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DISTRIBUTIONAL IMPACT OF COMMODITY PRICE SHOCKS: AUSTRALIA OVER A CENTURY

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ABSTRACT

Distributional Impact of Commodity Price Shocks: Australia over a Century*

This paper explores the distributional impact of commodity price shocks over the both the short and very long run. Using a GARCH model, we find that Australia experienced more volatility than many commodity exporting poor countries between 1865 and 2007. A single equation error correction model suggests that commodity price shocks increase the income share of the top 1, 0.05, and 0.01 percent in the short run. The very top end of the income distribution benefits from commodity booms disproportionately more than the rest of society. The short run effect is mainly driven by wool and mining and not agricultural commodities. A sustained increase in the price of renewables (wool) reduces inequality whereas the same for non-renewable resources (minerals) increases inequality. We expect that the initial distribution of land and mineral resources explains the asymmetric result.

JEL Classification: F14, F43, N17 and O13
Keywords: Australia, commodity exporters, commodity price shocks and income inequality

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1. Introduction

Commodity price shocks have powerful but unequal effects on labour, capital and land. A large literature, often referred to as the 'Dutch Disease' literature, documents the effects of commodity booms on factors of production (Gregory 1976; Corden and Neary 1982). An increase in global commodity demand and a subsequent rise in commodity prices trigger a sharp rise in commodity exports. Typically, this causes an appreciation in the exporter's real exchange rate which in turn harms competitiveness of other tradable sectors, like agriculture and manufacturing. As a result, employment in agriculture and manufacturing might decline following a resource boom.

Even though the mechanisms through which resource booms affect employment in a resource rich economy are well understood, surprisingly little is known about their distributional impact. On the theory front, the distributional impact of a commodity price shock should br modest if resources are mobile. However, if there are constraints on the intersectoral factor mobility then the distributional consequences of a price shock might be significant. Furthermore, political economy theorists assert that natural resources could have a significant impact on distribution through an institutions channel (Engerman and Sokoloff 1997, 2012; Acemoglu and Robinson 2006, 2012; Acemoglu *et al.* 2005).[1] They argue that natural resources influence the initial distribution of wealth and income, and thus of economic power. The distribution of economic power determines, in turn, the shape of future institutions and policies. Income and wealth inequality might, therefore, persist over the very

[1] Note that one of the key empirical foundations of the Engerman and Sokoloff argument is that inequality in Latin America was higher than North America. Perhaps, but what about Europe? Williamson (2010) and Milanovic *et al.* (2011) report that Latin American inequality around 1870 was in fact no higher than that of western Europe around 1800 when and where industrialization first started.

long run. The nature and magnitude of the impact of natural resources on income and wealth distribution is, however, dependent on the type of natural resources, their initial ownership, and other initial conditions.

The theoretical ambiguity associated with the impact of resource booms on income distribution makes this an ideal empirical question. Yet, the empirical literature on this topic is surprisingly thin. One reason for this could be the paucity of time series data on inequality in resource rich economies. A simple plot of the number of Gini observations per country and resource rent to GDP ratio in Figure 1 illustrates the research challenge. A negative correlation is apparent: resource rich countries have less inequality data.

This paper aims to address this gap by investigating the effects of Australian resource booms on income distribution over a century (1921-2004). In doing so, we are able to bypass the common limitations of omitted variable bias and the lack of internal validity associated with cross-national studies. Why choose Australia over other resource rich countries? First, Australia exports minerals, pastoral products and foodstuffs. Therefore, its history allows us to track any potential heterogeneous effects across commodities. Second, Australia offers high quality time series data on both commodity prices (Bhattacharyya and Williamson 2011) and income inequality measured by top income shares (Atkinson and Leigh 2007). Third, Australia has experienced more frequent and intense commodity price shocks than many resource rich developing countries. Therefore, Australian experience could yield useful insights even for commodity-exporting poor countries. In fact, we will argue that there are good reasons to think our findings can be generalized.

The analysis is conducted in three stages. First, the size and frequency of commodity price shocks experienced by Australia is compared with the rest of the world over the periods 1865-1940 and 1960-2007. We find that Australia experienced more volatility than many commodity exporting developing countries. Second, a single equation error correction model is estimated to quantify the effect of commodity price shocks on inequality, the latter measured by the income share of the top 1, 0.05, and 0.01 percents during 1921-2004. After controlling for GDP growth, interwar and wartime conditions, trade union density, direct tax shares in GDP, and enterprise wage bargaining, we find that commodity price shocks increased the income share of the top 1, 0.05, and 0.01 percents considerably. We also calculate the respective long run multipliers. Third, we examine the heterogeneous effects of wool, agriculture goods and mining prices. Wool and mining prices have been the main drivers of Australian inequality in the short run. In the long run, however, high wool prices reduce inequality whereas high mining prices increase it.

The empirical literature on the inequality and resource boom connection is relatively thin. Three recent recent studies deal with this topic.[2] Gylfason and Zoega (2003) use a neoclassical model to demonstrate that natural resource dependence increases inequality and reduces growth in cross-section data. Goderis and Malone (2011) use a two-sector growth model with learning-by-doing to demonstrate how resource booms drive inequality. Using panel data covering 90 countries and the period 1965 to 1999, they argue that resource booms have a negative short-term effect but no long-term effect. In contrast, Ross (2007) uses a qualitative approach, outlining policies to reduce inequality in resource rich countries. None of these studies analyse the effect of commodity price booms on distribution using very long term time series data as we do here.

Our study also relates to a large literature on the economic consequences of volatility. These studies typically focus on terms of trade volatility and show that it has a negative impact on long run growth (Fatás and Mihov 2006; Blattman *et al.* 2007; Loayza *et al.* 2007;

[2] For a review of the early research on this topic, see Aghion and Williamson (1998).

Koren and Tenreyro 2007; Poelhekke and van der Ploeg 2009; Williamson 2008, 2011).[3] Blattman *et al.* (2007) exploit the period 1870-1939, and Williamson (2008) exploits the period 1780-1913, but all the other papers focus on the post-1960 decades.[4]

Our study is also related to a growing literature on inequality measurement, especially of top income shares (Banerjee and Piketty 2005; Atkinson and Leigh 2007; Roine *et al.* 2009). These studies have documented income inequality using tax records which in their view is an improvement over the earlier use of household consumption and income surveys. Deininger and Squire (1996) offer one of the earliest examples of inequality computations using household data. Atkinson *et al.* (2009) present an excellent survey of this literature.

Finally, our study is also related to the resource curse literature. Sachs and Warner (2001, 2005) note that resource rich countries on average grow much slower than resource poor countries. Subsequent studies have argued that natural resources may lower the economic performance because they strengthen powerful groups and foster rent-seeking activities (e.g. Collier 2000; Torvik 2002). Others have argued that whether natural resources are a curse or a blessing depends on country-specific circumstances especially institutional quality (e.g. Mehlum *et al.* 2006; Robinson *et al.* 2006; Collier and Hoeffler 2009; Bhattacharyya and Hodler 2010; Bhattacharyya and Collier 2013) and ethnic fractionalisation. Hodler (2006), Ross (2011), and van der Ploeg (2011) present exhaustive surveys of this literature.

The remainder of this paper is organized as follows: Section 2 describes how we measure commodity price and inequality in the long run. We also examine the extent to which the commodity price shocks experienced by Australia relative to the rest of the world.

[3] Some of the early research on the impact of term of trade volatility on long-run growth are Ramey and Ramey (1995), Mendoza (1997), Deaton and Miller (1996), Kose and Reizman (2001), Bleaney and Greenway (2001), and Hadass and Williamson (2003).

[4] Using commodity price data since 1700, Jacks *et al.* (2011) show that globalization is associated with less commodity price volatility.

Section 3 introduces our empirical strategy to estimate the impact of commodity price shocks on top incomes and presents the results. Section 4 concludes.

2. A Century of Commodity Price Shocks and Inequality in Australia

Measuring Commodity Price and Inequality in the Long Run

The ratio of export to import prices (P_X/P_M), or the net barter terms of trade, is often used as a measure of commodity price movements. In order to assess the impact of these external price shocks on the economy as a whole, however, the prices of those two tradables should also be related to the prices of non-tradables. That is, a commodity export price boom (or bust) must be expressed relative to all other prices in the domestic economy in order to assess its impact on resource allocation and income distribution. Hence, the external terms of trade does not by itself offer an adequate measure of commodity price booms and busts relative to the rest of the economy. A more effective measure is P_X/P_Y which we use here and where P_y is the GDP implicit price deflator.

Australia has experienced frequent commodity price shocks since 1890. Figure 2 reports the movement in (P_X/P_M), P_X/P_Y and P_M/P_Y between 1890 and 2007. The internal relative prices P_X/P_Y and P_M/P_Y show less volatility than the external terms of trade P_X/P_M which is exactly what theory predicts (Dornbusch 1970).

Australia has undergone three major commodity price episodes over the past century[5]. The first half of the 1920s experienced a sharp increase in Australian commodity prices. The second major price shock occurred during the Korean War episode from the late 1940s to the early-mid 1950s and the third is what we have seen since 2003.[6] In terms of magnitude, the

[5] When Augmented Dickey-Fuller tests are performed on the price series, we do not find structural breaks. However, our plotted series clearly indicate the relative importance of the price shock episodes that we identify here.

[6] Bhattacharyya and Williamson (2011) provide a detailed historical account of these episodes.

Korean War boom appears to be more dramatic.

The relative prices of Australia's three major export commodities are plotted in Figure 3: wool, minerals, and agriculture goods. The 1920s boom was mainly driven by wool whereas the current boom has been driven by minerals. In contrast, the Korean War boom experienced relative price increases in all three commodity groups.

Inequality over our sample period is measured by the income shares of the top 1, 0.05 and 0.01 percent of the richest Australians (Atkinson and Leigh 2007).[7] The top income shares data has several advantages over household or income surveys supplying Gini coefficients of inequality. The surveys rely on the quality of responses from those interviewed, and over or underreporting can compromise the quality of the inequality measures. In contrast, top income shares are constructed using much more reliable tax data. The latter also allow us to analyse inequality over the very long run, which is not possible with survey-based inequality data since they are infrequent in present times absent from distant times.

Australian top income shares are plotted in Figure 4. The most notable feature here is the long run 20th century decline in this inequality measure, an event shared by almost all industrialized economies (Atkinson and Piketty 2008; see also Gordon and Dew-Becker 2008). The second notable feature is the rise in inequality across the 1980s and 1990s, again a feature shared by most other industrialized economies. However, Australia recorded two distinct departures from those long-run trends: the Korean War commodity price boom and bust, and the recent mining-led boom.

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[7] Like almost all studies exploring inequality, this one deals with nominal incomes. However, commodity price booms generate real exchange rate appreciation, a rise in non-tradable prices and a fall in import prices. To the extent that top income groups spend a much higher share of their incomes on now-more-expensive non-tradable services, while the working class spends a larger share on now-cheaper imports, real income inequality may rise by less than nominal inequality. We do not pursue these issues here, but see Gregory and Sheehan (2013).

Commodity Price Shocks in Australia and the Rest of the World

In order to explore the magnitude of the commodity price volatility experienced by Australia, we invoke a more rigorous exercise. Following the works of Engle (1982) and Bollerslev (1986), the generalized autoregressive conditional heteroskedastic (GARCH) framework is viewed as an extremely robust approach to modelling volatility of time series. This approach distinguishes between unconditional and conditional variances. It also incorporates a long memory in the data generating process by utilising a flexible lag structure. In particular, the GARCH (p,q) specification assumes that the conditional variance equals:

$$\sigma_t^2 = E(e_t^2 \mid \Omega_t) = \alpha + \sum_{i=1}^{p} \gamma_i e_{t-i}^2 + \sum_{i=1}^{q} \delta_j \sigma_{t-j}^2 \qquad (1)$$

where e_t is the t^{th} error term from an autoregressive model. In other words, the conditional variance here depends on its own past values as well as lagged values of the residual term.

Here we choose a very parsimonious GARCH (1,1) specification. Deb *et al.* (1996) notes that even in a parsimonious GARCH (1,1) specification the time serious behaviour of commodity price volatility is well captured.

Figure 5 plots the conditional variance of Australian commodity prices P_X/P_Y covering the period 1890 to 2008. This involved a two-step proceedure. First, the commodity price data was first differenced. Second, they were estimated as a GARCH (1,1) process and plotted over time. The plot reveals that there is no evidence of trend in commodity price volatility over time. However, the Korean War boom does stand out as the major volatility episode in Australia's commodity price history. This finding is consistent with Jacks *et al.* (2011) who report an increase in commodity price volatility during wartime.

Next we explore Australian commodity price volatility relative to the rest of the world. Figure 6 compares its volatility with that of Indonesia, India, Canada, and the USA over the period 1865-1940, by plotting the ratio of conditional variances. If the ratio is greater than 1 then it implies that Australia experienced more volatility than the country in question: parity in volatility between Australia and the country in question is signified by the horizontal line at the co-ordinate (0,1). On average, Australia experienced more volatility than India, Canada and the USA. Over the period 1920-1940, Australia had significantly greater commodity price volatility than did primary product exporting peripheral countries such as Indonesia and India. This exercise is repeated in Figure 7 for Argentina, Brazil, Nigeria, and Canada for the period 1960-2007, where we find the following: Australian commodity price volatility has been greater than Canada but less than Brazil throughout; Australian commodity price volatility during the current commodity boom is greater than that of Nigeria; and Australian commodity price volatility appears to be about on par with Argentina.

3. The Distributional Impact of Commodity Price Shocks

Economic Fundamentals

In order to explain the Australian connection between commodity prices and inequality since 1921, we review the long term trends of some of the key variables that will be used in our econometric analysis. Table 1 reports means of these variables, and it is apparent that the history of these variables could be divided into two eras: 1921-1941 and 1941-2004. The means are significantly different, suggesting that they contained significantly different economic fundamentals. The first period includes the Great Depression and the run up to the Second World War where the unemployment rate was so much higher and growth rate of GDP and real wages so much lower relative to the post-1941 period. In addition, inequality was much higher during the interwar years as was the case for most industrialized economies before inequality started falling in the 1930s, but especially after the Second World War and the rise of the welfare state. Trade union density was also much lower during

1921-1941, consistent with wartime and postwar growth in manufacturing and the related trade union movement.

Empirical Strategy

In order to analyse the effect of commodity price shocks on inequality over our Australian century, the following single equation error correction model is estimated:

$$\Delta \ln(TIS1\%)_t = \alpha + \beta_0 \Delta \ln(P_X / P_Y)_t + \beta_1 [\ln(TIS1\%)_{t-1} - \ln(P_X / P_Y)_{t-1}] + \Phi \mathbf{X}_t + \varepsilon_t \qquad (2)$$

where $\Delta \ln(TIS1\%)_t, \Delta \ln(P_X / P_Y)_t, [\ln(TIS1\%)_{t-1} - \ln(P_X / P_Y)_{t-1}]$ are the changes in log income share of the top 1 per cent, the change in log commodity export price relative to the GDP deflator, and the error correction term, respectively. The latter term captures any deviation from the long run equilibrium. The model also includes a vector of control variables $\mathbf{X}_t$ containing the GDP growth rate and a dummy variable for the period 1921-1941 (capturing the different economic fundamentals in that period).[8]

The coefficient of interest is β_0 which captures the short term effect of a commodity price shock on top income shares. The coefficient β_1 on the error correction term estimates the speed of return to the long run equilibrium after a short run deviation. All the major variables used here are integrated of the order one or I(1) and therefore our single equation error correction approach involving first differences is valid. Table 2 reports the unit root tests using both the adjusted Dickey-Fuller and Phillips-Perron approaches.

Commodity Price Shocks and Top Incomes

Table 3 explores the impact of commodity price shocks on inequality in the short run, and column 1 reports a 0.35 commodity price elasticity with respect to the top 1% income

[8] Using the more formal Zivot and Andrews test, we cannot find any 1941 structural break in $\ln(TIS1\%)_t$. However, we do find a 1951 structural break in $\Delta \ln(TIS1\%)_t$. See below and column 2 of Table 3.

share. In other words, a one percentage point increase in the commodity price growth rate would lead to a 0.35 percentage point increase in the top share growth rate. This seems like a large effect to us given the sample means are 10.7% and 7.3% in the two periods. The error correction term in column 1 is -0.05 and significant. This signifies that the error correction approach is appropriate as the coefficient lies between 0 and -1.

Column 1 includes a dummy variable for 1921-1941. As we argued above, this periodization is motivated by the economic fundamentals and history reported in Table 1. A more formal approach would be to conduct structural break tests. When a Zivot-Andrews structural break test is applied to the $\Delta \ln(TIS1\%)_t$ a structural break is found for 1951. As a robustness check, therefore, we replace the 1921-1941 dummy with a 1921-1951 dummy in column 2. Our results remain unaffected.

Additional controls to our main specification are added in columns 3 and 4. Column 3 adds war dummies for World War II and the Korean War. The coefficients are negative, suggesting a decline in inequality during the conflict, presumably due to price and rent controls, government constraints on profits, and appeals to patriotism. However, the effects are not significant and our main result remains unaffected. Column 4 adds trade union density, the direct tax share in GDP, and an enterprise bargaining dummy as further controls. The signs on these coefficients suggest that the increase in trade union density and the tax share in GDP during the post-war period may have reduced inequality. Furthermore, the introduction of enterprise bargaining towards the end of the century (1997) also may have lowered inequality as measured here.[9] However, none of the coefficients on these additional control variables are significant.

[9] Note that national wage decisions in Australia throughout the majority of the previous century were made via centralized wage setting institutions such as the Commonwealth Arbitration and Conciliation Court, Commonwealth Arbitration and Conciliation Commission, and Australian Industrial Relations Commission. This centralized wage setting process was significantly weakened by the introduction of enterprise bargaining in 1996/7.

During this century, the non-farm sector was the engine of Australian growth (Maddock and McLean 1987; Bhattacharyya and Williamson 2011). Since the non-farm sector could have impacted income distribution differently than did the rest of the economy, column 5 replaces the GDP growth rate with the non-farm GDP growth rate. Similar to aggregate GDP growth, non-farm GDP growth also appears to increase inequality in the short run. In column 6, we replace $\Delta \ln(P_X / P_Y)_t$ by $\Delta \ln(P_X / P_M)_t$, the terms of trade measure. Our result remains qualitatively unchanged.

Top Income Share Response by Commodity Group

Different natural resource exports might generate different development outcomes. Indeed, the resource curse literature suggests that countries exporting non-renewable resources (minerals, oil and gas) are more adversely affected than countries exporting renewable natural resources such as agricultural goods (Isham *et al.* 2005; Bhattacharyya and Collier 2013). But in high income and mature economies like Australia, more of the rents from extractive and non-renewable activities, such as mines and wells, accrue to the state. If the state implements progressive taxation and redistribution policies then at least some of these commodity-price-boom-induced rents will not serve to raise inequality. But some will, and that portion is higher the poorer the country and the weaker the government. In contrast, rents from agriculture, forestry and the pastoral economy accrue largely to local households and firms. They are, by definition, also sustainable. Hence, we might expect a substantially smaller proportion of these rents to be redistributed and thereby to increase inequality (depending on the initial distribution of land, of course). Table 4 resolves these theoretical ambiguities. There we report that it is mining (column 1) and wool (column 3) price booms that have increased Australian top income shares, at least in the short run. The effect of a change in the relative price of agricultural commodities (column 2) is positive but statistically insignificant.

Column 4 tests the significance of these coefficients when they are all included in the same model, and the positive effects of wool and mining prices survive. The coefficient on the agriculture price becomes negative but it is still statistically insignificant.

We conclude that wool and mining price booms increase top incomes in the short run. It appears that a shock in the price of agricultural commodities does not exert any statistically significant effect on top income shares. As we shall see below, however, the long run effects are somewhat different.

Commodity Price Shocks and the Very Top Incomes

So far we have focused on the income share of the top 1 per cent. In this section we check whether there is any heterogeneity within these top incomes. Table 5 reports the impact of a commodity price shock on the income share of the top 0.05 and 0.01 shares. Column 1 shows that the effect of a commodity price shock on the change in log income share of the top 0.05 per cent [$\ln(TIS0.05\%)_t$] is positive, statistically significant, and has a coefficient estimate of 0.38 which is a bit bigger than the 0.35 estimate reported for the top 1 per cent in column 1, Table 3. This implies that the beneficiaries of a commodity price shock are at the very top end of the income distribution. In the absence of data, we can only speculate that these are the owners of natural resources in the commodity export sector. Column 2 corroborates the hypothesis that the beneficiaries of a commodity price boom are at the very top end of the income distribution: when the dependent variable is changed to the log income share of the top 0.01 per cent [$\ln(TIS0.01\%)_t$], the estimated coefficient on $\Delta\ln(P_X / P_Y)_t$ increases to 0.45 and is strongly significant.

The Long Run Effects of Commodity Price Booms

The analysis thus far has focused on the short run distributional impact of commodity price shocks. Table 6 explores the long run equilibrium relationship between commodity price and income distribution. It is done in two steps. First, we estimate the following model:

$$\Delta \ln(TIS1\%)_t = \alpha_0 + \gamma_0 \ln(TIS1\%)_{t-1} + \gamma_1 \ln(P_X / P_Y)_t + \gamma_2 \Delta \ln(P_X / P_Y)_t + \xi_t \qquad (3)$$

The predicted values of $\Delta \ln(TIS1\%)_t$ from equation (3) are then used in equation (4) to estimate the long run equilibrium effects (also known as the Bewley (1979) transformation equation):

$$\ln(TIS1\%)_t = \alpha_1 + \delta_0 \Delta \ln(TIS1\%)_t + \delta_1 \ln(P_X / P_Y)_t + \delta_2 \Delta \ln(P_X / P_Y)_t + \eta_t \qquad (4)$$

The long run equilibrium effect is given by the coefficient δ_1: it estimates the long term effect of a one unit increase in $\ln(P_X / P_Y)_t$ on $\ln(TIS1\%)_t$. This long term effect will be distributed over future time periods according to the rate of error correction.

Column 1 of Table 6 estimates the long run equilibrium relationship between $\ln(TIS1\%)_t$ and the overall commodity price $\ln(P_X / P_Y)_t$: the effect is positive and significant. In the long run, the rich gain disproportionately more from an increase in commodity prices compared with the rest of the population, thereby increasing inequality. Columns 2-4 report the long run impact of wool, minerals and agriculture prices separately. We find that a sustained increase in wool prices benefits the rest of the society more than the top: wool price booms reduce inequality in the long run. In contrast, a prolonged mining or petroleum price boom enriches the top of the income distribution more than the rest of country. The effect of an increase in the prices of agricultural commodities is not statistically significant. These results are consistent with the resource curse literature which reports that non-renewable resource price booms are associated with poorer development outcomes than that of renewable resource price booms such as for agricultural products (Isham *et al.* 2005; Bhattacharyya and Collier 2013). No doubt, this result is likely to be driven in large part by the fact that farm land is distributed more equally than mineral resourcfe ownership, especially in “regions of recent settlement” dominated by the family farm.

Columns 5 and 6 explore the long run relationship between the overall commodity price $\ln(P_X / P_Y)_t$, on the one hand, and $\ln(TIS0.05\%)_t$ and $\ln(TIS0.01\%)_t$ on the other. The effect is positive and significant in both cases, and the magnitude of the long term effect also increases from 0.17 in column 1, to 0.40 in column 5, and to 0.84 in column 6. This result offers further support for the hypothesis that a sustained increase in commodity price benefits the very top more than the rest of the society.

4. Concluding Remarks

Studies of the distributional impact of commodity price shocks over the very long run are rare. Being a major commodity exporting country with good time series data, makes Australia the perfect candidate for an assessment of the inequality and commodity price boom connection. This paper investigates the effects of resource booms on income distribution in Australia over the century from 1921 to 2004. Using a GARCH model, we find that Australia experienced more volatility than many commodity exporting developing countries during the periods 1865-1940 and 1960-2007. Using a single equation error correction model, we also find that commodity price shocks increased the income share of the top 1, 0.05, and 0.01 per cents in the short run. The effect is robust after controlling for GDP growth, interwar and war, trade union density, direct tax shares in GDP, and enterprise wage bargaining. The short run effect is heterogeneous across different commodity groups as it is driven mainly by wool and mining and not agricultural commodities. The very top end of the income distribution (the top 0.05 and 0.01 per cents) benefit from commodity booms disproportionately more than the rest of the society.

We also look at the long run equilibrium relationship between commodity price and top incomes. All top income groups (1, 0.05, and 0.01 per cents) benefit from a sustained increase in commodity prices. The very top groups (0.05, and 0.01 per cents) benefit more than the top 1 per cent suggesting that the owners of land and mineral resources in the commodity sector inhabit the very top end of the income distribution. Sustained price increase in renewables such as wool reduces inequality whereas the same in non-renewable resources such as minerals and petroleum increases inequality. Agriculture does not seem to have any effect, perhaps because land used for that purpose is distributed much more equally.

Even though Australia is a developed and industrialized commodity exporting country, the price volatility it experienced since the late 19th century was greater than that for the average commodity exporting low income country. Thus, studying the distributional impact of commodity price shocks in Australia (Canada and New Zealand) could yield important lessons for primary producers from the developmental south. In short, our analysis seems timely and relevant, not just for Australia, but for all resource rich developing countries.

Our analysis shows that resource booms tend to exacerbate inequality. The recent literature on the economic consequences of inequality argues that high and persistent inequality not only harms growth but also adversely affects institutions (Aghion *et al.* 1999; Engerman and Sokoloff 1997, 2012; Acemoglu and Johnson 2006, 2012; Acemoglu *et al.* 2005). Therefore, it is important for resource rich developing countries to design appropriate policies to tackle inequality that emerges as a consequence of commodity export booms. Whether their political economy makes that possible is, of course, less likely than for mature economies like Australia. Thus, we hope that future research will seek good time series data from developing countries to see whether the magnitudes of impact are bigger than what we find for Australia as the political economy literature would predict.

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Data appendix

Commodity Export Price relative to GDP deflator (P_X / P_Y): Weighted average of export price of wool, minerals, and agricultural commodities relative to GDP deflator over the period 1890-2007. *Source*: Bhattacharyya and Williamson (2011).

Export Price of wool relative to GDP deflator (P_{XW} / P_Y): Weighted average of wholesale export price of wool in New South Wales and Victoria relative to GDP deflator over the period 1890-2007. Production of greasy wool is used as weights. *Source*: Bhattacharyya and Williamson (2011).

Export Price of mining relative to GDP deflator (P_{XM} / P_Y): Weighted average of export price of metals (silver, copper, tin, zinc, lead, gold) and coal relative to GDP deflator over the period 1890-2007. Production of metals and coal are used as weights. *Source*: Bhattacharyya and Williamson (2011).

Export Price of agricultural commodities relative to GDP deflator (P_{XA} / P_Y): Weighted average of export price of agricultural commodities (wheat, cereals, forestry and fisheries) relative to GDP deflator over the period 1890-2007. Productions of these commodities are used as weights. *Source*: Bhattacharyya and Williamson (2011).

Import Price relative to GDP deflator (P_X / P_Y): Import price index commodities relative to GDP deflator over the period 1890-2007. *Source*: Bhattacharyya and Williamson (2011).

Income Shares of the top 1%, 0.05%, 0.01% $[(TIS1\%), (TIS0.05\%), (TIS0.01\%)]$: *Source*:

Atkinson and Leigh (2007).

Commodity Export Price for Canada, Indonesia, India, and USA for the period 1865-1940: These prices are used in Figure 5. *Source*: Blattman et al. (2007).

Commodity Export Price for Argentina, Brazil, Canada, and Nigeria for the period 1960-2007: These prices are used in Figure 6. *Source*: Burke and Leigh (2010).

GDP Growth rate: Growth rate calculated using real GDP (measured at 1990 constant prices). *Source:* Bhattacharyya and Williamson (2011).

Non-Farm GDP Growth rate: Growth rate calculated using real Non-Farm GDP (measured at 1990 constant prices). *Source:* Bhattacharyya and Hatton (2011).

Trade Union Density: Defined as trade union membership as a proportion of employment. *Source:* Bhattacharyya and Hatton (2011).

Direct Tax Share: Share of Income Tax to Nominal GDP. *Source:* Bhattacharyya and Hatton (2011).

Figure 1: Resource Wealth and Missing Inequality Data

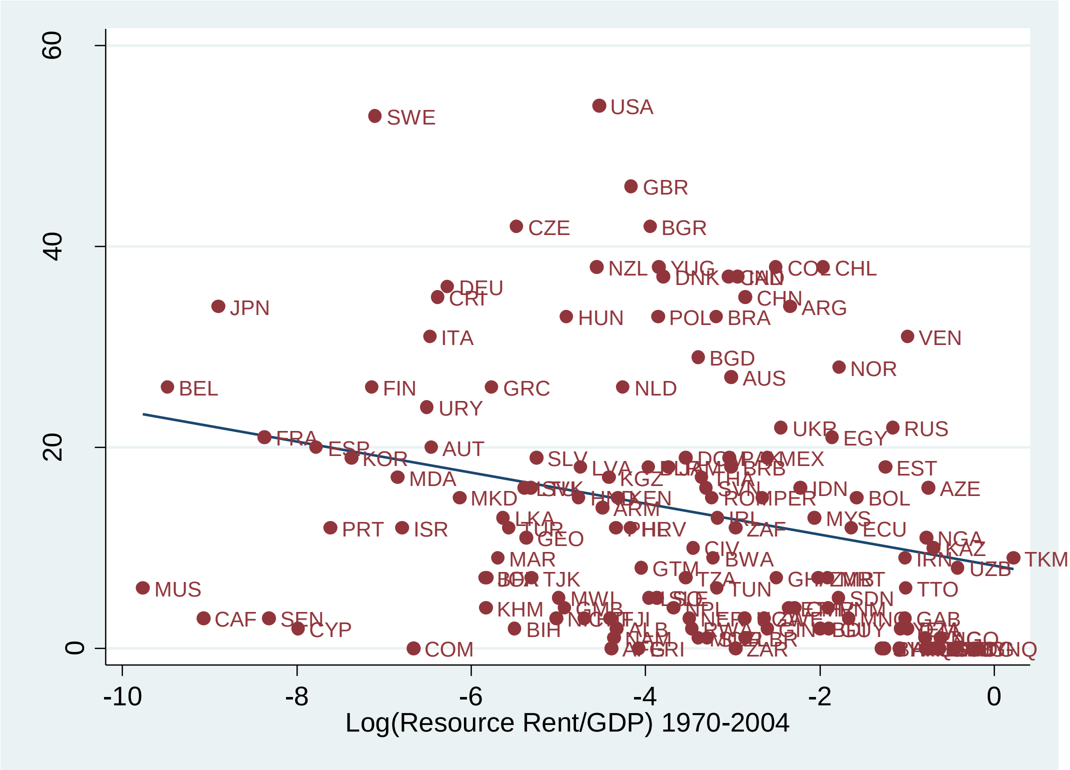


Figure 2: Australian Terms of Trade Time Series 1890 to 2007

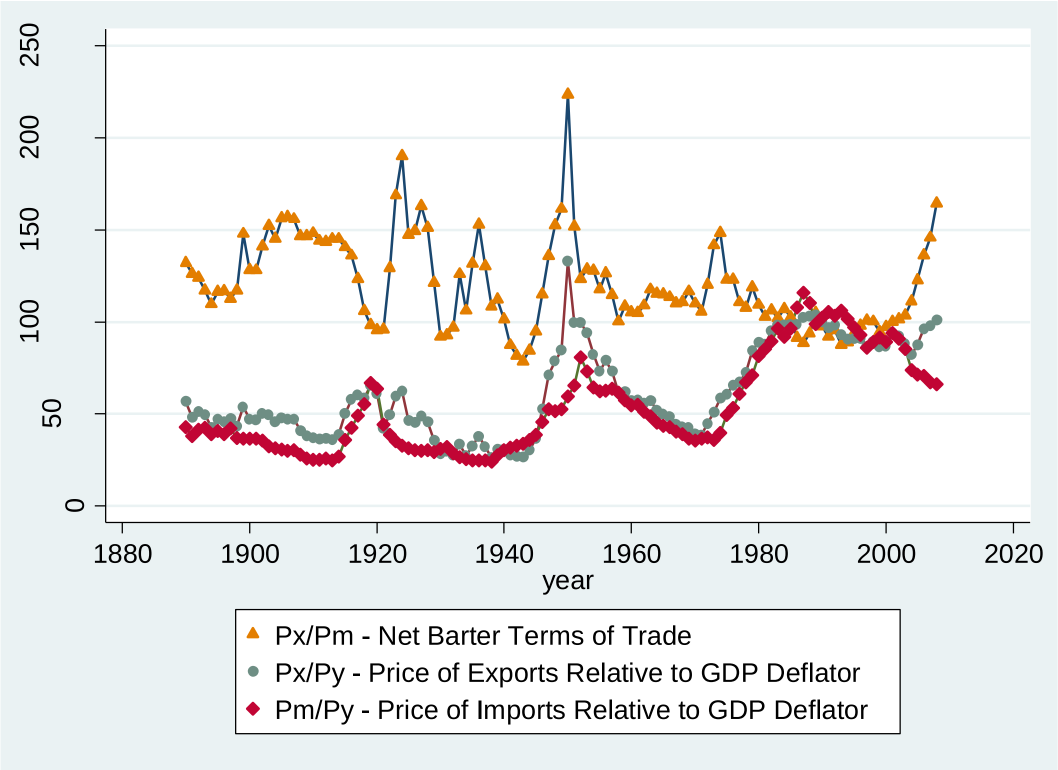


Figure 3: Export Prices of Wool, Mining, and Agriculture Relative to P_{GDP}

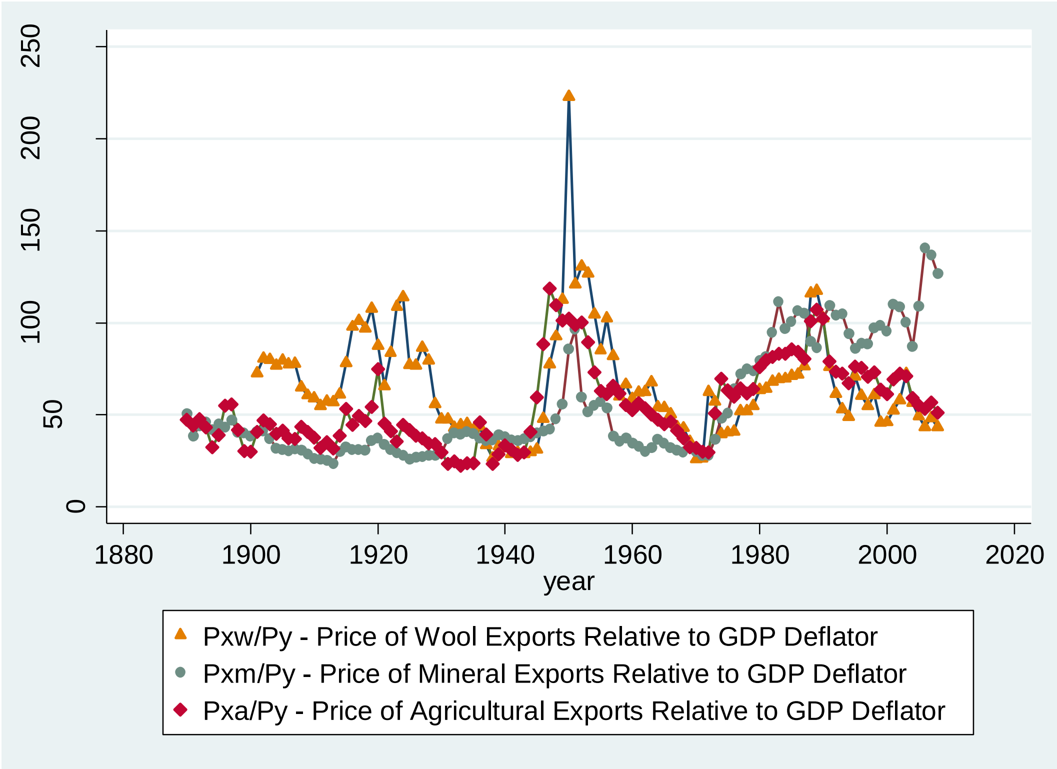
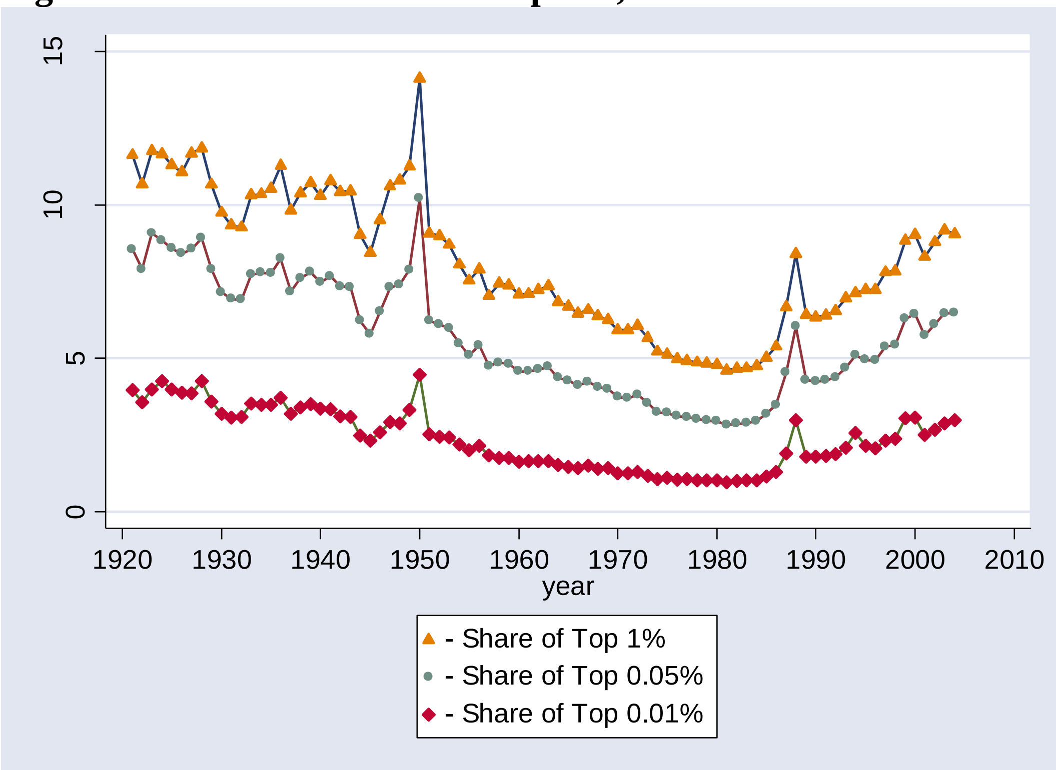


Figure 4: Income Share of the Top 1%, 0.05% and 0.01% since 1921



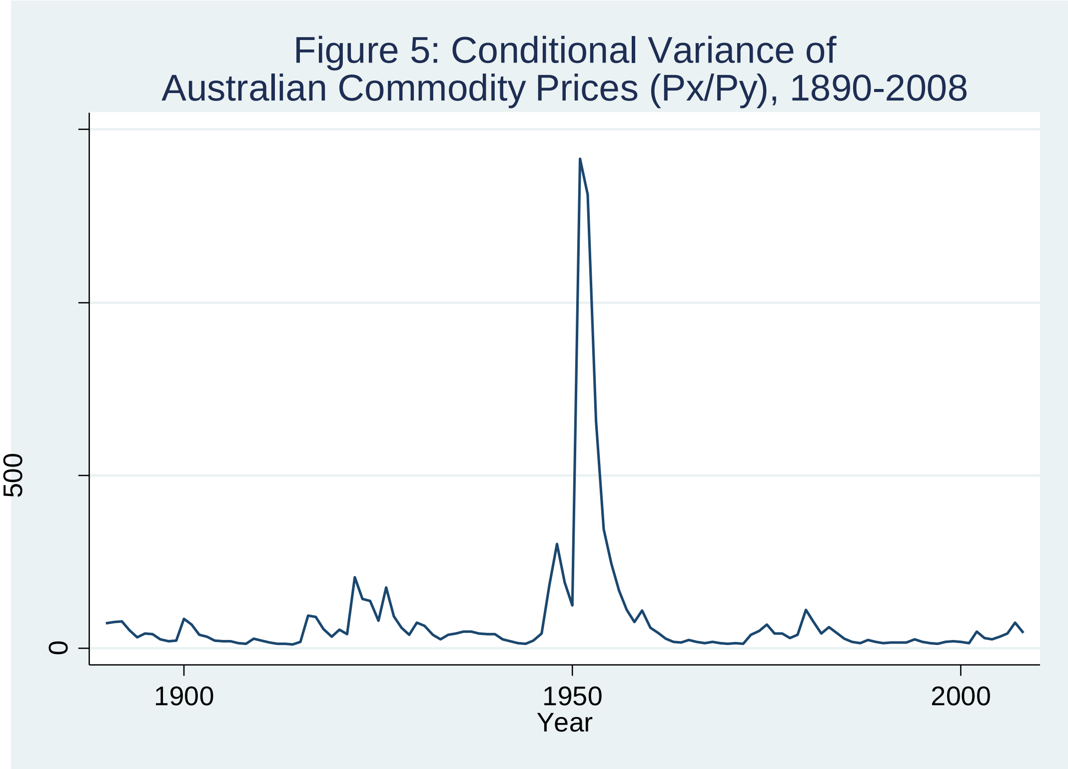


Figure 5: Conditional Variance of
Australian Commodity Prices (Px/Py), 1890-2008
500
0
1900
1950
2000
Year

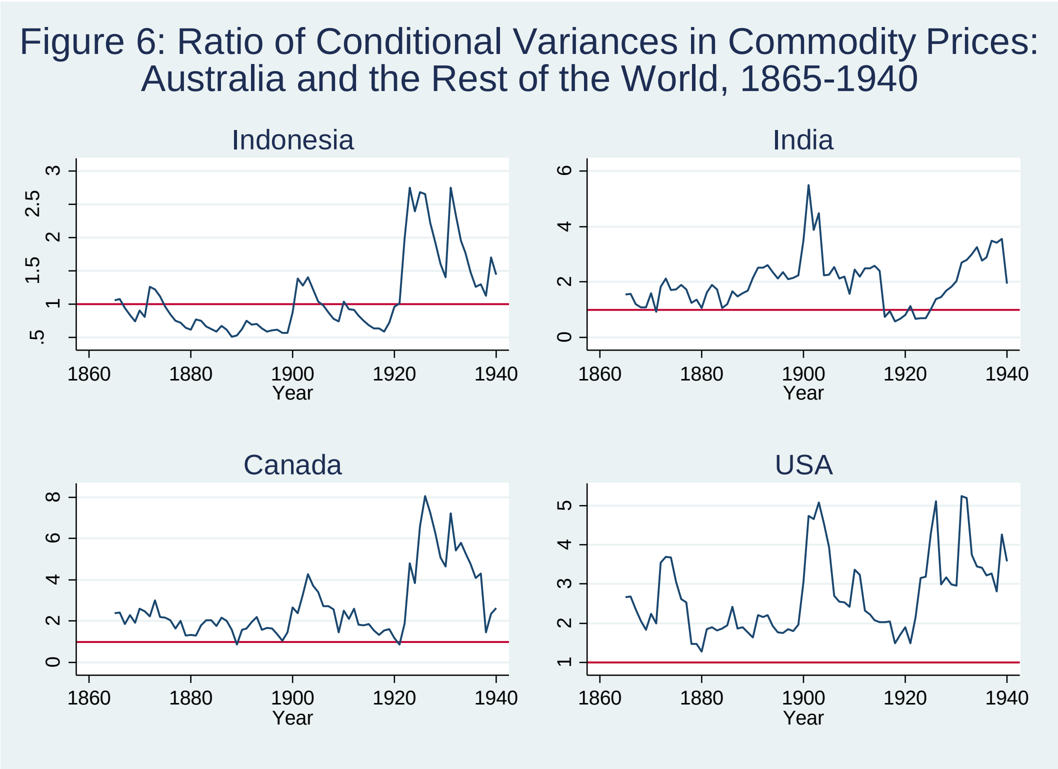


Figure 6: Ratio of Conditional Variances in Commodity Prices:
Australia and the Rest of the World, 1865-1940
Indonesia
India
Canada
USA
1860
1880
1900
1920
1940
Year

Figure 7: Ratio of Conditional Variances in Commodity Prices: Australia and the Rest of the World, 1960-2007

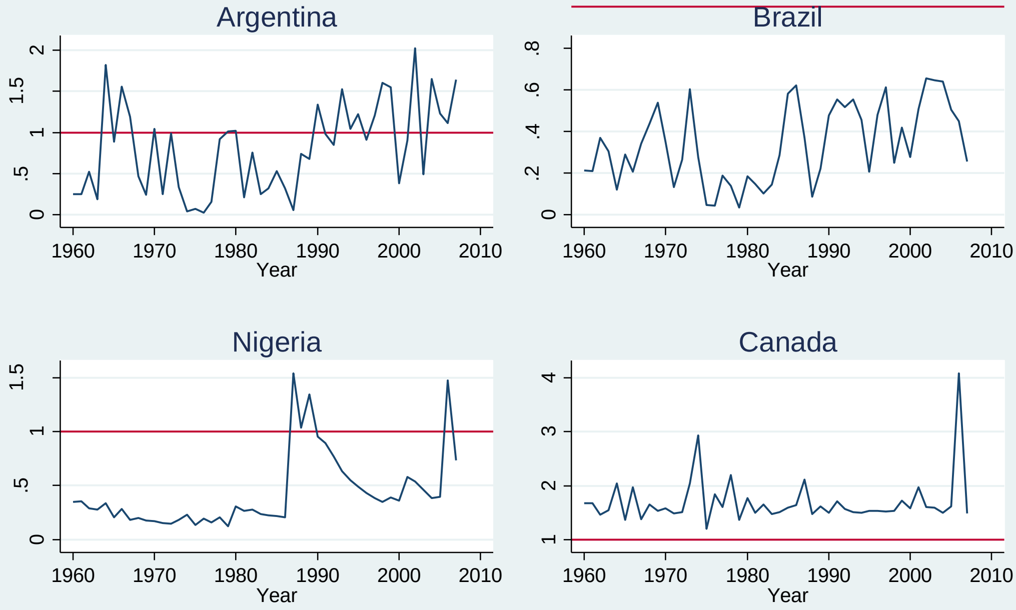


Table 1: Economic Fundamentals in Two Eras

Variables	1921-1941	1941-2004
Income Share of the top 1%	10.72	7.30
Growth Rate of Real GDP	2.4	3.6
Growth Rate of Real Wage	3.1	6.9
Unemployment Rate	7.03	4.44
Structural Change Index based on Employment	5.8	2.3
Structural Change Index based on GDP	9.4	3.2
Trade Union Density	26.9	40.1
Tax Share to GDP	2.5	11.6

Notes: GDP, gross domestic product. For variable definition and source see Data Appendix.

Table 2: Unit Root Tests

	Adjusted Dickey-Fuller (ADF) Test		Phillips-Perron (PP) Test	
	Levels	First Differenced	Levels	First Differenced
$\ln(P_X / P_Y)_t$	-1.35	-9.74***	-6.92	-114.50***
$\ln(P_M / P_Y)_t$	-0.94	-6.45***	-4.56	-62.28***
$\ln(P_X / P_M)_t$	-1.09	-9.14***	-5.41	-93.12***
$\ln(P_{XW} / P_Y)_t$	-2.49	-9.62***	-9.59	-94.36***
$\ln(P_{XM} / P_Y)_t$	-0.57	-8.71***	-2.02	-79.77***
$\ln(P_{XA} / P_Y)_t$	-2.42	-9.18***	-11.95	-82.38***
$\ln(TIS1\%)_t$	-1.71	-10.01***	-4.32	-88.56***
$\ln(TIS0.05\%)_t$	-1.65	-9.89***	-3.95	-87.01***
$\ln(TIS0.01\%)_t$	-1.66	-9.67***	-4.02	-82.09***
$\ln(GDP)_t$	-1.45	-8.44***	-0.52	-93.39***

Notes: For ADF, Akaike Information Criteria (AIC) is used to select lag length and the maximum number of lags is set at five. For PP, Barlett-Kernel is used as the spectral estimation method. The bandwidth is selected using the Newey-West method. *, **, and *** indicate 10%, 5% and 1% levels of significance respectively. For variable definition and source see Data Appendix.

Table 3: Commodity Price Shocks and Top Income Shares in Australia, 1921-2004: Main Econometric Results

	Dependent Variable: Change in Log Income Share of the Top 1 Per cent [$\Delta\ln(TIS1\%)_t$]					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\ln(P_X / P_Y)_t$	0.35*** (0.10)	0.31*** (0.11)	0.35*** (0.10)	0.38*** (0.12)	0.36*** (0.10)	
$\Delta\ln(P_X / P_M)_t$						0.30** (0.13)
$\ln(TIS1\%)_{t-1} - \ln(P_X / P_Y)_{t-1}$	-0.05*** (0.018)	-0.05*** (0.019)	-0.05** (0.02)	-0.05** (0.025)	-0.05*** (0.018)	
$\ln(TIS1\%)_{t-1} - \ln(P_X / P_M)_{t-1}$						-0.05** (0.021)
GDP Growth Rate	0.45*** (0.16)	0.43** (0.20)	0.46** (0.17)	0.42** (0.19)		0.17 (0.21)
Non-Farm GDP Growth rate					0.37*** (0.11)	
Dummy 1921-1941	0.07*** (0.027)		0.06** (0.024)	0.03 (0.044)	0.07*** (0.027)	0.05* (0.028)
Dummy 1921-1951		0.01 (0.061)				
Dummy World War II (1939-1945)			-0.006 (0.026)	0.009 (0.035)		
Dummy Korean War (1950-1953)			-0.069 (0.083)	-0.058 (0.081)		
Log Trade Union Density$_{t-1}$				-0.058 (0.041)		
Log Direct Tax Share$_{t-1}$				-0.027 (0.049)		
Dummy Enterprise bargaining (1997-2004)				-0.001 (0.042)		
R^2	0.27	0.22	0.29	0.31	0.28	0.20
Durbin Watson	2.11	2.10	2.24	2.27	2.08	2.21
Durbin's Alternative test	0.44	0.54	0.18	0.14	0.53	0.21
Breusch-Godfrey LM test	0.43	0.52	0.17	0.12	0.51	0.19
Ramsey RESET test	0.18	0.66	0.19	0.29	0.18	0.18
Number of Observations	83	83	83	83	83	83

Notes: Figures in the parenthesis are robust standard errors and *, **, *** indicate 10%, 5%, and 1% levels of significance respectively. For variable definition and source see Data Appendix. Each column reports the Durbin Watson statistic which is approximately equal to $2(1-r)$, where r is the sample autocorrelation of the residuals. Therefore a value close to 2 indicates no autocorrelation. The *p*-values of Durbin's Alternative test and Breusch-Godfrey LM test are also reported. Note that rejection of the null in these tests implies autocorrelation. Finally, *p*-values of Ramsey RESET test for omitted variables are also reported. A rejection of the null here implies the model suffers from omitted variable bias.

Table 4: Varieties of Commodities and Top Income Shares in Australia, 1921-2004

	Dependent Variable: Change in Log Income Share of the Top 1 Per cent [$\Delta \ln(TIS1\%)_t$]			
	(1)	(2)	(3)	(4)
$\Delta \ln(P_{XW} / P_Y)_t$	0.21***			0.19***
	(0.064)			(0.064)
$\Delta \ln(P_{XA} / P_Y)_t$		0.06		-0.034
		(0.054)		(0.048)
$\Delta \ln(P_{XM} / P_Y)_t$			0.13**	0.12*
			(0.05)	(0.071)
$\ln(TIS1\%)_{t-1} - \ln(P_{XW} / P_Y)_{t-1}$	-0.026**			-0.037
	(0.01)			(0.039)
$\ln(TIS1\%)_{t-1} - \ln(P_{XA} / P_Y)_{t-1}$		-0.054**		-0.049
		(0.022)		(0.053)
$\ln(TIS1\%)_{t-1} - \ln(P_{XM} / P_Y)_{t-1}$			-0.04**	-0.031
			(0.016)	(0.021)
GDP Growth Rate	0.41**	0.44**	0.39*	0.43***
	(0.15)	(0.20)	(0.24)	(0.15)
Dummy 1921-1941	0.021	0.06**	0.04*	0.08**
	(0.018)	(0.031)	(0.025)	(0.039)
R^2	0.28	0.07	0.08	0.36
Durbin Watson	2.08	2.29	2.30	2.21
Durbin's Alternative test	0.52	0.14	0.13	0.23
Breusch-Godfrey LM test	0.50	0.13	0.12	0.21
Ramsey RESET test	0.18	0.21	0.16	0.19
Number of Observations	83	83	83	83

Notes: Figures in the parenthesis are robust standard errors and *, **, *** indicate 10%, 5%, and 1% levels of significance respectively. For variable definition and source see Data Appendix. Each column reports the Durbin Watson statistic which is approximately equal to $2(1-r)$, where is the sample autocorrelation of the residuals. Therefore a value close to 2 indicates no autocorrelation. The p-values of Durbin's Alternative test and Breusch-Godfrey LM test are also reported. Note that rejection of the null in these tests implies autocorrelation. Finally, *p*-values of Ramsey RESET test for omitted variables are also reported. A rejection of the null here implies the model suffers from omitted variable bias.

Table 5: Commodity Price Shocks and the very Top in Australia, 1921-2004

	Change in Log Income Share of the Top 0.05 Per cent [$\Delta \ln(TIS0.05\%)_t$]	**Change in Log Income Share of the Top 0.01 Per cent** [$\Delta \ln(TIS0.01\%)_t$]
	(1)	(2)
$\Delta \ln(P_X / P_Y)_t$	0.38***	0.45***
	(0.11)	(0.13)
$\ln(TIS0.05\%)_{t-1} - \ln(P_X / P_Y)_{t-1}$	-0.06***	
	(0.021)	
$\ln(TIS0.01\%)_{t-1} - \ln(P_X / P_Y)_{t-1}$		-0.08***
		(0.026)
GDP Growth Rate	0.47***	0.52**
	(0.17)	(0.21)
Dummy 1921-1941	0.08**	0.12***
	(0.03)	(0.04)
R^2	0.25	0.21
Durbin Watson	2.12	2.08
Durbin's Alternative test	0.45	0.58
Breusch-Godfrey LM test	0.44	0.57
Ramsey RESET test	0.13	0.31
Number of Observations	83	83

Notes: Figures in the parenthesis are robust standard errors and *, **, *** indicate 10%, 5%, and 1% levels of significance respectively. For variable definition and source see Data Appendix. Each column reports the Durbin Watson statistic which is approximately equal to $2(1-r)$, where is the sample autocorrelation of the residuals. Therefore a value close to 2 indicates no autocorrelation. The p-values of Durbin's Alternative test and Breusch-Godfrey LM test are also reported. Note that rejection of the null in these tests implies autocorrelation. Finally, *p*-values of Ramsey RESET test for omitted variables are also reported. A rejection of the null here implies the model suffers from omitted variable bias.

Table 6: Commodity Price Shocks and the very Top in Australia: Long Run Effects

	Log Income Share of the Top 1 Per cent [$\ln(TIS1\%)_t$]				**Log Income Share of the Top 0.05 Per cent** [$\ln(TIS0.05\%)_t$]	**Log Income Share of the Top 0.01 Per cent** [$\ln(TIS0.01\%)_t$]
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(P_X / P_Y)_t$	0.17***				0.40***	0.84***
	(0.041)				(0.055)	(0.078)
$\ln(P_{XW} / P_Y)_t$		-0.18***				
		(0.027)				
$\ln(P_{XM} / P_Y)_t$			0.26***			
			(0.048)			
$\ln(P_{XA} / P_Y)_t$				-0.01		
				(0.038)		

Notes: Figures in the parenthesis are robust standard errors and *, **, *** indicate 10%, 5%, and 1% levels of significance respectively. For variable definition and source see Data Appendix. These are long run effects (or long run multiplier) calculated using a two-step process involving the Bewley (1979) transformation described in the text.