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Using real expenditure to assess policy impacts

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Using real expenditure to assess policy impacts*

Key points

- National-accounts-based measures of activity or income are not suitable as measures of welfare.
- Utility-based measures require a number of theoretical assumptions, cannot be reconciled with data, and are hard to explain to non-technical audiences.
- Real Gross National Absorption (GNA) is a national-accounts-based measure of expenditure and can be interpreted as a measure of welfare.
- It measures the purchasing power of income earned by residents (from domestic and overseas sources), reflecting net payments overseas and relative prices.
- It offers an intuitive framework for explaining and decomposing changes in national expenditure, whether in CGE or macroeconomic models.

Introduction

Measuring the economy-wide welfare impact of policy and other changes remains a challenge. With changing trade policies in foreign markets, patterns of productivity slowdown in developed countries, and debate on the relative merits of competing public infrastructure investments, accurately gauging welfare implications for Australians is important. Simple national-accounting aggregates (such as GDP or private consumption) tell only part of the story, while more theoretically complete, utility-based measures are harder to relate to policy-makers and non-technical audiences.

This note proposes real Gross National Absorption (GNA) as a measure of the overall impacts on a national economy of policy changes in applied analyses. It is derived from national accounts data, and shows the extent to which changes in national income increase the purchasing power of residents. Being based in national accounts, it is easily calculated and decomposed, aiding interpretation and explanation of results to non-technical audiences (an advantage over utility-based measures such as equivalent variation (EV), which cannot be easily linked to national accounting aggregates). By design GNA includes factors

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typically omitted from other national accounts indicators, including savings, net income from overseas, and changes in relative prices (an advantage over other macro-aggregates such as GDP and consumption).

The first section of this note outlines two widely-used approaches to measuring welfare: utility-based measures and national-accounts-based measures. The next section explains the GNA approach, its derivation and interpretation. Technical material in the appendixes provides examples using applied models (code and data), and compares the results to other national accounting aggregates.

Welfare results are reported in a number of ways

CGE models are used to assess the impacts of policy changes on a country. A number of results are typically reported to support these assessments, including industry-level variables like output, employment and prices, as well as macroeconomic variables like GDP, consumption and the trade balance. Measuring welfare is more challenging, and analysts use two main approaches , each with their own advantages and limitations.

Utility-based measures

Applied CGE modellers frequently use utility-based measures to show the welfare impacts of policy changes. For example, EV is one such welfare measure, showing the money-metric utility that households obtain from the consumption of goods and services.[1] These types of indicators are complicated to measure and explain, because they rely on assumptions about people's preferences. Not being linked to national accounts data, exposition of the mechanisms driving changes, and attempts to reconcile those changes with other reported results, can be difficult.

Utility-based measures omit important components of domestic welfare. The EV measure, derived from household consumption, does not account for taxes paid to the government (which finances valuable services) and savings used for investment (which supports future consumption). One method used to address these omissions is to combine household, government and the investment of savings to form a "super household", so that a national welfare measure of EV can be derived from the super household's utility.[2] This approach, however, is not based on the theory underpinning the CGE models, as the investment and government demands are not derived from the same utility-maximising behaviour as

[1] For example, the LINKAGE model uses an EV measure, derived from an extended linear expenditure system (ELES) (van der Mensbrugghe 2005). The MONASH model calculates a welfare measure as differences in the Laspeyres and Paasche indexes of real household expenditure (Dixon and Rimmer 2002).

[2] For example, the GTAP model uses an EV measure based on a utility function for a "super household" in each country; the utility function is a Cobb-Douglas function of real expenditure on private consumption, current public expenditure and net savings (Hertel 1997).

household consumption. This exacerbates the challenges associated with reconciling the measures with national accounts data, and further complicates exposition and interpretation.

National-accounts-based measures

National-accounts aggregates are also used to gauge the welfare impacts of policy change. GDP and other indicators of national income are straightforward to calculate and frequently reported in CGE model results. However, GDP shows the goods and services that are produced by a country (or the factor payments made in a country), which are not necessarily consumed (or received) in full by residents. Welfare is determined not only by how much income a country can generate, but by how many goods and services residents could purchase with that income. Purchasing power has to be taken into account if national income is used as a welfare measure.

A measure of the purchasing power must relate income to a relevant price index. For example, Dixon (2016) defines a measure of real income as nominal GDP deflated by the consumer price index (CPI), instead of the GDP deflator. It is argued that the CPI captures terms of trade effects, which are absent from the GDP deflator. However, the CPI is based on private household expenditure, which uses only part of a country’s total income. Further, as an income measure, GDP includes returns accruing overseas, so further corrections are required.

An alternative national-accounts-based measure: real expenditure

An alternative measure, proposed in this paper, is real GNA, a measure of real national expenditure. This measure combines the strengths of utility-based and national-accounts-based approaches. It incorporates all of the components found in utility-based measures — the amount of household and government consumption national income can generate, domestically sourced savings and investment net of overseas payments, all converted to implicit quantities or real values through appropriately defined deflators — but it calculates those components from pre-existing national-accounting aggregates.

The measure of real GNA is explained in this section. The explanation starts with a derivation from the nominal national-accounting variables, and then uses deflators to illustrate their real components. The process setting out the derivation not only provides a foundation for the measure, but also provides an intuitive guide for exposing results (both in terms of results from models, as well as changes in reported macro-statistics). By tracking through the components of real GNA via the sequence of macro-accounting identities and price differentials, policy analysts have a structured way of explaining the mechanisms driving the impacts on the whole economy that could result from policy changes.

Deriving a measure of real expenditure from national accounting relationships

National income can be measured from the production and consumption sides. On the production side, national income is equal to the value of sales of all goods and services that a country produced for final users. In the system of national accounts, this is called Gross Domestic Product (GDP), defined as the value of goods and services used by households (C) and government (G), for final consumption and investment (I), and for export (X), net of imports (M):

$$GDP = C + G + I + (X - M) = GDA + TAB \quad (1)$$

The sum of consumption, government and investment is referred to as Gross Domestic Absorption (GDA)[3] and the difference between exports and imports is the trade account balance (TAB) (set out in a country's balance of payments (BoP)).

Nominal GDP is also equal to the sum of factor incomes, which is the same as industry value added. If imports are subtracted from C, G and I, GDP can be rearranged as the value of domestic production:

$$GDP = C^{Dom} + G^{Dom} + I^{Dom} + X \quad (2)$$

Equation (2) shows the sources of national income in terms of sales of produced goods and services. It does not show how such income is spent by residents.

GDP is an accurate measure of national income if no foreign income is included. In an open economy where foreign factors may be used in domestic production, a more accurate measure of national income is given by Gross National Product (GNP)[4], which is defined as GDP plus the income accruing domestically for locally-owned factors used in foreign countries (D), minus the income paid to foreigners for the factors they own locally (F). The difference between the receipts (D) and payments (F) is a country's income account balance (IAB) in its BoP:

$$GNP = GDA + (X - M) + (D - F) = GDP + IAB \quad (3)$$

If the current account is not balanced, the difference is made up by net investment; for example, a deficit is financed by net inflows of investment from overseas, with national investment (I) greater than national savings (S),

$$(M - X) + (F - D) = I - S \quad (4)$$

Equation (4) shows that national income can be measured in two ways. On the left-hand side, the current account balance (CAB) plus GDA gives the production-side measure of national income, GNP. On the right-hand side of the equation, the capital account balance (KAB)

3 GDA is also referred to as gross national expenditure (GNE).

4 GNP is also referred to as gross national income (GNI).

plus GDA produces a consumption-side measure of national income. The two measures of national income are identical in nominal terms. However, they are not necessarily the same in real terms. This is because the product composition of a country's capital account is not the same as the composition of its current account, and therefore the price deflators are likely to be different. To distinguish it from GNP, the consumption side measure of national income is referred to in this paper as Gross National Absorption (GNA). It is defined as GDA plus savings net of investment, or the KAB:

$$GNA = GDA + (S - I) = C + G + S \qquad (5)$$

As a component of GDA, investment (I) can be cancelled out on the middle of equation (5), leaving GNA expressed as a measure of national expenditure on C, G and S only. National saving (S) represents the expenditure on capital goods, invested in the home or foreign countries. S is not necessarily equal to I, as saving can be invested overseas.

The equations above show the relationship between national income (GNP) and expenditure (GNA) in nominal terms. Equation (5) can be used to explain changes in the composition of spending, and equation (3) changes in the composition of income. This can be linked back to sales of domestic production through equation (2), and foreign accounts via (4).

Welfare comes from what a country can buy with its income

A country's welfare is not solely determined by its income from sales of its products (GNP), but more importantly by the goods and services it can buy with that income. This is the purchasing power, or real expenditure, of a country's national income, which is captured by real GNA.

Let $Q_{(r)}^{GNA}$ denote real GNA for country *r*. It can be derived as nominal GNA deflated by a price index, $P_{(r)}^{GNA}$. By defining $P_{(r)}^{GNA}$ as the quantity-share weighted average of the prices of its three components ($P_{(r)}^{C}$, $P_{(r)}^{G}$ and $P_{(r)}^{S}$), the following identity is implied:

$$Q_{(r)}^{GNA} = Q_{(r)}^{C} + Q_{(r)}^{G} + Q_{(r)}^{S} \qquad (6)$$

The key practical challenge in this calculation is the savings price index $P_{(r)}^{S}$. Unlike $P_{(r)}^{C}$ and $P_{(r)}^{G}$ (which can be derived from the prices of goods and services purchased by households and government), $P_{(r)}^{S}$ has to be derived from the prices of all inputs to the capital purchased with the savings. Appendix A contains a numerical example illustrating the data required for an accurate derivation of $P_{(r)}^{S}$.

Alternatively, $Q_{(r)}^{GNA}$ can be calculated as $Q_{(r)}^{GNP}$ adjusted by real BoP, $Q_{(r)}^{BoP}$. This is because the gap between $Q_{(r)}^{GNA}$ and $Q_{(r)}^{GNP}$ is the real difference between the capital and the current account. By combining equations (5), (3) and (4), and deflating the elements, real GNA is equal to:

$$
\begin{aligned}
Q_{(r)}^{GNA} &= Q_{(r)}^{GNP} + \left(Q_{(r)}^{S} - Q_{(r)}^{I}\right) - \left(Q_{(r)}^{X} - Q_{(r)}^{M}\right) - \left(Q_{(r)}^{D} - Q_{(r)}^{F}\right) \\
&= Q_{(r)}^{GNP} + \left(Q_{(r)}^{KAB} - Q_{(r)}^{TAB} - Q_{(r)}^{IAB}\right) \\
&= Q_{(r)}^{GNP} + Q_{(r)}^{BoP} \qquad (7)
\end{aligned}
$$

This implies that the GNA price deflator, $P_{(r)}^{GNA}$ can also be derived as a quantity-share weighted average of the GNP deflator $P_{(r)}^{GNP}$ and BoP price index $P_{(r)}^{BoP}$. The GNP deflator $P_{(r)}^{GNP}$ is easy to calculate. However, the calculation of $P_{(r)}^{BoP}$ is more complicated. It is the difference between the price indexes for the current account and capital account balances. Each of these price indexes needs to be calculated separately. For example, the price index for TAB, $P_{(r)}^{TAB}$, is the export price index $P_{(r)}^{X}$ minus the import price index $P_{(r)}^{M}$, weighted by their respective quantity shares. Note that $P_{(r)}^{TAB}$ is not a measure of the terms of trade (ToT is defined as the ratio of $P_{(r)}^{X}$ to $P_{(r)}^{M}$). It measures the effect of ToT changes on the real balance of a country's trade account.

As $P_{(r)}^{BoP}$ is a price difference in a country's BoP accounts, it could take a positive or negative value, which leads to a positive or negative $Q_{(r)}^{BoP}$ for an individual country. Globally, $Q_{(r)}^{BoP}$ must sum to zero, because the gain or loss for any individual country is just a transfer of real income from or to other countries.

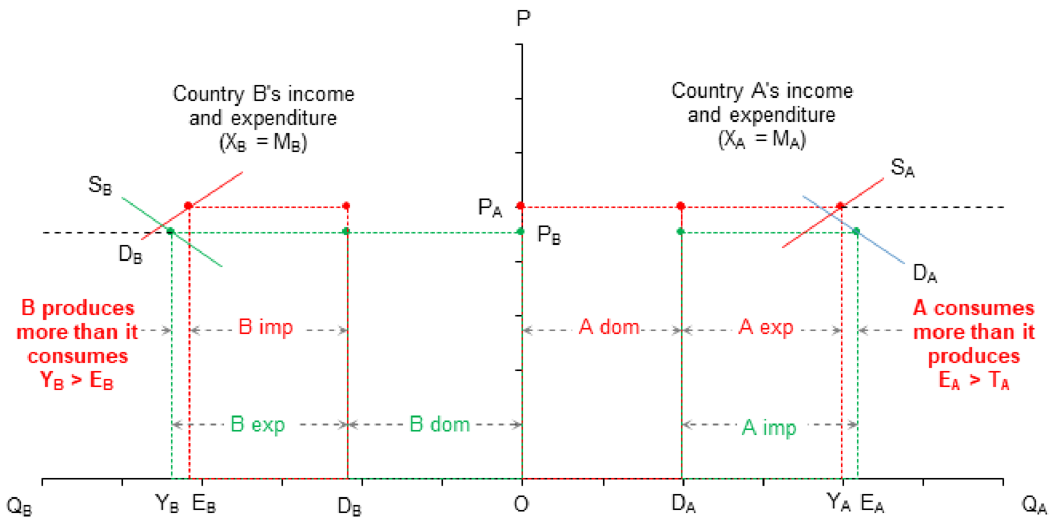
The link of $Q_{(r)}^{GNA}$ with $Q_{(r)}^{GNP}$ and $Q_{(r)}^{BoP}$ in equation (7) provides an intuitive explanation of why real GNA can be used to assess welfare. It shows that a country's welfare depends not only on how many real goods and services it can produce ($Q_{(r)}^{GNP}$), but also on the net gains it can obtain from foreign trade and investment with other countries ($Q_{(r)}^{BoP}$). The latter is due to the relative price differences between countries. For example, if the price of exports is higher than the price of its imports, a country receives a net income gain from trade. Similarly, if the price of foreign capital goods that a country purchases is lower than the price of home capital goods that foreign countries purchase, the country has a net gain from its capital account because the same savings can purchase more foreign capital goods. Such gains can also be described as increases in the purchasing power of a country's nominal income.

The components of equation (7) allows for a detailed analysis of how national income is produced and how it is redistributed between countries by the differences in their terms of trade and investment.

A graphical explanation of real income and expenditure

The relations between real income and expenditure and their implication for welfare comparison can be illustrated using a simple two-country world model, shown in figure 1. In the figure, the right and left panels show the income and expenditure of countries A and B, respectively. It is assumed that the price of output is higher in country A than in country B. On the production side, each country produces output Y at price P, consumes D and export the rest (Y – D). Its national income can therefore be calculated as equal to P*Y. As one country's exports is the other country's imports, by swapping the areas of exports, each country's consumption E can be shown as equal to D plus import (E – D). National expenditure can therefore be calculated as equal to P*D plus the area of its imports (or the other country's exports). As trade is balanced (the areas of exports and imports are equal), national income and expenditure must be equal in nominal terms. However, their real income and expenditure are not equal: country A consumes more goods than it produces, while country B produces more goods than it consumes. Therefore, a net gain, measured as the gap between Y and E, is transferred from B to A. This is because country A enjoys a beneficial terms of trade, which results in country B exporting more in real terms to balance its trade with A. This gives country A's income a greater purchasing power.

Figure 1 **Income and expenditure in a two-country world model**



Measuring the effects of a policy change

The effect of a policy change can be described by the changes in real expenditure (GNA), defined as a sum of the changes in the consumptions of household and government and national savings:

$$\Delta Q^{GNA}_{(r)} = \Delta Q^{C}_{(r)} + \Delta Q^{G}_{(r)} + \Delta Q^{S}_{(r)} \quad (8)$$

Alternatively, it can be defined in terms of the changes in real income (GNP) plus the changes in real BoP accounts:

$$\Delta Q^{GNA}_{(r)} = \Delta Q^{GNP}_{(r)} + \Delta Q^{BoP}_{(r)} \quad (9)$$

This expression can be manipulated further to express $\Delta Q^{GNA}_{(r)}$ as a function of changes in income and change in external relative prices:

$$\Delta Q_{(r)}^{GNA} = \Delta Q_{(r)}^{GNP} - \Delta P_{(r)}^{BoP} \quad (10)$$

where $\Delta P_{(r)}^{BoP}$ is the changes in the price index for the BoP. This is because the changes in nominal BoP must equal zero, so that $\Delta Q_{(r)}^{BoP} = -\Delta P_{(r)}^{BoP}$. Since $\Delta Q_{(r)}^{BoP}$ can be replaced by $-\Delta P_{(r)}^{BoP}$, it can be replaced with the following sum of price changes,

$$\Delta Q_{(r)}^{BoP} = \Delta P_{(r)}^{TAB} + \Delta P_{(r)}^{IAB} - \Delta P_{(r)}^{KAB} \quad (11)$$

Note that the three components of $\Delta P_{(r)}^{BoP}$ capture the effects of changes in relative prices in a country's current and capital accounts, or the terms of trade and investment effects. This implies that the welfare effects of a policy change can be explained by changes in real income, from a country's production, and changes in net transfers from other countries that are due to the changes in the terms of trade, investment and factor prices. So welfare changes are a function of changes in the income produced by residents, adjusted for any changes in purchasing power of this income.

Although the basic idea behind the concept of real expenditure is straightforward, there are practical difficulties in measuring real expenditure in CGE models. This is partly due to the lack of detailed information on bilateral BoP accounts, especially on the flows of investment between countries. Without such information, an important component in calculating real GNA, saving price index, cannot be accurately calculated. In appendix A, a global CGE model is used as a numerical example to show what additional data are required for accurately measuring real GNP and GNA. In appendix B, two examples of other CGE models are also used to show, if the required BoP account data are unavailable, what alternative methods can be applied to obtain an approximate measure of real GNA, which can still be interpreted as a welfare indicator in those models.

Appendix A: Measuring real GNA in a global CGE model with full BoP data

In this appendix, a modified GTAP model with an extended database that includes the existing trade matrix and two new matrixes of bilateral capital and investment[5] is used to demonstrate how accurate measures of real national income (GNP) and expenditure (GNA) are computed.

Model and database extension

The modification is based on the version 6.2 of the GTAP model (Hertel and McDougall 2003) and version 7.0 of its database (Narayanan and Walmsley 2008). With foreign capital ownership, it is assumed that the firm's demand for capital is a CES composite of domestic and foreign capital stocks. The after-tax incomes of foreign capital owners are transferred from countries where the capital is located to their owner countries. The bilateral foreign capital income matrix for five economies and the rest of the world is shown in table A1.

Table A1 **Foreign income matrix for selected countries (US$ billion)**

		To						
		AUS	CHN	JPN	USA	EUN	ROW	Total
	AUS	0	0.5	1.1	7.6	4.7	5.8	19.6
	CHN	0.2	0	0.6	7.4	4.3	2.8	15.3
	JPN	5.0	5.3	0	108.5	50.1	46.0	214.9
From	USA	27.0	7.7	28.3	0	342.9	290.9	696.8
	EUN	11.9	5.8	10.1	282.2	0	205.5	515.5
	ROW	4.4	9.0	6.0	124.9	131.3	0	275.6
	Total	48.5	28.2	46.1	530.7	533.1	551.0	1,737.7

Source: Productivity Commission 2010b.

5 This model was used to analyse the effects of various trade agreements for a report on *Bilateral and regional trade agreements* (Productivity Commission 2010a). The details of the model and database are referred to the supplement to the report (Productivity Commission 2010b).

The bilateral gross saving-investment matrix is shown in table A2, which is extended from the national saving and investment data, implied in the database with additional data from the IMF's *International Financial Statistics* (IMF).[6]

Table A2 **Gross saving-investment matrix for selected countries (US$ billion)**

		To						
		AUS	CHN	JPN	USA	EUN	ROW	Total
	AUS	101.7	0.1	0.4	6.0	2.6	2.7	113.3
	CHN	1.9	679.9	1.9	55.6	22.3	8.7	770.3
	JPN	9.9	1.8	1,074.0	199.0	63.9	31.3	1,380.0
From	USA	22.0	1.1	8.8	1,453.8	179.1	131.8	1,796.6
	EUN	11.5	1.0	3.7	251.5	2,108.6	94.7	2,471.1
	ROW	9.5	4.5	6.1	232.4	158.8	1,787.1	2,198.5
	Total	156.5	688.2	1,095.0	2,198.5	2,535.2	2,056.4	8,729.7

Source: Productivity Commission 2010b.

The row totals are the national gross savings, while the column totals are the national gross investment. The differences between national investment and savings are the net foreign investment. Savings can be invested at home and abroad to maximise expected returns.

Measuring the effects of a policy change on real GNP and real GNA

The modified model can now be used to simulate the effects of a policy change on the different measures of national income and expenditure. The policy change is a bilateral, 25 per cent increase in tariffs on goods traded between the USA and China. The simulated changes in real national income, expenditure and utility are presented in table A3.

6 The IMF's financial statistics provide foreign investment flow and stock data (column totals), while the GTAP database provides national saving data (row totals). Bilateral elements are extrapolated using shares from bilateral FDI as reported in CEPII. For details, see Productivity Commission 2010b.

Table A3 **Changes in real GDP, GDA, GNP and GNA with full BoP data (US$ billion)**

	d_qGDP	d_qGDA	d_qGNP	d_qGNA
AUS	0.18	0.18	0.12	0.13
CHN	-41.12	-57.40	-40.04	-57.62
JPN	3.12	5.85	2.60	5.05
KOR	1.70	2.60	1.60	2.43
CAN	1.77	3.13	1.32	2.85
USA	-32.47	-29.39	-28.35	-24.83
MEX	7.28	8.76	6.78	8.37
EUN	8.73	12.33	6.95	10.77
ROW	12.92	16.04	11.13	14.95
World	**-37.89**	**-37.89**	**-37.89**	**-37.89**

Source: The author's simulation.

In this table, the variable `d_qGNP` is defined as the change in real GDP plus the change in the foreign income account balance, that is, the real income generated by the use of capital abroad, net of the real income paid to foreign owners of capital.

```
d_qGNP(r) = d_qGDP(r) + sum{s,reg, FCapInc(r,k)/100 * qK_j(r,s)
                                   - FCapInc(s,r)/100 * qK_j(s,r)}; (A1)
```

where `FCapInc(r,s)` is the bilateral foreign capital income matrix, shown in table A1, and `qK_j(r,s)` is the region *s* demand for capital owned by region *r*.

The variable `d_qGDA` is defined as the change in private and public consumption plus the change in gross investment.

```
d_qGDA(r) = d_qPRIV(r) + d_qGOV(r) + d_qcgds(r);                  (A2)
```

The variable `d_qGNA` is defined as the changes in private and public consumption plus the changes in real savings, aggregated from the capital goods purchased at home and abroad.

```
d_qGNA(r) = d_qPRIV(r) + d_qGOV(r)
          + sum{s,reg, GSavGInv(r,s)/100 * qGInv(r,s)};           (A3)
```

where `GSavGInv(r,s)` is the bilateral gross saving-investment matrix, shown in table A2, and `qGInv(r,s)` is the percentage change variable for the investment demand of region *s* for savings from region *r*.

Globally, all measures of production, income and expenditure decrease by the same amount in real terms (table A3). This is because the four measures capture, from different aspects, the production and utilisation of the same real income in the world. Changes in the global allocation of production, income and expenditure differ however across countries. The real GDP and GDA represent the real income and expenditure, produced and consumed within a country, while real GNP and GNA represent the real income and expenditure, produced and consumed by residents, accounting for any foreign ownership. Real GNP and GNA are indicators of how a country's real income is produced and how this income is consumed by residents. Especially, real GNA indicates the purchasing power of a country's national income, which is an accurate measure of the benefits or losses from a policy change.

Decomposing results for real GNA

As mentioned in the previous section, the change in real GNA can be decomposed into changes in real GNP and the terms of trade and investment effects on the BoP accounts,

```
d_qGNA2(r) = d_qGNP(r) + d_qBOP(r);
```
(A4)

where `d_qBOP(r)` is the real change in the BoP, defined as the difference between the current and capital account balances, caused by international relative price changes,

```
d_qBOP(r) = d_pTAB(r) + d_pIAB(r) - d_pKAB(r);
```
(A5)

where `d_pTAB(r)` is the effect of terms of trade changes on the balance of trade,

```
d_pTAB(r) = sum{i,TRAD_COMM, sum{s,REG, VXWD(i,r,s)/100 * pfob(i,r,s)}}
                           + sum{m,MARG_COMM, VST(m,r)/100 * pm(m,r)}
            - sum{i,TRAD_COMM, sum{s,REG, VIWS(i,s,r)/100 * pcif(i,s,r)}};
```
(A6)

`d_pIAB(r)` is the effect of rental price changes on the balance of foreign income account:

```
d_pIAB(r) = sum{s,reg, VOA_cap_j(r,s)/100 * psK_j(r,s)
                     - VOA_cap_j(s,r)/100 * psK_j(s,r)};
```
(A7)

where `VOA_cap_j(r,s)` is the bilateral capital stock matrix and `psK_j(r,s)` is the rental price of capital, net of income tax.

`d_pKAB(r)` is the effect of investment goods price changes on the balance of capital account:

```
d_pKAB(r) = sum{s,reg, GSavGInv(r,s)/100 * pcgds(s)
                     - GSavGInv(s,r)/100 * pcgds(r)};
```
(A8)

The decomposition of changes in real GNA is shown in table A4.

Table A4 **Decomposition of the changes in real GNA (US$ billion)**

	d_qGNA2	d_qGNP	d_qBOP	d_pTAB	d_pIAB	d_pKAB
AUS	0.13	0.12	0.00	-0.01	0.02	0.01
CHN	-57.62	-40.04	-17.57	-17.74	0.75	0.59
JPN	5.05	2.60	2.45	3.14	0.55	1.24
KOR	2.43	1.60	0.83	1.04	-0.04	0.17
CAN	2.85	1.32	1.53	1.68	-0.38	-0.23
USA	-24.83	-28.35	3.52	1.65	-1.42	-3.28
MEX	8.37	6.78	1.59	1.64	-0.30	-0.25
EUN	10.77	6.95	3.82	3.74	1.10	1.03
ROW	14.95	11.13	3.82	4.85	-0.29	0.73
World	**-37.89**	**-37.89**	**0**	**0**	**0**	**0**

Source: The author's simulation.

The first column is the results for the alternative measure of changes in real GNA, which are identical to that shown in table A3, where it is derived from the quantity changes in C, G and S. The increase in tariffs on trade between the US and China distorts domestic relative prices in both economies, resulting in a misallocation of resources in both countries. The loss in allocative efficiency is revealed by the decreases in real national income in the two countries: real GNP declines by US$28.35 billion in the US and US$40.04 billion in China. Moreover, the tariff increase also affects the international relative prices between countries, which alter the purchasing power of national income produced. The results show that the US benefits from these relative price changes, while China suffers a loss from such changes. These effects are captured by the changes in the two countries' BoP accounts: the US gains by US$3.52 billion and China loses by US$17.57 billion. Overall, China's real GNA, declines by US$57.67 billion, greater than the decline in its production income, GNP, while the US real national expenditure, GNA, declines by US$24.83 billion, less than its produced national income.

It can also be seen from the table what contributes to the BoP results. In the case of China, the change in its BoP results almost entirely from the worsening of its terms of trade. In the case of the US, the gains in the terms of trade (d_pTAB) is largely offset by the loss in its net foreign income (d_pIAB). Therefore, the gains in its capital account dominate the overall gains in its BoP.

This decomposition of changes in real GNA provides an intuitive way of interpreting welfare effects of a policy change. Changes in real GNA can be decomposed into a factor allocation efficiency effect across industries and across borders and a broadly defined terms of trade effect. The former is captured by any change in real GNP, while the latter is captured by the changes in a country's external accounts that result from changes in international relative prices and the changes in quantities that they cause. The change in a country's real GNP represents the gains or losses in physical production. The change in the BoP reflects the changes in the purchasing power of national income, which redistributes the produced national income between countries through variations in international relative prices.

Appendix B: Measuring real GNA in CGE models with limited BoP data

Most policy-oriented CGE models do not include complete BoP data, particularly, bilateral capital account data, which is required to measure real GNA accurately. In this section, two examples are provided to test the alternative ways of measuring real GNA in CGE models with limited BoP data.

Real GNA in a global model without bilateral capital account data

This section uses the GTAP model and its version 7 database (Narayanan and Walmsley 2008) to show how to calculate real GNA in a global CGE model with limited BoP data. The GTAP database includes only bilateral trade account data. Without the saving-investment matrix, foreign capital investment can only be estimated as net flows between the national saving and investment aggregates that are implied in the database. The model is used to simulate the impacts of the same policy change as used in appendix A, a 25 per cent rise in the US tariffs on the bilateral imports between the US and China.

According to the GTAP model theory, the saving price for a country is defined as the investment goods price for the country, adjusted by a scaling factor.

```
psave(r) = pcgds(r)
     + sum(s,REG, [[NETINV(s) - SAVE(s)] / GLOBINV] * pcgds(s)); (A9)
```

where psave(r) and pcgds(r) are the price of saving, net of depreciation, and the price of capital goods. The second term is the scaling factor, which is defined as the world average price of capital goods, weighted by the shares of net foreign investment in global investment. This scaling factor is used to ensure equality between global saving and investment.

Once the saving price is obtained, the real saving qsave(r) can be derived as the nominal saving divided by psave(r). Changes in real GNA can then be defined as

```
d_qGNA(r) = d_pPRIV(r) + d_qGOV(r) + d_qsave(r) + d_qDEP(r); (A10)
```

where d_qsave(r) is a quantitative index for the net savings of country *r*, derived from the nominal income and the saving price, psave(r).

The GTAP model defines a change variable, EV, which is also based on the saving price as defined above. It is therefore convenient to compare the change in real GNA with EV. As EV is net of depreciation, to be comparable with real GNA, the change in real depreciation needs to be added to EV to form a new variable `EVplus`.

```
EVplus(r) = EV(r) + d_qDEP(r);
```
(A11)

Table A5 reports various measures of national account aggregates, real GDA, GDP and GNA, and EVplus. As foreign factors and income are not identified via separate variables in the standard GTAP model, national income (GNP) is equal to GDP.

Table A5 **Changes in real GDA, GDP, GNA and EVplus with the GTAP model (US$ billion)**

	d_qGDA	d_qGDP	d_qGNA	EVplus
AUS	0.00	0.03	-0.06	-0.06
CHN	-54.86	-41.39	-57.06	-57.85
JPN	4.83	2.17	4.48	4.47
KOR	2.18	1.43	2.12	2.11
CAN	3.17	1.64	3.13	3.11
USA	-34.19	-34.47	-30.71	-30.64
MEX	9.20	7.19	8.80	8.75
EUN	7.93	4.50	7.30	7.29
ROW	12.85	10.02	13.11	13.09
World	**-48.90**	**-48.90**	**-48.90**	**-49.71**

Source: The author's simulation.

At the global level, real GDA, GDP and GNA are all equal because they measure the same global output, whereas EVplus does not. This is because EV is a money metric measure of utility, which is not based on national income. This is an advantage of real GNA: changes in real expenditure can be fully accounted for by changes in the production and distribution of real income.

At the individual economy level, changes in real GNA can also be measured as changes in real GDP plus the changes in the components of the BoP that result from terms of trade and investment changes. In the GTAP model, this may be defined as,

```
d_qGNA2(r) = d_qGDP(r) + d_pTAB(r) – d_pKAB(r);
```
(A12)

where `d_pTAB(r)` is the change in the trade balance due to terms of trade effects and `d_pKAB(r)` is the changes in the capital account, due to changes in the prices of investment goods. The former is easy to calculate, as shown in equation A6. Without a bilateral saving-investment matrix, however, the latter can only be defined using the saving price estimated in equation A9 above,

```
d_pKAB(r) = SAVE(r)/100 * psave(r) - NETINV(r)/100 * pcgds(r);
```
(A13)

The results are shown in table A6. The two methods of measurement produce identical results for real GNA. The changes in real GNA can also be decomposed into changes in real GDP and two BoP accounts. These results are broadly consistent with those in table A4.

Table A6 **Decomposition of the changes in real GNA with the standard GTAP model (US$ billion)**

	d_qGNA	d_qGNA2	d_qGDP	d_pTAB	d_pKAB
AUS	-0.06	-0.06	0.03	-0.02	0.07
CHN	-57.06	-57.06	-41.39	-17.38	-1.71
JPN	4.48	4.48	2.17	3.12	0.81
KOR	2.12	2.12	1.43	1.03	0.34
CAN	3.13	3.13	1.64	1.73	0.24
USA	-30.71	-30.71	-34.47	1.24	-2.52
MEX	8.80	8.80	7.19	1.72	0.10
EUN	7.30	7.30	4.50	3.75	0.95
ROW	13.11	13.11	10.02	4.81	1.72
World	**-48.90**	**-48.90**	**-48.90**	**0**	**0**

Source: The author's simulation.

There are also some differences for real GNA. For example, the price changes for capital account balance, `d_pKAB`, show less variations across countries in table A6 than in table A4. This is because the calculation of `d_pKAB` is based on national aggregate saving and investment, while in the previous model, it is based on a bilateral saving-investment matrix. Without this matrix, the saving price in the GTAP model cannot be defined as a weighted average of the prices of capital goods in all countries where the savings are invested. In the GTAP model, the saving price is instead defined as equal to a country's own investment price index, adjusted by a uniform scaling factor, which implies no country-specific differences in saving prices.

Without the information on how savings are invested across countries, saving prices cannot be accurately determined for individual countries. As a result, the country-specific variations in the changes in real GNA cannot be fully captured. For an accurate measure of saving price, the information on a bilateral saving-investment matrix is essential. Without such information, simplifying assumptions have to be made when defining a saving price. Different assumptions may lead to different definitions of saving prices. Although it is impossible to know how accurate they are, saving prices can still be measured consistently so that national account identities remain intact. So long as saving prices are estimated so that real expenditures add up to real incomes globally, real GNA can be calculated and used as an approximate (usually a lower bound, because the true differences are likely to be averaged out) welfare indicator for policy analysis in these global models.

Real GNA in a single-country model

Unlike global models, single-country CGE models do not include information on the behaviours of the rest of the world. Assumptions are usually made to model the responses of the rest of the world to the country's trade and investment activities. For example, in the case of a small country, the foreign prices of its imports and the foreign demands for its exports are assumed to be constant. If foreign capital is used in production, the payment of foreign capital income can be subtracted from the country's GDP to measure GNP. Real GNA can also be calculated using limited information on foreign investment. This is illustrated below with a model of the Australian economy, based on the 2012-13 input-output table (ABS, 2015).[7]

As the database reveals, Australia's GDP is AU$1,520,444 million, which is also its GNA. It has a trade deficit of AU$14,958 million, which implies a net inflow of foreign investment of the same amount. Without further information, it is assumed that the total savings of AU$416,911 million are spent entirely on purchasing domestic investment goods.

The simulation is a removal of all tariffs on the country's imports. The effects of this policy are presented in table A7. The supply-side effects of this policy change can be measured using the standard national accounting variables. The nominal GDP of the country decreases by 0.378 per cent, or AU$5,750 million. As the GDP deflator decreases more by 0.393 per cent, real GDP increases by 0.015 per cent, or AU$222 million.

Table A7 **Effects of trade liberalisation on national income and expenditure with the Australian model**

	GDP		GNA1		GNA2	
	%	AU$ million	%	AU$ million	%	AU$ million
Value	-0.378	-5,750	-0.378	-5,750	-0.378	-5,750
Price	-0.393	-5,972	-0.334	-5,076	-0.334	-5,076
Quantity	0.015	222	-0.044	-674	-0.044	-674

Source: The author's simulation.

On the demand side, without full BoP data, real GNA can only be measured approximately with the two methods introduced in previous sections. The first one, GNA1, is derived from nominal GDP (which is equal to GNP in this model, absent foreign capital and income), deflated by the GNA price index, which is a weighted average of the prices of the goods and services used in the consumptions of household and government, in inventory change and in investment—the latter being composed of investments made locally and abroad. All these price indexes are available in the model's solution, except for the investment price index,

7 A version of this model was used in a research report on *Rising protectionism: challenges, threats and opportunities for Australia* (Productivity Commission 2017a). The details of the model and database are found in the technical supplement (Productivity Commission 2017b).

which should be a weighted average of the prices of capital goods in the proportions of the investment flows because the savings is used to finance the purchase of investment goods locally and abroad. In percentage changes, the saving price `pSav` may be expressed as

```
pSav = 1/SAVE * (INVEST * pInv + NFI * pNFI);
```
(A14)

where saving (`SAVE`) is equal to domestic investment (`INVEST`) plus net foreign investment (`NFI`). On the right hand side of the equation, the price of net foreign investment `pNFI` is an unknown variable. Like other foreign variables in single-country models, without any additional information, it might be assumed constant for convenience, that is, independent of policy changes. According to the input-output table, Australia has a trade deficit of AU$14,958 million. This implies that its domestic investment is partially financed by an inflow of foreign savings. The saving price is, therefore, determined by the price of domestic investment, multiplied by the ratio of domestic investment to savings.

Once the saving price is determined, the price deflator for GNA can be calculated as a weighted average of the price indexes for household and government consumptions, inventory and the investment that is financed by the domestic savings. As shown in table A7, the result for the GNA2 price deflator is –0.334 per cent. As the nominal GNA declines by 0.378 per cent, this implies that the real GNA2 declines by 0.044 per cent, or AU$673 million.

The second measure, GNA2, is derived as the change in real GDP (AU$222 million) *plus* the change in trade balance (–AU$834 million), *minus* the change in the investment balance (AU$62 million). The change in GNA1 is therefore –AU$673 million, or a decline of 0.044 per cent from the base year, and the implied change in the GNA1 price deflator is therefore –0.334 per cent. This result shows that the terms of trade loss dominates the decline in real GNA.

The results are identical because the change in the terms of trade and investment captures the change in the GNA price deflator. This suggests that both measures of real GNA in this single-country model are a good indicator for real national expenditure, suitable for being used as an approximate measure of welfare for such models.

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