiency triangles. These can be computed (with reference to Figure 1) as

$$\text{efficiency triangles} = \sum_{i \in H} \left[\int_{M_{Ii}}^{M_{Fi}} A_i * M_i^{-1/\eta_i} dM_i - \left(M_{Fi} - M_{Ii}\right) * P_{Fi} \right] \quad . \qquad (2)$$

In equation (2)

M_{Ii} and M_{Fi} are the initial and final quantities of imports of commodity i, that is the quantities before and after the removal of major import restraints;

P_{Fi} is the final landed-duty-paid price of imported commodity i, which is also the final c.i.f. price;

H is the set of high wedge commodities listed in Table 1; and

A_i and η_i are positive parameters in the import demand curve for i which we approximate by

$$P_i = A_i * M_i^{-1/\eta_i} \quad (3)$$

where

P_i is the landed-duty-paid price of imported commodity i.

In terms of Figure 1, equation (2) gives the area abc as the efficiency gain (the effect on GDP) [9] from the elimination of the wedge for commodity i. To evaluate abc we need values for A_i, η_i, P_{Ii}, P_{Fi}, M_{Ii} and M_{Fi}.

The values of A_i and η_i are chosen so that the demand curve, DD in Figure 1, passes through the initial and final price-quantity points. We assume without loss of generality that P_{Fi} equals 1 for all i and that P_{Ii} equals $1 + T3_i/100$ where the $T3_i$s are the wedges shown in column 3 of Table 1. With P_{Fi} equal to 1, the initial c.i.f. price for commodity i is $1 + T2_i/100$ where the $T2_i$s are export-tax wedges shown in column 2 of Table 1. The initial quantity (M_{Ii}) of imports of commodity i is $MCIF_i/(1 + T2_i/100)$ where $MCIF_i$ is the c.i.f. value of imports of commodity i shown in column 4 of Table 1.

[9] Removal of import restraints increases GDP by allowing imports valued in the domestic economy at x (area adeb in Figure 1) to be paid for by exports embodying resources valued at y (area cdeb), where y < x. In calculating x and y it is not relevant to consider who collects the export-tax wedges. This becomes relevant when we consider the welfare effects of removing import restraints.

The final quantity (M_{Fi}) imports of commodity i is obtained from M_{Ii} and the percentage changes in column 8 of Table 1.

With the demand parameters (A_i, η_i) and prices and quantities (P_{Ii}, P_{Fi}, M_{Ii}, M_{Fi}) set as described above, the RHS of equation (2) gives $1.688 billion or 0.017 per cent of GDP. Together, our back-of-the-envelope calculations for the capital effect (-0.017 per cent of GDP) and the efficiency effect (+0.017 per cent of GDP) suggest zero change in GDP, which is the USAGE-ITC result.

(e) Public and private consumption and the terms-of-trade

Removal of the 45 wedges generates percentage increases in real private and public consumption of 0.070 per cent (rows 8 and 9, Table 2). There are two sources of consumption gain. The first is the efficiency gain of about 0.017 per cent of GDP identified in the previous subsection. With public and private being 86.7 per cent of GDP, the efficiency gain translates into a consumption increase of 0.020 per cent (= 0.017/0.867). The second source of consumption gain is an improvement in the terms of trade (to be explained below). As can be seen from row 12 in Table 2, the terms of trade improves by 0.381 per cent. This increases the purchasing power of real GDP by increasing the prices of commodities produced in the U.S. relative to the prices of commodities absorbed in the U.S. The shares of exports and imports in GDP are 10.5 and 14.5 per cent. Thus, an improvement in the terms of trade of 0.381 per cent increases the purchasing power of GDP by about 0.048 per cent [= 0.381×(0.105+0.145)/2]. This translates into an increase in C+G of about 0.055 per cent (= 0.048/0.867). Together, our back-of-the-envelope calculations of the efficiency gain and the terms-of-trade effect suggest an increase in public and private consumption of 0.075 per cent (=0.020 + 0.055), close the USAGE-ITC result of 0.070 per cent.

The terms-of-trade improvement is the net outcome of three effects. First, there is a directly assumed improvement in the terms of trade from the elimination of export tax equivalents. As can be seen from Table 1 these amount to $7.9 billion, that is about 0.54 per cent of imports (7.9 out of 1460). Thus their elimination generates a direct improvement of 0.54 per cent in the term of trade. Second, there is an increase in exports of 0.533 per cent. In USAGE-ITC we assume export demand elasticities of -3. Thus the increase in exports reduces the terms of trade by 0.18 per cent (=0.533/3). Third, there is an increase in imports of 0.732 per cent. In USAGE-ITC we adopt small but positive import supply elasticities: we assume that increases in U.S. demands for imports generate increases in foreign supply prices. By multiplying the USAGE-ITC import supply elasticities by the percentage changes in import volumes, we find in the present simulation that movements along foreign supply curves generate a terms-of-trade reduction of about 0.04 per cent. Together our back-of-the-envelope calculations of the three effects imply a terms-of-trade improvement of 0.32 per cent (=0.54 – 0.18 – 0.04), close to the USAGE-ITC result of 0.38.

(f) Deterioration in the real trade balance

Because C+G is 86.7 per cent of GDP and investment (I) is only 17.7 per cent, the contribution of the increase in C+G (0.867*0.070) to real GDP far out-weighs the contribution of the decrease in I (-0.177*0.061). Consequently, with zero change in real GDP, there must be an increase in real imports relative to real exports. As discussed earlier, the percentage increase in imports (M) is 0.732 per cent which is about 0.2 percentage points greater than the percentage increase in exports (X, 0.533 per cent, row 11, Table 2). The 0.2 percentage point gap between imports and exports is implied by the results that we have already considered for GDP, C, G, I and M. The increase in exports of 0.533 per cent is facilitated in USAGE-ITC by a real devaluation of 0.373 per cent (row

1, Table 1). Despite noticeable deterioration in the real balance of trade, there is almost no movement in the nominal balance of trade (row 16, Table 2): the terms of trade improvement offsets the decline in X − M.

(g) Real wage rates before and after tax

The final results in Table 2 worthy of comment are those for wages (rows 2 and 3). With terms-of-trade and efficiency improvements worth 0.048 and 0.017 per cent of GDP, our first guess was that the simulated long-run increase in the real after-tax wage rate would be about 0.097 per cent. In working this out we assumed that in the long-run the benefits of terms-of-trade and efficiency improvements would accrue entirely to the fixed factor, labor. With the labor share of GDP being about 67 per cent, we obtained an increase in the wage rate of 0.097 [=(0.048+0.017)/0.67]. However the increase in the USAGE-ITC simulation is only 0.002 per cent. There are two factors explaining the subdued response of the real after-tax wage rate. First, in our simulation, income shifts from labor to capital. As explained earlier, the policy generates an increase in the price deflator for investment goods relative to the price deflator for GDP, with a corresponding increase in rental rates relative to wage rates. Second, under our assumption of fixed real national saving, the government imposes a sharp increase in labor taxes. Although the loss in tariff revenue is only $12.327 billion (see column 5, Table 1) and its replacement would require an extra tax on labor income of 0.18 per cent ($12.327 billion is 0.18 per cent of the nation's wage bill), the simulated tax increase is 0.284 per cent (the gap between the results in rows 2 and 3, Table 2). With a significant increase in the price of capital goods relative to the price of consumption goods, the mere replacement of lost tariff revenue is not sufficient to maintain *real* national saving. The government must move its budget towards surplus.

3 Effects on output by commodity

A good starting point for understanding the USAGE-ITC results in column 9 of Table 1 for U.S. outputs of heavily protected commodities is the equation

$$x_d = z - \theta \times S_m \times (1 - S_{marg}) \times (p_d - p_m) \ . \quad (4)$$

This is a stylized version of the demand by a typical agent in USAGE-ITC for the domestic variety of a commodity. In the equation, x_d is the percentage change in the agent's demand for the domestic variety; S_m is the share of the agent's expenditure on the commodity that is accounted for by the imported variety; and the remaining notation is the same as that in equation (1). To illustrate the use of equation (4) in explaining output results, we work through a straight-forward example: Luggage, commodity 209 in Table 1.

The principal users of Luggage are households. They have an import share (S_m) for this commodity of 0.80 and an Armington elasticity (θ) of 3.1. The wedge on Luggage in 2002 was 13.20 per cent. Thus the removal of the wedge has an impact effect on the landed-duty-paid price of Luggage of -11.66 per cent (= -13.2/1.132). Part of this is offset by nominal devaluation of 0.520 per cent (= -0.373 - 0.147, rows 1 and 15, Table 2)[10], leaving the final change in the landed-duty-paid price of imported Luggage at -11.14 per cent. From detailed USAGE-ITC results, not shown here, we find that the basic price of domestic Luggage falls by 1.02 per cent. This reflects reductions in the costs to the domestic Luggage industry of imported Broadwoven fabrics and Coated fabrics (commodities 102 and 107): both of these commodities are major inputs to Luggage and both appear in Table 1 with significant wedges. Together the movements in the basic prices of imported and domestic Luggage imply a reduction in the relative basic price of the imported variety of 10.12 per cent (= -11.14 +1.02). This shrinks to 5.96 per cent when we move to purchasers' prices for households. In common with other consumer goods, the sale of Luggage to households incurs considerable margins costs (about 41 per cent of purchasers' prices). With the value of $(1 - S_{marg}) \times (p_d - p_m)$ at 5.96 and with $S_m = 0.80$ and $\theta = 3.1$, the substitution term on the RHS of (4) gives a reduction in household demand for domestically produced Luggage of 14.8 per cent. Because Luggage becomes cheaper (the overall purchasers' price to consumers of domestic and imported luggage falls by 5.3 per cent), households buy more of it. The household elasticity of demand for Luggage in USAGE-ITC is about -0.73. Thus the reduction in the price of Luggage boosts demand by 3.9 per cent (= 0.73×5.3). In terms of equation (4), z = 3.9 where z is the percentage change in household demand for the Luggage import-domestic composite. Combining the activity effect with the substitution effect gives a reduction in household demand for domestic Luggage of 10.9 per cent (= 14.8 – 3.9). The reduction in total output of domestic Luggage (9.6 per cent, Table 2) is smaller than the reduction in household demand for domestic Luggage. This is mainly because there are significant exports of Luggage (about 17 per cent of total sales). Exports of Luggage are stimulated by the reductions in the costs of imported inputs and the devaluation that accompanies the reductions in import restraints.

For Luggage and for most of the other commodities in Table 1 substitution effects are dominant in determining the reduction in domestic output. However, for some negatively affected commodities, activity effects are dominant. Consider for example Knit fabric mills (commodity 114, Table 1). Imports of this commodity are small, giving an S_m of about 0.10. While margins are quite small (S_{marg} =0.063 per cent) and the Armington elasticity is moderately high, the low import share limits the substitution effect on

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[10] The movement in the nominal exchange rate is given by the movement in the real exchange rate minus the

domestic demand for the domestic product to about -3 per cent. Most of the reduction of 7.33 per cent in domestic output of Knit fabric mills arises from activity contraction in the industries that use Knit fabric mills as an intermediate input, particularly the Apparel producers. As can be seen from Table 1, the removal of import restraints reduces output of Apparel by 5.34 per cent. For Knit fabric mills, this represents a contraction in the relevant activity level of about 4 per cent.

Despite suffering significant wedge reductions, some of the commodities in Table 1 show negligible output contraction (or even a small expansion, commodities 58, 98, 123 and 373). These commodities fall into two groups. The first group has very small import shares (S_m) in their domestic markets. Members of this group include Fluid milk and Ice cream. The second group has significant exports. Output of these commodities benefits from devaluation. Members of this group include Cigarettes, Tobacco stem redry and Fabricated textile products (commodities 98, 101 and 123).

Table 3 shows that a common feature of nearly all the commodities for which USAGE-ITC projects an output increase of more than 0.4 per cent is a high share of exports in total sales (greater than 20 per cent). For example, the commodity with the largest positive output response to the removal of wedges is Vegetable mills (commodity 90) with an export share of 54 per cent. Output of high export-share commodities is stimulated by devaluation. For Vegetable mills there is an additional factor: U.S. production costs of Vegetable mills are reduced by elimination of wedges on inputs of imported Oil bearing crops (commodity 15, Table 1), making U.S. Vegetable mills particularly competitive on international markets.

Not all of the commodities in Table 3 have high export shares. There are nine with export shares less than 20 per cent. They are: Chocolate; Cigars; Water transport

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movement in the price deflator for GDP.

international; Candy; Retail trade; Flavors and syrups; Cigarettes; TV cabinets; and Textile bags.

U.S. output of Chocolate, Candy and Flavors and syrups (commodities 79, 81 and 87) benefits from a sharp reduction in the price of sugar, one of the principal inputs to the production of these commodities. As can be seen from Table 1, sugar is the commodity with the highest wedge (119.32 per cent). Similarly, U.S. output of Cigars and Cigarettes (commodities 99 and 98) benefits from a reduction in the price of imported Tobacco stem redry and U.S. output of Textile bags (commodity 118) benefits from a reduction in the prices of imported textile inputs.

Water transport international (commodity 502) is the provision by U.S. companies of shipping services outside the U.S. These services are used mainly to facilitate flows of goods into and out of the U.S. They are modeled in USAGE-ITC as margins on imports and exports, not as direct exports. In the present simulation, output of Water transport international is stimulated by expansion in U.S. trade, both exports and imports.

Retail trade (commodity 416) benefits in the wedge-removal simulation from a shift in consumer expenditure towards products that happen to carry high retail margins. These include Apparel and other textile products. Substitution towards these products is generated by reductions in their prices relative to those of other consumer goods.

TV cabinets (commodity 141) face almost no import competition and have negligible exports. Because 98 per cent of their sales are to the Household audio/video (commodity 340), the output of TV cabinets moves closely in line with that of Household audio/video. As can be seen from Table 3, Household audio/ video benefits from a high export share giving it an output response to the removal of import restraints of 0.43 per cent. This explains nearly all of the response (0.45 per cent) in the output of TV cabinets.

4 Effects on employment by state

The last column of Table 4 shows percentage effects on employment by state calculated by applying a regional extension to the USAGE-ITC results generated in the wedge-removal simulation. The regional extension is tops-down, that is it generates state results from the national results without affecting the national results.[11] As explained in Dixon and Rimmer (2002, section 36), a tops-down approach is suitable for simulating the regional effects of a national policy change (such as the removal of tariffs and quotas). It is not suitable for simulating the effects of shocks that emanate at the state level (e.g. changes in state taxes).[12] The details of the regional extension applied in this paper can be found in Dixon and Rimmer (2004).

The most striking feature of the state results in Table 4 is the narrowness of their range. The worst affected states are Idaho and North Carolina which lose 0.498 and 0.477 per cent of their jobs, while the most favored state, Washington, obtains a 0.214 per cent increase in jobs. Idaho and North Carolina are adversely affected because they have relatively high shares of their employment in the production of commodities for which national production shrinks when tariffs and quotas are removed. Idaho suffers from over-representation in its employment of sugar crops, sugar products and dairy products while North Carolina suffers from over-representation of textile production. However, even for Idaho and North Carolina the shares of these losing activities in state-wide employment is small. Idaho’s employment share in sugar, sugar crops and dairy-related activities is 0.91 per cent (compared with the national share of 0.18 per cent) while North Carolina’s

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[11] The tops-down approach was pioneered in the context of input-output analysis by Leontief *et al.* (1965). It was introduced to CGE modeling by Dixon *et al.* (1978).

[12] Simulation of the effects of such shocks requires a bottoms-up approach where the nation is treated as a group of regional economies connected by trade and factor flows, see for example Liew, 1984. The theoretical structure of bottoms-up regional models is similar to that of world models such as GTAP (Hertel, 1997).

employment share in textile activities is 3.14 per cent (compared with the national share of 0.59 per cent). For Idaho, the contraction of sugar and dairy production imparts a direct loss of employment of 0.13 per cent while for North Carolina the contraction of textile employment imparts a direct loss of employment of 0.17 per cent. Even with high multipliers, about 3, these direct employment loses translate into total employment loses for the two states of less than half a per cent.

At the other end of Table 4, Washington is the most advantaged state. It benefits from over-representation in its economy of export-oriented commodities such as aircraft and aircraft equipment. However, as can be seen from Table 3, the removal of tariffs and quotas generates an output expansion for a typical export-oriented commodity of only about 0.6 per cent. Thus, even for states with an over-representation of export-oriented activity, the total employment gain can be no more than a small fraction of 1 per cent.

Do state employment shares and percentage changes in commodity outputs at the national level explain all of our regional employment results? To answer this question we regress the employment results in the last column of Table 4 against a national index worked out for region r as:

$$\text{NationalIndex}(r) = \Sigma_j \, \text{Sh}(j,r) \times \text{emp\_com}(j) \qquad (5)$$

where

Sh(j,r) is the share of employment in region r accounted for by production of good j; and

emp_com(j) is the percentage change in employment at the national level in the production of commodity j.

Values for the national index are in the first column of Table 4.

The outcome of the regression is:

$$\mathrm{Emp}(r) = -0.023 + 2.755 \times \mathrm{NationalIndex}(r), \quad r \in \mathrm{REG} \tag{6}$$

R-squared = 0.73

where

Emp(r) is the percentage change in employment in state r (last column of Table 4); and

REG is the set of 51 regions.

In (6), the coefficient on NationalIndex(r) has expected sign. Its magnitude (2.755) is also plausible. It indicates multiplier effects of the size often found in input-output studies, between 2 and 3. If region r has a mix of industries that give it an initial 1 per cent employment gain relative to the nation [NationalIndex(r)=1], then r's eventual employment advantage is 2.755 per cent. This multiplier effect arises because the sourcing of inputs (especially service inputs) by industries in region r is skewed towards suppliers in region r. However, NationalIndex(r) explains only 73 per cent of the variation across the states in the USAGE-ITC employment results. As illustrated in Figure 2, there must be other factors contributing to the state employment effects.

On studying Figure 2, we see that regression equation (6) strongly under-predicts the USAGE-ITC employment results for Washington, California and South Carolina. A factor that these three states have in common is major ports. In our USAGE-ITC simulation, a state benefits from having a major port via the trade-expanding effects of the removal of import restraints. The idea that ports are the missing factor in the NationalIndex explanation of the USAGE-ITC state employment results is strengthened by (6)'s over prediction of employment results for Idaho and North Dakota. These states have no major ports. On this basis we decided to add a port index to our regression explanation of the USAGE-ITC results. The index we chose was a ratio of two shares: the state's share of U.S. trade going through its ports and the state's share of national employment. The values of this index are in the second column of Table 4. With the port index included, our regression equation becomes:

$$Emp(r) = -0.050 + 3.164*NationalIndex(r) + 0.056*PortIndex(r), \quad r \in REG, \qquad (7)$$

$$R\text{-squared} = 0.88$$

The port index enters the regression with the expected sign and raises R-squared to 0.88. Nevertheless, as can be seen from Figure 3, our explanation of the state employment results is still incomplete. For example, regression equation (7) strongly under predicts the USAGE-ITC employment results for Hawaii, Nevada and Arizona.

A common feature of these three states is over-representation of tourism activities. In the USAGE-ITC simulation, removal of tariffs and quotas is good for domestic tourist activities. This is because devaluation makes holidays abroad expensive for U.S. residents causing substitution in our model towards holidays at home. It also stimulates foreign tourism in the U.S. These favorable effects for tourist destinations such as Hawaii, Nevada and Arizona are taken into account in USAGE-ITC but are not fully recognized in regression equation (7). In USAGE-ITC there is no direct employment in the tourism industries. These industries simply supply a package of hotel, entertainment, restaurant and travel services. Consequently, favorable movements in the output of the tourism industries enter the national index in only a muted way through their effects on employment in hotels, etc. The regression (but not USAGE-ITC) fails to recognize that regions in which hotels, etc. are used mainly in tourism activities benefit in the USAGE-ITC simulation relative to regions in which hotels, etc. are used mainly for other purposes.

Thus we decided to add a holiday index to our regression equation. This is calculated for region r as the ratio of r's share in tourism activities to r's share in national employment.[13] The values of this index are in the third column of Table 4. With the inclusion of the holiday index, the regression equation becomes:

$$Emp(r) = -0.063 + 3.121*NationalIndex(r) + 0.056*PortIndex(r) + 0.011*HolidayIndex(r)$$

$$r \in REG, \quad R\text{-squared} = 0.90 \qquad (8)$$

The inclusion of the holiday index improves the overall fit of the regression equation and moves the fitted values for Hawaii and Nevada close to the USAGE-ITC results (Figure 4). For Arizona, the gap between the fitted value and the USAGE-ITC result is reduced.

Although regression equation (8) gives a good explanation of the employment result for most states, some quite large gaps between the fitted values and the USAGE-ITC results remain. By investigating these gaps we can increase our understanding of the mechanisms in the USAGE-ITC model. For example, Figure 4 shows that the regression equation strongly over-estimates the USAGE-ITC results for Minnesota, Wisconsin, Idaho and South Dakota. We found that this is related to dairy activities. These four states are relatively large producers of milk. A fact that is built into USAGE-ITC but not into regression equation (8) is that the share of milk production in the four states sold to manufacturing (butter, cheese, etc.) is higher than in other states. By omitting this fact, the regression under-estimates the damage to the four states caused in our simulation by the contraction of the outputs of milk products.

5 Concluding remarks

The results in this paper indicate that the removal of major tariffs and quotas would have only small long-run effects on the U.S. macroeconomy. The annual welfare gain,

[13] We included three USAGE -ITC industries in the numerator of this index: Holiday, Export tourism and Export education.

measured by the long-run percentage increase in private and public consumption is 0.07 per cent. That the projected effects are small should not be surprising. Table 1 indicates that the tariffs and quotas considered in this paper are equivalent to tariffs that generate revenue of $20 billion. This is only 0.2 per cent of GDP.

For most industries, output would change by between -1 and 1 per cent. However, there are a few industries for which output changes would be quite large. USAGE-ITC projects contractions in sugar and butter output of more than 20 per cent and contractions in the outputs of several textile industries of between 5 and 10 per cent. For export-oriented industries, USAGE-ITC projects small increases in output, exceeding 1 per cent for only three industries.

For the states, USAGE-ITC projects employment changes of between -0.498 and 0.214 per cent. The narrowness in the range of these results reflects two factors. First, the removal of major U.S. tariffs and quotas would have little impact on the outputs of most industries. Second, the few industries in which there would be a significant impact make up only minor parts of the state economies. This is true even for the states in which heavily protected industries such as dairy, sugar and textiles are concentrated.

Every simulation result generated by a detailed CGE model such as USAGE-ITC depends potentially on millions of data items, elasticity values and behavioral assumptions. Nevertheless, as demonstrated in sections 2 to 4 it is possible to explain the results, qualitatively and quantitatively, in terms of elementary mechanisms. In section 2 we explained the macro results of our tariff-cut simulation in a sequence, starting with imports and working through aggregate capital, aggregate investment, net foreign liabilities, GDP and welfare, consumption and the terms-of-trade, the balance of trade, and wage rates. In section 3 we explained the results for import-sensitive industries in terms of: the sizes of the tariff wedges; import shares in the U.S. market; Armington elasticities;

margin shares in purchasers' prices; and movements in the costs of intermediate inputs. For export-oriented industries we explained the results in terms of: direct and indirect shares of total sales accounted for by exports; movements in the costs of intermediate inputs; export demand elasticities; and the movement in the real exchange rate. In section 4 we used a regression equation to explain the results for employment by state in terms of: the industrial composition of employment in each state; multiplier effects; port activity; and tourist activity.

Explanations such as those in sections 2 to 4 make it possible for policy advisers to obtain a deep understanding of CGE results without requiring time-consuming absorption of voluminous technical documentation. These explanations can also be considered a powerful form of sensitivity analysis. For example, once it is understood how a model such as USAGE-ITC projects the output movement of a commodity, then it becomes clear how the projection would change if we were to adopt different values for the trade elasticities.

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Table 1. Data for 2002 for the 45 commodities with the highest wedges and the effects of removing these wedges

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
								USAGE-ITC results Percentage changes		
	Tariff rate, T1	Export tax equiv., T2	Price wedge, T3	Imports (c.i.f., $m), MCIF	Tariff collection C1[(a)]	Value of export tax, C2[(b)]	Value of wedge, C3[(c)]	Imports	Output	Armington elasticity
78 Sugar	1.02	117.11	119.32	1389	14	749	763	167.48	-27.9	5.00
55 Butter	19.46	33.94	60.00	248	48	63	111	162.31	-23.11	5.00
56 Cheese	11.42	25.65	40.00	806	92	165	257	116.34	-4.66	5.00
57 Dairy, dried etc.	4.48	29.21	35.00	658	29	149	178	124.94	-7.42	5.00
101 TobStemRedry	6.66	15.64	23.34	669	45	90	135	53.23	-5.14	3.00
115 Apparel	10.88	9.93	21.89	66878	7276	6041	13317	10.92	-5.34	2.00
58 Icecream	10.37	8.73	20.01	8	1	1	1	92.42	0.02	5.00
117 Housefurnish	6.26	12.45	19.49	3067	192	340	532	8.31	-0.9	1.00
116 Curtains	8.95	6.03	15.52	260	23	15	38	20.58	-2.23	3.00
59 Fluidmilk	13.65	0.00	13.65	23	3	0	3	49.69	-1.2	5.00
209 Luggage	13.20	0.00	13.20	3432	453	0	453	7.77	-9.6	3.10
102 Broadfabric	7.86	4.76	12.99	4609	362	209	572	32.07	-7.27	4.00
208 Leathrgloves	12.99	0.00	12.99	404	52	0	52	5.64	-3.16	1.40
114 Knitfabric	12.68	0.00	12.68	897	114	0	114	20.34	-7.33	2.80
15 OilBearCrops	1.79	9.96	11.93	180	3	16	20	48.74	-0.02	5.00
199 RubPlFootwr	11.78	0.00	11.78	5540	653	0	653	3.74	-1.29	1.30
207 Slippers	11.28	0.00	11.28	134	15	0	15	4.57	-0.74	1.00
210 WmnsHandbag	11.22	0.00	11.22	1576	177	0	177	6.2	-6.77	3.10
113 Hosierynec	9.38	0.81	10.27	444	42	4	45	8.2	-1.33	2.00
206 Shoes, not rubber	9.77	0.00	9.77	13929	1361	0	1361	2.96	-0.83	1.00
105 Threadmills	7.08	1.97	9.19	62	4	1	6	9.53	-2.55	2.40
98 Cigarettes	8.97	0.00	8.97	124	11	0	11	14.84	0.53	2.70
211 PerLeathrGds	8.66	0.00	8.66	798	69	0	69	7.98	-5.39	3.50
221 VitChinaTble	8.63	0.00	8.63	390	34	0	34	7.02	-6.76	2.40
217 CeramicTile	8.45	0.00	8.45	963	81	0	81	4.59	-6.31	2.50
112 Womenhosiery	6.55	0.52	7.10	641	42	3	45	7.46	-0.77	2.50
60 Cannedfish	3.59	2.58	6.26	1754	63	44	107	7.6	-7.13	5.00
383 CostumJewel	6.15	0.00	6.15	1344	83	0	83	6.49	-2.09	3.00
306 Ballbearings	5.82	0.00	5.82	1974	115	0	115	11.56	-3.72	4.00

…Table 1 continues

Table 1 continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
								USAGE-ITC results Percentage changes		
	Tariff rate, T1	Export tax equiv., T2	Price wedge, T3	Imports (c.i.f., $m), MCIF	Tariff collection C1[(a)]	Value of export tax, C2[(b)]	Value of wedge, C3[(c)]	Imports	Output	Armington elasticity
373 Watches	5.43	0.00	5.43	3328	181	0	181	1.6	0.38	1.00
119 Canvasprods	5.38	0.00	5.38	339	18	0	18	7.02	-1.3	3.00
222 Earthenware	5.29	0.00	5.29	557	29	0	29	1.24	-2.91	2.40
104 YarnFinish	4.81	0.43	5.26	753	36	3	39	3.99	-5.18	2.50
388 Pens	4.94	0.00	4.94	1378	68	0	68	3.49	-1.82	3.00
120 Pleating	4.79	0.00	4.79	127	6	0	6	2.16	-1.59	1.40
213 Glass	4.65	0.00	4.65	3947	184	0	184	5.84	-1.31	2.60
269 Cutlery	4.65	0.00	4.65	851	40	0	40	8.61	-2.61	5.00
270 Handtools	4.32	0.00	4.32	1646	71	0	71	1.7	-0.24	1.00
66 Frozenfruit	4.21	0.00	4.21	1538	65	0	65	10.96	-1.63	5.00
103 Narrowfabric	4.18	0.01	4.19	525	22	0	22	1.96	-2.09	3.00
186 MmadeFibOth	3.47	0.00	3.47	1985	69	0	69	-3.5	-2.88	1.00
123 FabTextileProds	2.43	0.96	3.41	2022	49	19	68	0.74	0.21	1.00
109 CordageTwine	3.10	0.28	3.39	226	7	1	8	2.18	-0.83	2.00
111 Textilegoods	2.28	0.01	2.29	632	14	0	14	1.37	-0.39	1.80
107 Coatdfabric	2.22	0.05	2.27	434	10	0	10	1.77	-0.37	2.60
Averages or totals										
45 high-wedge coms.	9.23[(d)]	6.30[(e)]	16.12[(f)]	133489	12327	7913	20240			
Other commodities	0.58[(d)]	0.00[(e)]	0.58[(f)]	1326902	7712	0	7712			
All commodities	1.37[(d)]	0.54[(e)]	1.92[(f)]	1460390	20039	7913	27952			

(a) Calculated as C1 = (T1/100)*MCIF.

(b) Calculated as C2 = (T2/100)*[MCIF/(1+T2/100)].

(c) Calculated as C3 = C1 + C2 = (T3/100)*[MCIF/(1+T2/100)] where T3 = 100*[(1+T1/100)*(1+T2/100)-1].

(d) Average of T1's using MCIF weights.

(e) Average of T2's using MCIF/(1+T2/100) as weights.

(f) Average of T3's using MCIF/(1+T2/100) as weights.

Table 2. Macro effects of removing major U.S. tariffs and quotas: USAGE-ITC results

Percentage changes		
1	Real exchange rate	-0.373
2	Real wage rate (before tax), cpi deflated	0.286
3	Real wage rate (after tax), cpi deflated	0.002
4	Capital stock	-0.062
5	Real investment	-0.061
6	Employment	0.000
7	Real GDP	0.000
8	Real private consumption	0.070
9	Real public consumption	0.070
10	Imports, volume	0.732
11	Exports, volume	0.533
12	Terms of trade	0.381
13	Price deflator, consumption (cpi)	0.000
14	Price deflator, investment	0.336
15	Price deflator, GDP	0.147
Changes expressed as per cent of GDP		
16	Balance of trade	-0.001
17	Net foreign liabilities	-0.097

Table 3. Exports shares of output in 2002, and the effects on output of removing major U.S. tariffs and quotas

USAGE-ITC Commodity	Export share (per cent)	USAGE-ITC results *Percentage changes* Output
90 Vegetmills	54	4.66
79 Chocolate	19	3.41
99 Cigars	7	1.04
500 Export education	100	0.99
100 Tobacco snuff	39	0.91
479 Scrap	20	0.91
502 Water transport, international	0	0.87
344 Electron tube	36	0.77
286 Oil & gas field machinery	82	0.66
499 Export Tourism	100	0.66
295 Roll mill mach	24	0.64
147 PubBldFurnit	22	0.63
81 Candy	2	0.63
202 RubPlHose	30	0.62
292 MachToolForm	53	0.61
416 RetailTrade	0	0.58
87 FlavorSyrups	8	0.58
291 MachToolCut	33	0.55
98 Cigarettes	18	0.53
329 Carbonprods	37	0.49
310 IndMachEquip	57	0.48
232 AsbestosPrd	44	0.48
376 LabInstrum	47	0.47
285 MiningMachin	53	0.47
249 NferRollnec	37	0.46
280 Turbines	67	0.46
205 BootCutStock	89	0.46
351 ElectMachnec	63	0.45
141 TvCabinets	1	0.45
118 Textilebags	4	0.45
303 PrintMach	43	0.45
358 AircrftEquip	43	0.44
340 HldAudioVid	36	0.43
320 VendingMach	20	0.43
21 Ironmetlores	25	0.42
276 SteelSpring	36	0.41

Table 4. State characteristics and effects on employment of removing major U.S. tariffs and quotas

State	Indexes used in explaining state employment results			USAGE-ITC results *Percentage change*
	National	Port	Holiday	Employment
12 Idaho	-0.11	0.00	0.54	-0.498
33 North Carolina	-0.15	0.13	0.36	-0.477
34 North Dakota	-0.07	0.00	0.59	-0.353
40 South Carolina	-0.19	4.69	0.80	-0.314
39 Rhode Island	-0.10	0.00	0.46	-0.308
23 Minnesota	-0.01	0.00	0.42	-0.248
1 Alabama	-0.05	0.00	0.16	-0.240
49 Wisconsin	0.00	0.00	0.37	-0.219
50 Wyoming	-0.04	0.00	1.58	-0.182
29 New Hampshire	-0.01	0.00	0.59	-0.152
18 Louisiana	-0.02	0.87	0.60	-0.125
42 Tennessee	-0.03	0.00	0.40	-0.125
41 South Dakota	0.01	0.00	0.44	-0.111
10 Georgia	-0.05	1.91	0.57	-0.081
26 Montana	-0.01	0.00	0.96	-0.065
8 Delaware	-0.04	1.95	0.32	-0.063
17 Kentucky	0.01	0.00	0.19	-0.047
19 Maine	0.00	0.00	1.33	-0.047
45 Vermont	0.00	0.00	1.95	-0.045
21 Massachusetts	0.00	0.16	0.97	-0.045
27 Nebraska	0.01	0.00	0.20	-0.028
2 Alaska	0.00	0.00	1.83	-0.019
6 Colorado	0.01	0.00	1.06	-0.016
46 Virginia	-0.02	2.13	0.39	-0.013
38 Pennsylvania	0.01	0.21	0.46	-0.009
32 New York	-0.02	1.89	1.21	-0.004
30 New Jersey	0.00	0.00	0.59	-0.002
25 Missouri	0.02	0.00	0.24	0.004
24 Mississippi	0.01	0.27	0.15	0.008
15 Iowa	0.02	0.00	0.18	0.009
44 Utah	0.02	0.00	0.91	0.027
13 Illinois	0.02	0.00	0.49	0.034
51 Dist. of Columbia	0.02	0.00	3.64	0.045
48 West Virginia	0.03	0.00	0.16	0.060
7 Connecticut	0.02	0.00	0.28	0.061
43 Texas	0.02	0.71	0.65	0.062
36 Oklahoma	0.04	0.00	0.13	0.063
31 New Mexico	0.03	0.00	0.55	0.064
4 Arkansas	0.04	0.00	0.12	0.072
11 Hawaii	0.00	0.39	11.42	0.072
35 Ohio	0.04	0.00	0.23	0.076
20 Maryland	0.02	0.81	0.33	0.082
9 Florida	0.00	1.74	3.83	0.091
5 California	0.00	3.44	1.64	0.102
22 Michigan	0.05	0.00	0.26	0.102
37 Oregon	0.01	0.96	0.71	0.105
3 Arizona	0.02	0.00	2.03	0.107
16 Kansas	0.05	0.00	0.18	0.126
14 Indiana	0.05	0.00	0.21	0.127
28 Nevada	0.03	0.00	11.88	0.144
47 Washington	0.04	4.26	0.77	0.214
All states	0.00	1.00	1.00	0.000

Figure 1. Efficiency gain from removal of import restraints on commodity i

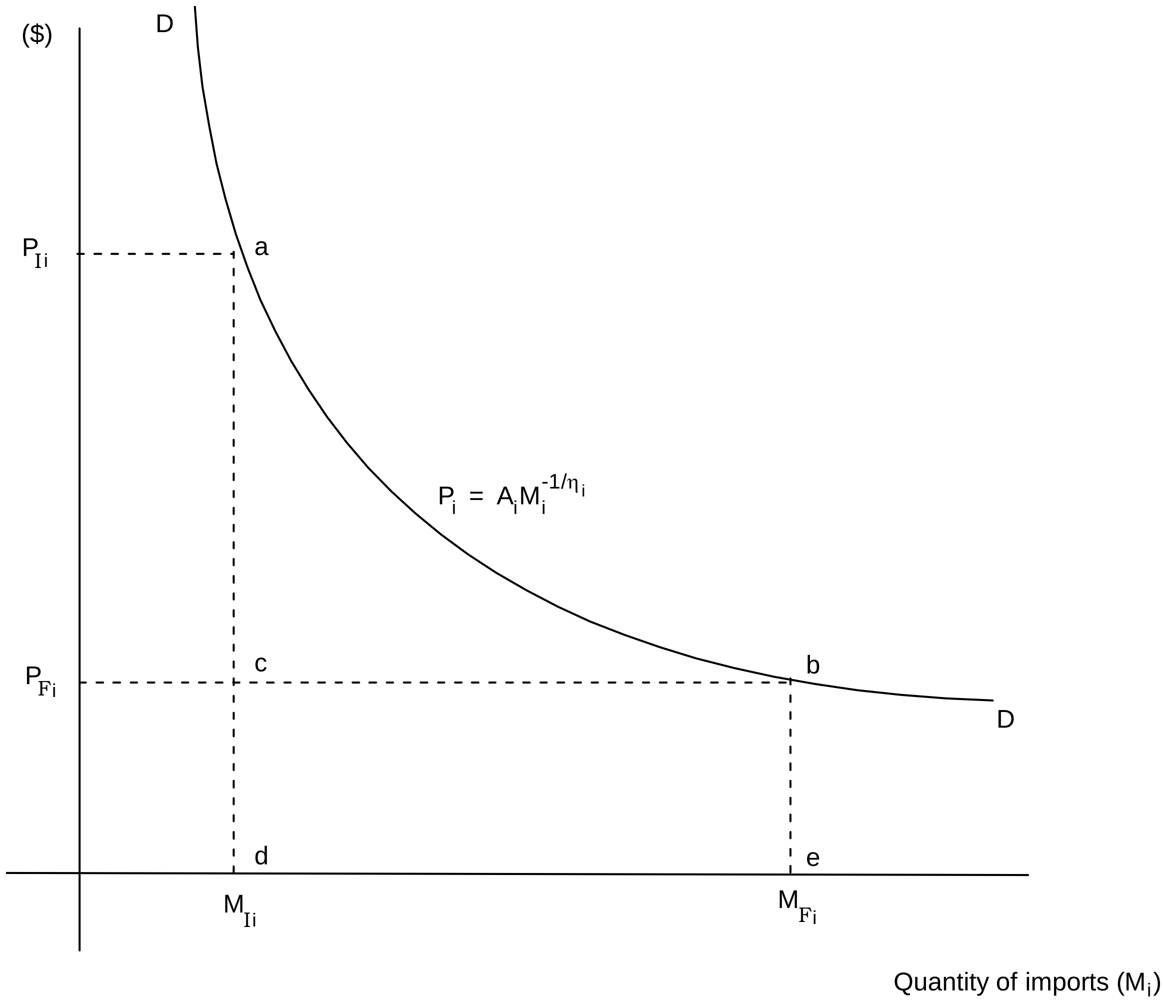

Figure 2. Employment effects of removing major U.S. tariffs and quotas explained by a one-variable regression: equation (6)

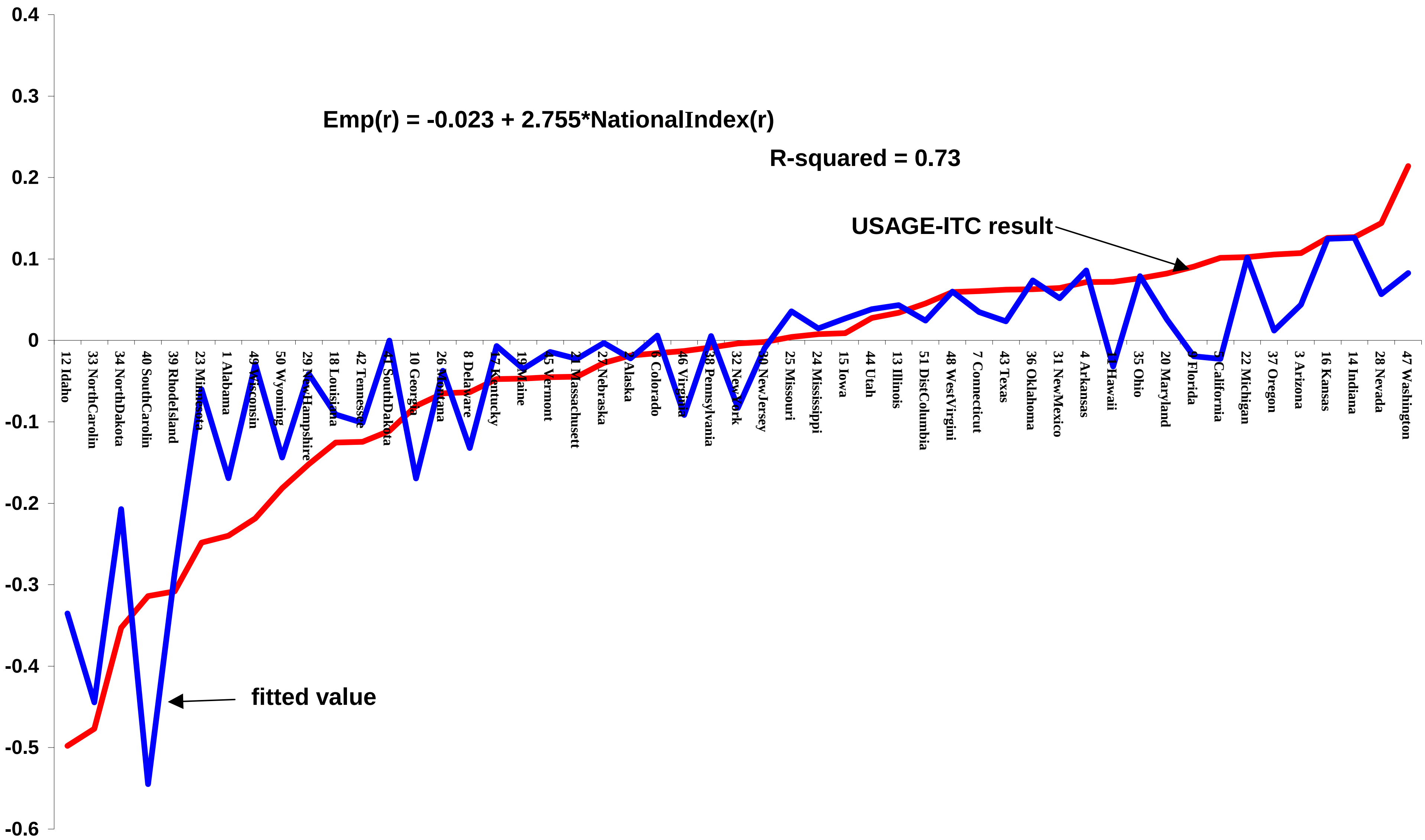

Figure 3. Employment effects of removing major U.S. tariffs and quotas explained by a two-variable regression: equation (7)

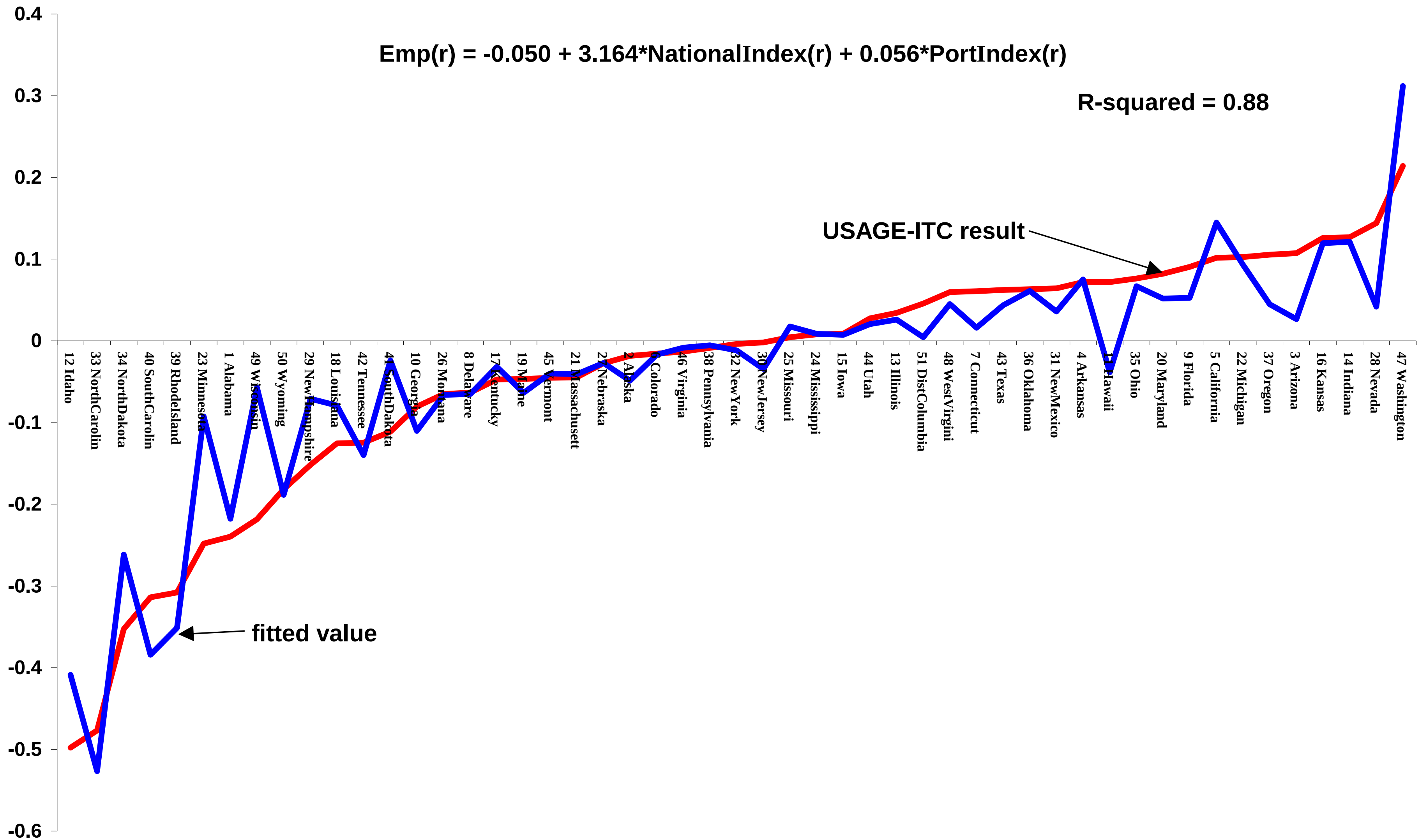

Figure 4. Employment effects of removing major U.S. tariffs and quotas explained by a three-variable regression: equation (8)