Online Supplementary Material

for

Windfall Resource Income, Productivity Growth, and Manufacturing Employment

August 22, 2014
S.1 Derivations
This appendix presents the derivations for the employment equations given in the text.

S.1.1 Derivations for Section 3.2
In this section there is no mining industry, and no windfall income. I set $\eta = 0$, write the good market clearing conditions (recalling that there is no international trade either):

$$Y_{at} = L_t C_{at}, \quad Y_{mt} = L_t C_{mt}, \quad Y_{st} = L_t C_{st}. \quad (S.1)$$

The equilibrium condition for the labor market is given in equation (6).

The first-order optimality conditions for the consumer’s utility maximization problem gives

$$\left( \eta_j \eta_m \frac{C_{mt}}{C_{jt}} \right)^{1/\nu} = \frac{P_{it}}{P_{mt}}, \quad j \in \{f, s\}. \quad (S.2)$$

Given perfect labor mobility across sectors, the first-order conditions for the firms’ profit maximization problem gives

$$\frac{P_{at}}{P_{mt}} = \frac{z_{mt}}{z_{at}}, \quad \frac{P_{st}}{P_{mt}} = \frac{z_{mt}}{z_{st}}. \quad (S.3)$$

Putting these two sets of first-order conditions together with the expressions for $C_{jt}$ gives

$$C_{at} = \left( \frac{\eta_a}{\eta_m} \right) \left( \frac{z_{at}}{z_{mt}} \right)^{\nu} (C_{mt} + \gamma_m) - \gamma_a, \quad (S.4)$$

$$C_{st} = \left( \frac{\eta_s}{\eta_m} \right) \left( \frac{z_{st}}{z_{mt}} \right)^{\nu} (C_{mt} + \gamma_m) - \gamma_s. \quad (S.5)$$

The goods-market clearing condition gives

$$z_{at} L_{at} = L_t \left( \left( \frac{\eta_a}{\eta_m} \right) \left( \frac{z_{at}}{z_{mt}} \right)^{\nu} (z_{mt} L_{mt}/L_t + \gamma_m) - \gamma_a \right), \quad (S.6)$$

$$z_{st} L_{st} = L_t \left( \left( \frac{\eta_s}{\eta_m} \right) \left( \frac{z_{st}}{z_{mt}} \right)^{\nu} (z_{mt} L_{mt}/L_t + \gamma_m) - \gamma_s \right). \quad (S.7)$$

Using the above expressions in the labor-market clearing condition gives

$$\frac{L_{at} + L_{mt} + L_{st}}{L_t} = \left( \left( \frac{\eta_a}{\eta_m} \right) \left( \frac{z_{mt}}{z_{at}} \right)^{1-\nu} \left( \frac{L_{mt}}{L_t} + \gamma_m \frac{z_{mt}}{z_{at}} \right) - \frac{\gamma_a}{z_{at}} \right) + \frac{L_{mt}}{L_t} \left( \left( \frac{\eta_s}{\eta_m} \right) \left( \frac{z_{mt}}{z_{st}} \right)^{1-\nu} \left( \frac{L_{mt}}{L_t} + \gamma_m \frac{z_{mt}}{z_{st}} \right) - \frac{\gamma_s}{z_{st}} \right). \quad (S.8)$$

Using the notation $l_{mt} = L_{mt}/L_t$ in the above equation, and solving for $l_{mt}$ gives equation (10).

S.1.2 Derivations for Section 3.3
In the general case with non-zero mining value-added, windfall income, and $0 < \eta < 1$, the first-order optimality conditions for the consumer’s utility maximization problem become

$$\left[ \left( \frac{\eta_j}{\eta_m} \right) \frac{C_{mt}}{C_{jt}} \right]^{1/\nu} = \frac{P_{it}}{Q_t}, \quad j \in \{a, s\}. \quad (S.9)$$
The budget constraint (5) can be written in per capita terms as

\[ P_{mt}Y_{mt}/L_t + P_{ot}Y_{ot}/L_t = P_{mt}M_t + P_{mt}^*M_t^*. \]

(S.10)

The right-hand side of this expression is \( Q_t C_{mt} \). Next define

\[ x_t = \frac{P_{ot}Y_{ot}}{L_t Q_t}. \]

Consequently, we have

\[ C_{mt} = \left( \frac{P_{mt}}{Q_t} \right) z_{mt} l_{mt} + x_t. \]

(S.11)

Using the above expression in the first-order optimality conditions gives

\[ l_{at} = \frac{L_{at}}{L_t} = \left( \frac{\eta_a}{\eta_m} \right) \left( \frac{Q_t}{P_{at}} \right)^{\nu} \left( \frac{z_{mt}}{z_{at}} \right) \left( \frac{P_{mt} l_{mt} + \frac{x_t}{z_{mt}} + \frac{\gamma_m}{z_{mt}}}{P_{mt}^* l_{mt} + \frac{x_t}{z_{mt}} + \frac{\gamma_m}{z_{mt}}} \right) - \frac{\gamma_a}{z_{at}}, \]

(S.12)

\[ l_{st} = \frac{L_{st}}{L_t} = \left( \frac{\eta_s}{\eta_m} \right) \left( \frac{Q_t}{P_{st}} \right)^{\nu} \left( \frac{z_{mt}}{z_{st}} \right) \left( \frac{P_{mt} l_{mt} + \frac{x_t}{z_{mt}} + \frac{\gamma_m}{z_{mt}}}{P_{mt}^* l_{mt} + \frac{x_t}{z_{mt}} + \frac{\gamma_m}{z_{mt}}} \right) - \frac{\gamma_s}{z_{st}}, \]

(S.13)

Next, define the following relative prices:

\[ \frac{P_{mt}}{Q_t} = \frac{P_{mt}}{P_{mt}^*} = \left( \frac{P_{mt}}{P_{mt}^*} \right)^{1-\mu} = q_t^{1-\mu}, \]

(S.14)

\[ \frac{Q_t}{P_{jt}} = \frac{P_{mt}^*}{P_{mt}^*} = \left( \frac{Q_t}{P_{jt}} \right)^{1-\mu} = \left( \frac{P_{mt}^*}{P_{mt}^*} \right)^{1-\mu}, \]

(S.15)

where, for \( j \in \{f,s\} \), the final equality follows from the first-order optimality conditions for the firms' profit maximization problem. Note also that

\[ \frac{x_t}{z_{mt}} = q^{1-\mu} \left( \frac{P_{ot}Y_{ot}/L_t}{P_{mt} Y_{mt}/L_{mt}} \right). \]

(S.16)

With these expressions in hand, the shares of employment in agriculture \( l_a \) and services \( l_s \) become

\[ l_{at} = \left( \frac{\eta_a}{\eta_m} \right) \left( \frac{z_{mt}}{z_{at}} \right)^{1-\nu} q_t^{(1-\mu)(1-\nu)} \left( l_{mt} + \frac{P_{ot}Y_{ot}/L_t}{P_{mt} Y_{mt}/L_{mt}} + q_t^{\mu-1} \frac{\gamma_m}{z_{mt}} \right) - \frac{\gamma_a}{z_{at}}, \]

(S.17)

\[ l_{st} = \left( \frac{\eta_s}{\eta_m} \right) \left( \frac{z_{mt}}{z_{st}} \right)^{1-\nu} q_t^{(1-\mu)(1-\nu)} \left( l_{mt} + \frac{P_{ot}Y_{ot}/L_t}{P_{mt} Y_{mt}/L_{mt}} + q_t^{\mu-1} \frac{\gamma_m}{z_{mt}} \right) - \frac{\gamma_s}{z_{st}}, \]

(S.18)

The labor-market clearing condition implies \( 1 = l_a + l_m + l_s \). Using this and the notation introduced in the main text in the above equation, and solving for \( l_{mt} \) deliver equation (13).
S.2 Supplementary figures and tables

S.2.1 Employment by industry, Canada (historical data).

The Canadian employment by industry data underlying figure S.1 is compiled from the following sources.

1871–1945: Covers “gainfully occupied” reported in census for 1871–1931 inclusive, and persons with jobs reported in the labor force survey for 1945. (1) Agriculture, Fishing, Trapping, and Forestry; (2) Mining; (3) Manufacturing; (4) Construction; (5) Tertiary Industries (Public Utilities plus Other Services) from Firestone (1958, Table 65).

1950–1960: Covers “total employment” from labor force surveys, and industry classifications based on Canadian Standard Industrial Classification (CSIC), 1948 edition. (1) Agriculture, Forestry, and Fishing; (2) Mining; (3) Manufacturing; (4) Construction; (5) Electricity, Gas, and Water; (6) Distribution (Commerce plus Transport, Communication, Storage); (7) Services; (8) Total employed from OECD (1963, p. 124) and OECD (1965, p. 28).


Figure S.1: Share of employment by industry, Canada (historical data)

Note: All data are as a percent of total industry employment. A) Agriculture includes agriculture, fishing, hunting and forestry, and Tertiary industry includes services plus electricity, gas and water. The peak for agricultural employment is approximate based on the fact that the level of agricultural employment in 1931 was higher than that of in 1945. B) Mining includes quarrying.

S.2.2 Hours worked employment

Figure S.2A–C shows the indexes of employment and total hours worked by industry in Canada. The tendencies one identifies by employment data are similar to those emerge from the hours worked data. In terms of shares, the broader tendencies are similar between the share of employment and share of hours worked by industry, and relative to employment, hours worked suggest a faster resource reallocation out of agriculture at the beginning of the sample period.

Figure S.2: Hours worked and employment, Canada

Note: “Employment” is number of persons engaged and “hours worked” is total hours worked by persons engaged. Source: KLEMS database.
S.2.3 Total factor productivity by industry

Figure S.3 shows the total factor productivity (TFP) estimates by industry from EU KLEMS database. (Statistics Canada refers to these as multifactor productivity estimates.) Notice that commodity producing industries in both countries have positive and strong TFP growth. However, in services only TFP growth in distribution is positive in Canada. All other major service industries exhibit negative TFP growth. Comparable data from the United States is also provided. (Triplett and Bosworth (2004) discuss estimating TFP in the service sector.) Have argued that in Canada official TFP underestimate realized productivity growth at the aggregate level. (It is possible that the negative TFP growth estimates in the service sector is a contributing factor to low aggregate estimates.) The response by Gu (2012) argues that Statistics Canada uses a methodology that is consistent with those used in other countries included in the EU KLEMS database.

Figure S.3: Total factor productivity by industry, Canada and U.S.

Note: Canadian data are from 1961 to 2010. U.S. data are from 1977 to 2007.
Sources: Canadian total factor productivity (TFP) are from the KLEMS database maintained by Statistics Canada. U.S. TFP are from EU KLEMS database.
S.2.4 Sensitivity results

Figure S.4 reports the sensitivity of the model-based share of employment in manufacturing to alternative parametrizations. Four different parametrizations are shown (see Table 1 for the complete parameter values):

1. The baseline model;
2. The model with productivity-growth effects only and parametrized based on the RMSE criterion;
3. An alternative value for $q$; and
4. An alternative value for $\Delta$. 
Figure S.4: Manufacturing employment in Canada (1961–2008): alternative parametrizations

Note: This figure compares realized manufacturing employment (normalized to 1 in 1961) with manufacturing employment from several parametrizations of the model in Section 3. The parameters reported in the figure are as follows: $\gamma_j$, $j \in \{f, n, s\}$ are the subsistence/endowment terms obtained by matching the share of employment by sector in 1961; $\nu$ is the elasticity of substitution in consumption between any two consumption goods obtained as the parameter with the lowest root mean squared error (RMSE) between actual and model-based share of employment series; and $\mu$ is the share of domestically-produced traded goods in non-food goods calibrated as explained in Appendix A. Share of employment in manufacturing in the baseline model is from figure 3. The series labelled as “Str. change stand alone” corresponds to the model with only the structural change effects and stand-alone parametrization; “$q = ToT$” uses the terms of trade (ToT4) instead of $q = P_m/P^*_m$; and “Dievert-Yu” use data on manufacturing terms of trade and net energy exports based on data in ?. See the main text for the model-based series, and Appendix A for data construction. The parameter values underlying the model-based data are reported in table 1.
S.2.5 Comparative analysis

Canada and Australia. Figure S.5 shows employment in manufacturing and the terms of trade in Australia and Canada.

![Graph A: Share of employment in manufacturing, 1970-2007](chart1.png)

![Graph B: The terms of trade, 1970-2007](chart2.png)

Figure S.5: Manufacturing employment and the terms of trade, Australia and Canada

Sources: A) Australian data are from EU KLEMS database (www.euklems.net, accessed 5 February 2013), and Canadian data are from KLEMS database as explained in Appendix A. B) Australian Bureau of Statistics, Australian System of National Accounts, Table 1: Key National Accounts Aggregates (www.abs.gov.au, accessed 5 February 2013), and Statistics Canada as explained in Appendix A.
Canada and United States. Although EU KLEMS (2012) contains internationally comparable data, the series for the United States do not start until 1977. Given this data constraint, the historical (1950–2010) comparative Canada and U.S. employment data underlying figure S.6 are compiled from the following sources.

Agriculture: For the United States, number of persons 16 years of age and over employed in agriculture from the Bureau of Labor Statistics, Employment status of the civilian noninstitutional population, 1940 to date, http://www.bls.gov/data/. For Canada, see the data source for figure S.1.

Total employment: For the United States, number of persons 16 years of age and over employed, civilian non-institutional population from the Bureau of Labor Statistics, Employment status of the civilian noninstitutional population, 1940 to date, http://www.bls.gov/data/. For Canada, see the data source for figure S.1.

Figure S.6: Employment by industry, Canada and the United States 1950–2010

Note: The correlation between Canadian manufacturing employment indexes in A) and Canadian manufacturing employment in B) is 0.84 for the period 1950–2010, and 0.99 for the period 1961–2010.

<table>
<thead>
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<tr>
<td>Actual data</td>
<td>333,942</td>
<td>357,136</td>
<td>215,307</td>
<td>−32,786</td>
<td>224,792</td>
<td>−231,870</td>
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<td>Baseline model</td>
<td>249,835</td>
<td>138,029</td>
<td>352,373</td>
<td>−13,531</td>
<td>1,375</td>
<td>−109,394</td>
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<tr>
<td>No windfall income</td>
<td>740,138</td>
<td>154,615</td>
<td>385,869</td>
<td>19,239</td>
<td>165,936</td>
<td>112,493</td>
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<td>Productivity-growth only</td>
<td>702,870</td>
<td>162,886</td>
<td>227,450</td>
<td>121,534</td>
<td>173,733</td>
<td>112,308</td>
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<tr>
<td>Alternative $\mu$</td>
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<td>384,536</td>
<td>−29,589</td>
<td>5,113</td>
<td>−106,433</td>
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<td>$q=$ToT4</td>
<td>354,953</td>
<td>221,316</td>
<td>194,047</td>
<td>149,683</td>
<td>18,162</td>
<td>−150,057</td>
</tr>
<tr>
<td>Diewert-Yu</td>
<td>224,394</td>
<td>156,331</td>
<td>197,249</td>
<td>101,912</td>
<td>21,296</td>
<td>−138,147</td>
</tr>
</tbody>
</table>

Note: This table shows the changes in the share of employment in manufacturing for the sample period and sub-periods for the actual and model-based series based on alternative parametrizations of the model in Section 3. See footnote 23 in the text for the method underlying these calculations. Note that a declining share of employment in manufacturing may be consistent with an increase in the level of manufacturing employment. The rows corresponding to the baseline model are based on data in figure 3. The remaining models are as follows: “No windfall income” turns off resource income effects by setting $P_{\alpha}Y_{\alpha} = 0$; “Productivity-growth only” turns off all international trade effects; “$q=$ToT4” uses the terms of trade instead of $q$; and “Diewert-Yu” uses the terms of trade and net energy exports based on data reported in Diewert and Yu (012b). Parameter values for the models with no windfall income and productivity-growth only are identical to the baseline model. See table 1 for the remaining parameter values underlying these calculations.