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Australia's Forgotten Copper Mining Boom: Understanding How South Australia Avoided Dutch Disease, 1843-1850

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Abstract

Great Britain established the new colony of South Australia in 1834 and migration from Britain to the colony began in 1836. After six turbulent years, the discovery of two large deposits of copper at Kapunda (1843/1844) and Burra (1844/1845) renewed the colony's economic prospects. Over the 1845-1850 period, SA supplied 8-9 percent of the world's copper production. Immigration to SA from Britain soared, with the colony's population more than tripling between 1844 and 1851. We augment the Beine et al. (2015) model of an economy with a booming resource sector to incorporate endogenous immigration, and use its comparative statics to frame our empirical investigation of the boom's effects on the export of other traded goods and worker living standards. Using newly developed SA wage and price series for this period, we find modest increases in SA living standards, increases in the export of wool and wheat, and a larger share of the labor force working in the non-traded goods sector. Finally, we conclude that the decision by Governor Grey to force broad ownership of the "monster" Burra mine and the use of rents from the booming sector to subsidize immigration helped SA avoid the corruption and rent-seeking associated with other resource booms.

Key words: copper mining; Dutch disease; standard of living; South Australia; immigration

JEL codes: Q33, N47, N57, F22

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I. Introduction

The colony of South Australia (SA) was conceived as an experiment for Edward Gibbon Wakefield's theory of systematic colonization. Broadly, the theory was oriented around sales (rather than grants) of small tracts of land seized from Aboriginal groups, concentration of settlement within a defined geographic area, and subsidization of passage for British workers needed to provide a labor force to newly established farms. Wakefield's ideas for "systematic colonization" became the basis for SA settlement in 1834.

One important feature of Wakefield's theory imbedded in the colony's founding documents was the requirement that 100 percent of the revenues from colonial land sales be dedicated to subsidizing the passage of migrants from Britain to SA. This "Wakefield Migration Mechanism" assisted 12,208 of the 13,842 people who migrated from Great Britain to the new colony over the 1836-1840 period.[1] The colony's initial seven years were rocky but were soon eclipsed by the discovery of copper deposits in 1842 followed by the opening of two large copper mines between 1843 and 1845: Kapunda and the "Monster" Burra Burra mine. Land with potential copper deposits was purchased from the government by speculators and these new land revenues triggered a new round of passage subsidies under the Wakefield Migration Mechanism. Assisted and unassisted migration from Great Britain soared, while thousands of colonists abandoned other Australian colonies to move to SA. Taken together, they propelled the SA population from 17,000 in 1844 to 64,000 in 1851. Augmented by this massive labor

[1] Assisted emigration stopped in 1840 with the depletion of the Emigration Fund and the ensuing 1840-1842 SA financial crisis.

influx, the SA copper industry produced and exported roughly 10 per cent of the world's annual copper supply by 1850.

Economic historians have not paid much attention to South Australia's copper boom and this may be understandable given the massive gold discoveries and mining boom that emerged in Victoria in 1851. A classic article by Rodney Maddock and Ian McLean (1984) applied Max Corden's (1984) immigration-augmented model of a small open economy with traded and non-traded goods to understand how Victoria's boom in gold mining affected other export sectors (a phenomenon known as "Dutch Disease") and how massive immigration to Victoria acted to partly offset the effects of Dutch Disease. South Australia's copper boom presents a remarkable parallel to the Victoria gold boom, with the sudden discovery of a valuable ore, a rapid and enormous increase in mining activity, and massive immigration from overseas and other Australian colonies in response to new opportunities and high wage rates. Both booms occurred in frontier economies, with European settlement beginning only 6 to 15 years prior to their resource booms.

In this article, we use Michel Beine, Serge Coloumbe, and Wessel Vermuelen's (2015) general equilibrium model of a small open economy with a booming sector to provide a framework for understanding how the 1843-1845 copper discoveries and subsequent immigration could have affected the SA economy over the 1844-1850 period. The SA case is particularly interesting, as it represents one of the first documented cases of an "Alberta Effect", in which the government redistributes some economic rents from the resource boom to the population and this, in turn, makes the colony more attractive to prospective immigrants. In SA, the precise mechanism by which the Alberta Effect operated was that

colonization officials in London used revenues from sales of four 20,000-acre land parcels in 1845/1846 to heavily subsidize passage for 15,824 migrants from Britain to SA between 1845 and 1850.[2] Our empirical analysis finds that the production and export of wheat and wool, the two other important sectors of the SA economy, increased substantially during the copper boom period, while the share of the labor force working in the non-traded goods sector increased substantially. Wages of both skilled and unskilled workers increased between 1844 and 1850, but when adjusted for the effects of changing consumer prices, the living standards of unskilled workers did not change during the copper boom period while living standards of skilled workers increased by 7.6 percent. We conclude that the Wakefield Migration Mechanism linking revenue from land sales to subsidized passage for migrants worked to the colony's advantage during the boom by facilitating rapid expansion of copper mining and minimizing adjustment costs imposed on other traded goods industries.

II. The Rise of Copper Mining in South Australia, 1842-1850

It was the movement of the SA population on to newly surveyed rural lands outside the capital of Adelaide during the early 1840s that sparked various accidental discoveries of copper. In 1841 geologist Johann Menge wrote about the likelihood of copper being found in the colony.[3] The first find was in 1842 near Montacute, about 16 kilometres from Adelaide (Bampton, 2003: 38). Twelve months later more deposits were discovered at Kapunda, 80

[2] The analysis ends at 1850, the year before the gold rushes in New South Wales and Victoria. Once the mining boom in the neighboring colonies began, there was a large outflow of skilled miners from SA copper mines to the gold fields and a curtailment of SA copper mine operations for about three years.
[3] Geologists' work in SA was sporadic and fragmented. In 1846 the government tasked a mineral surveyor to identify possible mineral lands but no formal geological survey was conducted until 1882 (Corbett, 1987). This stands in contrast to the 1840s copper boom in Michigan where geologists and geological surveys supported rational exploration and development (David and Wright, 1997).

kilometres from Adelaide and, in 1845, one of the richest copper mines in the world was found at Burra (Blainey, 1978). The Burra Burra mine started production in 1845 and during its first six months of operation produced 2,707 tons of copper ore (Davies, 1977: 35). Three years later ore production had increased to 9,283 tons and dividends paid to Burra Burra mine shareholders were 800 percent (Davies, 1977: 36). By 1850, Burra Burra's production had soared to 24,687 tons (Davies, 1977: 36). These discoveries helped build a robust export sector for the colony with associated linkage industries including insurance, finance, and construction. SA began exporting copper in 1845 with copper exports comprising just 8 percent of all exports (primarily wheat and wool). By 1850 copper amounted to 63 percent of all SA exports. Over the entire 1845-1850 period, SA supplied just over 5 percent of the world's copper (Davies, 1977: 32).

Who owned the SA copper deposits? Land regulations established in October 1835 did not reserve any mineral rights to the Crown. Thus, from 1835 until 1846 everyone who purchased Crown land was given freehold rights to all metals and minerals on or under the parcels they owned. As copper production and discoveries expanded from 1846, Earl Grey, the Secretary of State for War and the Colonies, advised the SA Governor to impose a mineral royalty on all unsold land in the colony. He did so on March 5 1846 via proclamation in the Government Gazette. However, fervent public backlash followed by an 1848 Supreme Court decision that such reservations were illegal under the 1842 Waste Land Act (5 and 6 Vic, c.36) led to the removal of the regulation without a single penny being collected by the government.

Copper mining in South Australia was concentrated in two big mines developed between 1843 and 1845: Kapunda and Burra Burra. Consider first the discovery and

development of the Kapunda Mine. Captain Charles Bagot leased a pastoral station close to Kapunda (Dutton, 1846; Payton 1978). The Captain's son discovered copper ore on the property and, shortly after, so too did Francis Dutton (Dutton, 1846). The surrounding land had already been surveyed and this precluded them from applying for a 20,000-acre survey and purchasing land for £1/acre under clause four of the 1842 Colonial Waste Land Act. Accordingly, Bagot and Dutton had the 80-acre section on which their discoveries had been made surveyed, keeping news of the discovery secret. They subsequently purchased the parcel at auction without competition for the upset price of £1/acre (Dutton, 1846). Once news of copper being found in the district became widespread however, further land auctions saw fierce competition. At these auctions Bagot purchased a further eight sections of land, totaling 867 acres, for £6,358.05 (Rettison, 1960: 7).

The Kapunda mine's output was considerable over its 1843-1879 lifespan. Rettison (1960: Appendix IV) shows that from 1843 to 1847 897 tons of copper ore were produced at Kapunda and from 1848 to 1850 a further 1,124 tons were extracted that is, a total of 2,021 tons of copper ore over a seven-year period. Production continued to increase over the next decade with 4,642 tons of ore produced between 1851 and 1860, an average of about 464 tons of copper ore per year (Rettison 1960: Appendix IV). We do not have details on the gross value of this production prior to 1858 but between that year and the mine's closure in 1879 output generated returns of close to £700,000 (Rettison 1960: Appendix IV).

Now consider the discovery and development of the "Monster" Burra Burra Mine. The mine was found by two shepherds, Thomas Pickett and William Streair, who both lived on the banks of the Burra Creek in 1845. Pickett and Streair were employed by different pastoralists

and their finds were discovered independently of one another (Auhl, 1940). Pickett was paid £10 by one unnamed syndicate for information on the exact location of the discovery and a further £10 by the South Australian Mining Company (SAMA) after the richness of the lode was proven (Auhl, 1940; Davies, 1977). Streair was paid £20 by SAMA for the details of the location. Subsequently, two rival groups emerged to contest for ownership of the land which was outside the surveyed districts and could only be purchased in a 20,000 acre parcel for £20,000.

Further, legislation required the £20,000 needed to buy the land had to be paid in "ready money" and the governor therefore, refused to accept bank bills or drafts as payment. The two competing groups rushed to raise the funds. One representing pastoral and capitalist interests including the SA Company, several owners of the Kapunda mine, and two (unidentified) British investors were popularly known as the "Nobs" (Johns, 2006). Two other groups, including the SAMA, merged. They consisted of 86 local merchants, tradespeople, and shopkeepers who were popularly known as the "Snobs" (Austin, 1863; Blainey, 1978).[4] Neither the Nobs nor the Snobs could raise the finance alone so they agreed to contribute £10,000 each to the purchase and choose 10,000 acres a piece. Once the sale was complete, the land was split down the middle, east to west, and a ballot determined the parties' order of choice (Austin, 1863). The Snobs won the ballot and chose the 10,000 acres encompassing the entire northern area of Pickett's discovery which became known as the Burra Burra mine. From the start of its operation until its closure in November, 1877 the Burra Burra yielded £4,749,224 worth of copper ore. The Nobs obtained the remaining 10,000 acres, naming it the Princess

[4] Specifically, the Snobs 86 members were made up of: 18 shopkeepers, 11 merchants, 11 professional men, 10 'gentlemen', 10 artisans, 8 farmers, 8 stockholders, 5 auctioneers, and 4 manufacturers (Pike, 1967: 332).

Royal mine. That mine closed in 1851 after yielding a mere £7,000 worth of copper ore (Austin, 1863: 19).

SA copper exports soared in the second half of the 1840s, growing from £12,613 in 1845 to £362,130 in 1850. Davies (1977: 32) estimates that 98.78 percent of SA's exports of copper between 1841 and 1850 came from the Burra Burra mine. Over just the 1845-1850 period SA copper exports amounted to 8-9 percent of world output (Davies, 1977: Appendix 13A and pp. 32-33). Did the massive increase in copper production and export between 1845 and 1850 lead to Dutch disease in SA?

III. An Open-Economy Dutch-Disease Model Augmented with Endogenous Immigration

Since Corden's development of the classic model of Dutch disease (Corden and Neary, 1982; Corden, 1984), economists (Corden, 1984; Wahba, 1998; Raveh, 2014; Beine et al., 2015) have argued that immigration can mitigate some of the adjustment costs that would otherwise be imposed on other export industries as a result of the booming sector. A few studies consider how immigration flows are affected when a government appropriates a portion of the economic rents generated by the booming sector and redistributes them to the population via tax reductions, lump-sum redistributions, public investment, or amenities funded by the government. If executed appropriately, these activities raise the benefit to immigration and incentivize more people to immigrate. Helliwell (1981) named this phenomenon the "Alberta Effect", first identified during the 1970s when the government of the Canadian Province of Alberta used resource rents from an oil boom to provide additional public goods to residents.

Beine et al. (2015) and Raveh (2014) found that the additional benefits to living in Alberta stimulated large increases in immigration flows from other provinces.[5]

The specific operation of the Alberta effect in SA was unusual because the colony's charter required the SA government to transfer a portion of rents from land sales to subsidize passage for new migrants from Great Britain rather than to the existing population. We refer to this as the Wakefield Migration Mechanism. Its operation meant that whenever copper deposits were discovered on public lands, mining ventures could only obtain access to the copper by purchasing these lands, either at auction or at a fixed price.[6] These land sales triggered a provision of the colony's charter that dedicated 42.5 percent of revenues from the sale of lands to partial or full subsidization of the cost of passage for qualified emigrants to SA.[7] The additional immigrants drawn to SA by this mechanism provided the potential for further mitigation and possible reversal of the effects of Dutch disease. This leads us to ask: Did the massive immigration to SA following the initial copper discoveries mitigate Dutch disease effects for the two other tradeable goods, wool and wheat, and for non-traded goods?

[5] Raveh (2014) tested for the Alberta effect using panel data for the 50 U.S. states, and found that expenditures by resource-abundant states more than completely offset Dutch disease effects, allowing "manufacturing sectors in those states [to] grow faster than those in resource-poor states" (p. 1343). Beine et al. (2015) test for the Alberta effect using panel data for all ten Canadian provinces for 1987-2007 and find strong evidence "that the immigration of workers into the booming provinces exerts a mitigating influence on the Dutch disease" (p. 1576).

[6] Between 1844 and 1847 almost 150,000 acres of public lands were sold (Cox, 1859).

[7] An 1842 change to the law governing the Emigration Fund altered the percentage of revenues from land sales dedicated to subsidizing emigration from 100 percent of revenues to 42.5 percent of revenues after deduction of expenses for survey, management, and sales. See Australian Waste Lands Act of 1842, 5 & 6 Vic. c. 36 §§ 18 and 19.

In this section, we develop a variant of the Beine et al. (2015) model of an open economy general equilibrium model with a booming resource sector. [8] Our variant endogenizes immigration by augmenting the model with an equation that incorporates the Wakefield Migration Mechanism. The augmented model enables us to analyze whether endogenous immigration can partly or fully mitigate the Dutch disease effects associated with resource booms. The model has two sectors that produce a non-traded good (N) and a traded good (T). Two representative firm produce goods using capital (K) and labor (L) with a Cobb-Douglass production technology in a competitive market. The supply of labor (L) is endogenous, with the nontraded sector using nL (with the share of labor, n, 0<n<1) and the traded sector using (1-n)L. Total factor productivity A_i is exogenous to each sector with no spillovers across sectors. The production functions for each sector are:

$$Y_N = A_N K_N^{\alpha_N} (nL)^{1-\alpha_N} \quad (1)$$

$$Y_T = A_T K_T^{\alpha_T} [(1-n)L]^{1-\alpha_T} \quad (2)$$

$$\alpha_i \leq 1 \ for \ i = N, T$$

Capital and labor are mobile across the two sectors, and capital is mobile internationally. The price of the tradeable good (P_T) is determined in the world market, and is set equal to 1. The price of the non-traded good (P_N) is determined in the SA domestic market, with its relative price $p = P_N/P_T$. Consumption of the non-traded good (C_N) equals the amount supplied (Y_N). Labor mobility across sectors equalizes the wage rate in both sectors at w, while the return on

[8] Wahba (1998) and Raveh (2014) also consider the case of a small open economy with a booming sector and endogenous immigration.

capital (r) is set in the world market. The booming copper sector is not explicitly modeled but following Beine et al. (2015) is "captured as a resource windfall" denoted as R.[9]

The consumer side of the model is very standard. Consumers maximize a CES-utility function from consuming the traded and non-traded goods,

$$U = \left[\gamma^{1/\theta}(C_T)^{(\theta-1)/\theta} + (1-\gamma)^{1/\theta}(C_N)^{(\theta-1)/\theta}\right]^{\theta/(1-\theta)} \quad (3)$$

subject to a budget constraint that consumption equals wealth:

$$Z = C_T + pC_N = wL + r(Q+R) \quad (4)$$

where Z is wealth, C_T is consumption of traded goods, Q is the capital stock, and parameters γ and θ determine the share of each of the two goods in consumption. We use the first-order conditions from equations 1-4 to solve for a two-equation system in p and n. Next we take log differences (represented by hatted values) to "express relationships as relative changes in these variables":[10]

$$\hat{p} = \frac{1-\alpha_N}{1-\alpha_T}\hat{A}_T - \hat{A}_N \quad (5)$$

$$\hat{n} = \frac{\psi_L}{1-\alpha_T}\hat{A}_T - \frac{\alpha_N}{1-\alpha_N}\hat{A}_N - \left[\gamma\theta + (1-\gamma) + \frac{\alpha_N}{1-\alpha_N}\right]\hat{p} + \frac{dR}{GNP} - (1-\psi_L)\hat{L} \quad (6)$$

$$\hat{w} = \frac{1}{1-\alpha_T}\hat{A}_T \quad (7)$$

[9] Modeling the copper sector explicitly changes the structure of the model's comparative statics only by introducing the change in aggregate productivity in the copper sector into the equilibrium conditions (Beine et al, 2015: 1578).

[10] We also list the result for $\hat{w}$, which can be subsumed in (5) and (6).

where ψ_L and ψ_K are the shares in income of labor and capital, respectively. First, equation 5 shows that $\hat{p}$ does not depend on $\hat{R}$. Rather the change in the relative price of nontraded goods depends on the relative changes in factor productivity in the two sectors. Second, equation 6 shows that the share of labor in the non-traded goods sector—and thus the output of the non-traded goods sector—is positively related to the size of the resource shock (dR). Max Corden labelled this relationship "the *spending effect*" (Corden, 1984; Corden and Neary, 1982). It is triggered by the additional income generated by new copper production, which is assumed to be fully spent, with a portion allocated to the non-traded normal good N. Production of N expands by drawing labor and capital from the traded good sector, thereby shrinking production of good T. Third, equation 6 shows that the change in the share of labor in the non-traded goods sector depends on the change in labor supply ($\hat{L}$). Consider first the case where there is no immigration. In this case, $\hat{L}$ must be negative due to the *resource movement effect*. Although we have not explicitly modeled the booming copper sector, production of copper requires labor and the sector draws some labor from both sectors N and T, thereby reducing output in both sectors (Beine, et al., 2015: 1581; Corden, 2004:360-361). Fourth, equation 7 shows that the change in the production of the two sectors is accomplished without a change in wages. Additional consumption of T comes from reduced exports of T.

Now consider the case when immigration is sufficiently large to offset the drain of labor into the copper sector, and therefore $\hat{L} > 0$. In this case, immigration acts to mitigate the effect of the resource boom on the share of labor moving into the non-traded good sector. The SA case is particularly interesting because there is an explicit mechanism–the Wakefield Migration

Mechanism–by which resource booms trigger additional immigration flows. We model this mechanism via the following equation:

$$\hat{L} = \left[\frac{a+b}{P_{GB}} + \frac{c}{P_{NSW}} - d\right]\hat{R} \tag{8}$$

where P_{GB} is the cost of passage for a migrant to move from Great Britain to SA, P_{NSW} is the cost for a migrant to move from New South Wales to SA, a is the fraction of the resource boom revenue devoted to subsidizing migration (0<a<1), b (b>0) is the response of unassisted migration from Great Britain, c (c>0) is the response of unassisted migration from New South Wales, d (d>0) is the size of the resource movement effect for each dollar of $\hat{R}$. Substituting equation 8 into equation 6, we obtain:

$$\hat{n} = \frac{\psi_L}{1-\alpha_T}\hat{A}_T - \frac{\alpha_N}{1-\alpha_N}\hat{A}_N - \left[\gamma\theta + (1-\gamma) + \frac{\alpha_N}{1-\alpha_N}\right]\hat{p} + \frac{dR}{GNP}$$

$$- \left(\frac{a+b}{P_{GB}} + \frac{c}{P_{NSW}} - d\right)(1-\psi_L)\hat{R} \tag{9}$$

The more that $[(a+b)/P_{GB} + c/P_{NSW}]$ exceeds d, the more that the movement of labor into the non-traded goods sector is mitigated.

Now consider equation 10 (derived by log differentiating equation 4) which shows how a resource boom changes wealth:

$$\hat{z} = \psi_L(\hat{w} + \hat{L}) + \psi_K\hat{R} \tag{10}$$

Substituting equations 6 and 8 into equation 10, we obtain:

$$\hat{z} = \psi_L\left[\left(\frac{1}{1-\alpha_T}\right)\hat{A}_T + \left(\frac{a+b}{P_{GB}} + \frac{c}{P_{NSW}} - d\right)\hat{R}\right] + \psi_K\hat{R} \tag{11}$$

This shows that the resource boom's effect on wealth operates completely via $\hat{R}$, as it is assumed in the model that changes in the productivity of the traded goods sectors are independent of the scale of the resource boom (see equation 8).

In sum, the immigration-augmented boom economy model shows that endogenous immigration induced by a booming sector (1) does not affect the colony's real wage rates which are determined by changes in sectoral productivity (equation 7); (2) mitigates or possibly reverses the growth in the share of the labor force working in the non-traded goods sector (equations 6 and 9); and (3) mitigates Dutch disease-induced declines in the colony's other major exports, wheat and wool.

IV. Using the Extended Dutch Disease Model to Understand the SA Copper Boom

Did endogenous immigration allow SA to avoid the effects of Dutch disease during the early years of the copper boom? To answer this question first requires an assessment of the extent of assisted and unassisted migration during the copper boom period. Prior to the copper discoveries, assisted migration had been suspended in 1840 due to the depletion of the colony's Emigration Fund. It was only in mid-1844 that a new round of SA land sales primarily associated with the copper boom refreshed the Emigration Fund. From 1844 through 1850, 18,761 assisted migrants arrived in SA from Great Britain (Table 1). Opportunities for workers during the SA copper boom were sufficiently good to induce 17,872 unassisted migrants from Great Britain and 14,276 unassisted migrants from the other Australian colonies (Table 1). The new immigration was primarily responsible for more than a tripling of the colony's European population in just seven years, from 17,366 in 1844 to 63,700 people in January 1851.

Our variant of the Beine et al. (2015) resource boom model predicts that changes in wage rates will be independent of migration (equation 7) and determined by changes in the productivity of traded goods. What happened to SA wage rates as immigration tripled the colony's population? Figure 1 displays the unweighted averages and standard deviations of nominal wages for five unskilled and 15 skilled occupations over the first 15 years of settlement. The average nominal wage for unskilled occupations hit a low in 1845, grew by 37.5 percent over the next two years, and then receded over the next three years (1847-1850) to a level 13 percent above the 1845 low. Nominal wages for skilled occupations hit a low in 1844, grow by 34.8 percent over the next four years, and then receded over the next two years (1848-1850) to a level 17.9 percent above the 1844 low.

How much of the wage increases during the copper boom period were offset by consumer price inflation? While the lack of a price index for SA in the 1840s precludes calculation of real wages, we have sufficient price data to calculate bare bones welfare ratios for a family of four. Economic historians have made extensive use of welfare ratios to compare changes in worker living standards over time (Allen, 2009; Panza and Williamson, 2019). A bares bones basket consists of food items providing 1,934 calories and 71 grams of protein per day per equivalent adult in the family. Welfare ratios count how many bare bones baskets a full-time worker can purchase each year. Figure 2 displays the averages and standard deviations of the bare bones welfare ratios for the same set of five unskilled and 15 skilled occupations. Average welfare ratios for unskilled workers reached a low (1.76 baskets) in 1842, increased to a high of 2.61 baskets in 1846, and then declined to 1844 levels (2.19 baskets in 1844) by 1850 (2.20 baskets). Average welfare ratios for skilled workers rose from 3.32 baskets in 1841 to a

high of 5.42 baskets in 1846, and then declined to 1845/1846 levels in 1850 (4.79 baskets). In sum, the average living standard of unskilled workers did not appreciably increase after 6 years of a copper boom, while the average living standard of skilled workers increased by just 7.6 percent over the 1845-1850 period.

Our variant of the Beine et al. (2015) model predicts that endogenous immigration in response to a resource boom mitigates the increase in the share of labor working in the non-traded goods sector. The SA government did not compile labor force data, and thus we cannot directly examine whether the share of labor in non-traded goods changed. We can, however, examine changes in the output and export of traded goods, such as wheat and wool, and changes in the output of non-traded goods. Changes in exports of traded goods provide a direct measure of whether the copper boom generated Dutch disease effects, while increases in the relative value of non-traded goods vis-à-vis traded goods are likely to be correlated with changes in the share of the labor force working in each sector.

For wheat, there were big increases in production and exports. The tripling of the colony's population from 1844 sent demands for basic foodstuffs soaring and farmers could expand production elastically by hiring newly arrived immigrant labor and opening readily available surveyed lands to wheat production. The number of acres planted in wheat more than doubled over the course of the copper boom, from 18,838 acres in 1845 to 41,807 acres in 1850 (Table 2).[11] The value of wheat (£38,000) exported in 1850, 16.1 percent of total harvest

[11] The 1847-1849 phase-out of Britain's corn laws as applied to the colonies could also have been responsible for some of the increase in acres cultivated in wheat and the increase in exports.

value, was 90 percent more than the value of wheat exported in 1848 (£20,000) which was 67 percent more than the value of wheat exported in 1846 (£12,000) (Table 3).[12]

For wool, there were also big increases in production and exports during the copper boom period. Wool output initially increased from 372,000 kilograms in 1844 to 985,000 kilograms in 1848, and then to 1,481,000 kilograms in 1850.[13] The value of wool exports followed a similar course, rising from £43,000 in 1844 to £98,000 in 1848 and £131,000 in 1850 (Table 3). Neither the wool nor wheat industries show signs of Dutch disease during the copper boom period, as exports from both industries robustly expanded.

Other export industries, including lead, live sheep, gum, and whalebone, were not as lucky. Exports from all industries excluding copper, wheat, and wool rose from £48,000 in 1844 to £97,000 in 1847 but then declined steadily to £39,000 in 1850 (Table 3). While some of this decline could be due to resource supply shocks or changing comparative advantage, it provides some evidence of Dutch disease in these small export industries. Perhaps the best test for Dutch disease from the data available to us is whether the overall value of exports excluding the value of copper exports increased over the copper boom period? The answer is yes, as non-copper exports increased steadily from £91,000 in 1844 to £208,000 in 1850. In sum, as the copper sector boomed, overall exports from other SA industries more than doubled. We conclude that trends in wool, wheat, and aggregate exports provide no evidence of Dutch disease in SA during the copper boom, while trends in other export industries provide weak evidence for Dutch disease in smaller export industries.

[12] South Australia Government (1907: 10).
[13] See Vamplew (1984: Table 11-9).

Did the output of the most important non-tradeable good, housing, increase substantially during the copper boom? A newspaper writer reported in 1849 that "[s]warms of small buildings...rise...as if by magic, in every part of the town [Adelaide] ..."[14] More precisely, data from the 1844, 1846, and 1851 SA Censuses reveal a big increase in home building over the 1846-1851 period in Adelaide, mining towns, and country areas.[15] Housing units in SA increased from 3,391 in 1844 to 4,176 in 1846—an increase of 393 units per year—and then jumped to 12,033 in 1851—an increase of 1,571 units per year between 1846 and 1851. Housing units in Adelaide increased from 1,314 in 1844 to 3,004 in 1851, while housing units in country areas and mining towns jumped from 2,077 to 9,029, reflecting the boom in the mining sector and agricultural sector expansion. In sum, while the very large increase in the output of housing informs us that the non-traded goods sector absorbed large numbers of new immigrants, we have insufficient data to determine whether the increase in output in the non-traded goods sectors outpaced the increase in output in the traded goods sector or whether the share of the (non-resource) labor force in the non-traded sector increased.

V. Discussion

Several factors contributed to help SA avoid the effects of Dutch disease: Massive immigration, legal controls around the government's use of land sales revenue, the emergence of complementarities between wool and copper exports, and secure property rights. First, as discussed above, high levels of immigration in the 1845-1850 period clearly helped SA avoid the

[14] From Adelaide Times, 7/5/1849, p. 3B, as quoted in McDougall and Vines (2006: 16).
[15] Australian Bureau of Statistics (1989), census returns for 1844, 1846, and 1851.

effects of Dutch disease.[16] The Wakefield Migration Mechanism heavily subsidized passage for 58.03 percent of migrants arriving from Great Britain during the 1844-1850 period. In addition, the relatively smooth reallocation of resources between sectors in 1844 was facilitated by the presence of several thousand settlers in SA who had previously been copper miners in Cornwall. Movement of Cornwall migrants from jobs in the agricultural and pastoral sectors to the copper mines should have been accompanied by relatively small losses in agricultural output and relatively large gains in copper mining output. Moreover, the direct adoption of Cornish mining techniques to develop SA copper mines, e.g., the surface, tribute, and tut work methods of operation, supported the smooth incorporation of skilled miners into the sector (Johns, 2006). SA newspaper articles that made extravagant claims of the mining prospects of the colony were enthusiastically reprinted in the Cornwall press (Payton, 2019). Moreover, letters home from the Cornwall miners, many of which found their way into local newspapers, also helped to ensure that the chain migration of skilled Cornwall miners to SA were good matches for the demand for miners in the colony's copper industry (Payton, 2019: 178-179).

Second, the outcome of the 1840-1841 financial crisis and subsequent British bailout had led to the imposition of stringent legal requirements around how the SA government utilized land revenues. Specifically, 42.5 per cent of land revenues had to be dedicated to passage subsidies for assisted migration. This created a commitment mechanism that prevented appropriation of these resource rents by rent-seeking interest groups or British politicians looking to fund programs more directly benefiting their home constituencies.

[16] Adjustment to accommodate a booming resource sector is deleterious only insofar as the lagging export sector, usually manufacturing, generates changes in its aggregate productivity that spill over to other sectors.

Third, there arose an unlikely complementarity in shipping between wool and copper exports. Prior to the discovery of copper, wool exporters had to pay for ballast on ships. This was because wool was light compared with its bulk requiring ships to be stabilized with heavy cargo (Davies, 1977). Davies (1977: 187) goes on to explain that before the copper discoveries in SA, ships masters were paying as high as 7 shillings 6 pence per ton at Port Adelaide for dead weight. Copper however, provided the perfect ballast for wool. In turn, wool allowed copper to be carried "at cheap dead weight rate and the savings involved (in not having to ballast and being paid to carry dead weight) allowed a reduction in the price of wool transportation" (Davis, 1977: 187-188).[17] In other words, the rise of the copper industry led to an increase in the price received by SA wool producers net of transportation costs.

SA's successful transition to an economy with a booming resource sector occurred within the context of the colony's well-defined property rights to land. From the start of settlement in November 1836, land was surveyed and subdivided before sale, thereby clearly delineating boundaries and the extent of ownership. A voluntary land registry was established in 1841 that facilitated public recording of land sales, mortgages, and liens. Squatting on public land was very limited and squatters abandoned lands when owners of newly surveyed and sold lands claimed them. SA's clearly delineated and enforced property rights can be compared to the situation in New South Wales where from the mid-1830s to the mid-1840s, squatters with large flocks of sheep moved beyond the official settlement boundaries to occupy land to which they had no formal title or clear, surveyed boundaries. This led to conflict between settlers

[17] Davis (1977: 187) uses the term 'dead weight' instead of ballast because, he argues, it was impossible to delineate between what was cargo and what was ballast so 'dead weight' is a more appropriate term to describe the function of copper and ore in shipping.

who relied on natural markers to delineate boundaries that were subject to some conjecture when challenged by rival parties (Alston, et al., 2012; Dye and La Croix, 2013).

The SA government's sale of crown land with potential copper deposits stands in contrast to the U.S. federal government's lease of lands in the U.S. state of Michigan, which experienced a copper boom from 1843 on the state's Keweenaw Peninsula. Leases were limited to 9 years, too short for miners to recover investments. No copper mining occurred until 1847 when the federal government agreed to sell land claims to miners.[18]

VI. Conclusion

South Australia's first copper discoveries triggered the sale of vast tracts of land in the colony, with 42.5 percent of the proceeds from these sales dedicated to subsidizing the passage of thousands of migrants from Great Britain. We analyze how this immigration affected the SA economy over the 1845 -1850 period and show the outcomes are consistent with the Baine et al. (2015) model where living standards of skilled and unskilled workers initially increased but then fell back to levels similar to those that had prevailed before the copper boom. It was the Wakefield Migration Mechanism that created the salutary effects of moderating wage increases for both skilled and unskilled workers during the boom. In turn, this allowed for a rapid expansion of copper mining without imposing big adjustment costs on the two other important export sectors in SA, wool and wheat. Thus, the mechanism linking land sales revenue to subsidizing migrant passage worked in the colony's favor and mitigated the effects of the Dutch disease often observed in economies with a booming resource sector.

[18] See Clay and Wright (2005) for a discussion of how mining district codes during the California gold rush created a system of property rights that balanced the rights of claim jumpers with the rights of claim holders and generated chronic insecurity and litigation among gold miners.

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Table 1: Emigrants to South Australia, 1844 – 1850

Year	Assisted Migrants from G.B.	Assisted Migrants from Cornwall	Unassisted Migrants from G.B.	Unassisted Migrants From Other Australian Colonies	Total Migrants
1844	43	na	77	777	1,114
1845	255	na	44	1,576	2,313
1846	1,479	422	256	1,048	3,521
1847	3,271	1,563	455	1,125	5,639
1848	3,731	1,861	1,231	903	6,774
1849	7,045	661	5,653	3,503	18,009
1850	2,422	268	5,483	4,176	13,160

Note: G.B. is Great Britain. *Source:* Migrants from other Australian colonies and outside G.B. from Pike (1967, Appendix A); migrants from Cornwall from British Parliamentary Papers (1851); and G.B. migrants from Haines and Shlomowitz (1992:115). Assisted migrants from Cornwall are included in assisted migrants from G.B. totals.

Table 2: South Australia Statistics, 1843-1850

Crop	**1843**	**1844**	**1845**	**1846**	**1847**	**1848**	**1849**	**1850**
Wheat-Acres	23,000	18,980	18,838	26,135	25,920	29,373	35,185	41,807
Barley-Acres	3,300	4,264	4,343	3,490	5,840	8,480	5,752	4,029
Other-Acres	2,390	2,444	2,662	3,669	4,681	10,696	4,048	5,590
Total-Acres	28,690	25,698	25,843	33,294	36,440	48,913	44,978	51,426
Population	17,196	18,999	22,460	25,893	31,153	38,666	52,904	63,700
Acres/person	1.67	1.35	1.15	1.29	1.17	1.27	0.85	0.81
GDP	405	393	529	953	1,119	1,716	1,599	2,159
NT-share	58.8	56.2	58.2	55.1	62.2	63.0	61.8	66.7

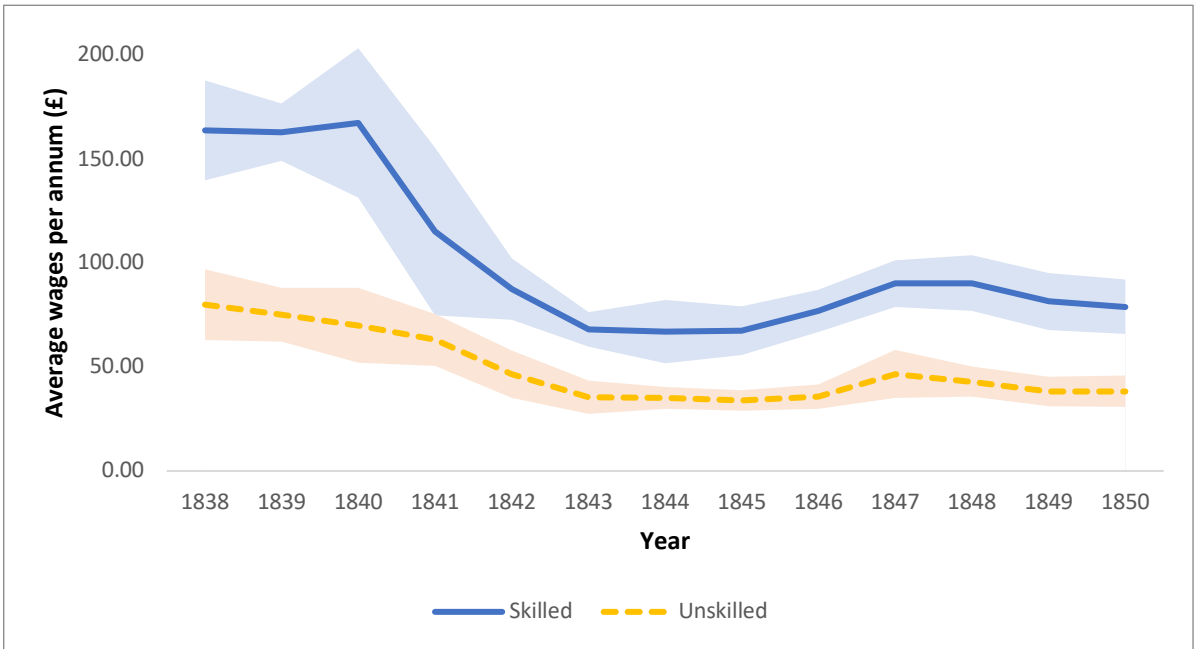
Sources: GDP and NT-share (share of non-traded goods in GDP without mining sector) are from Butlin and Sinclair (1986: 135). Crop data for 1843 and 1844 are from Colonial Secretary's Office, 31 January 1845; crop data for 1845-1847 are from Colonial Secretary's Office, *Reports Exhibiting the Past and Present*, Enclosure No. 19, April 1848; data for 1848-1850 are from House of Commons, British Parliamentary Papers, *The Reports … to Exhibit Generally the Past and Present State of Her Majesty's Colonial Possessions*, Enclosure No. 20 (1858:254); population data are from *Australian Historical Population Statistics* (2019:Table 1.1).

Table 3: South Australia Exports, 1844-1850

Year	All SA Exports (£)	Copper Exports (£)	Wool Exports (£)	Grain Exports (£)	All Other Exports (£)	All SA Exports but Copper (£)
1844	95	4	43	0	48	91
1845	148	13	72	13	50	135
1846	313	141	107	12	53	172
1847	350	172	56	26	97	179
1848	504	311	98	20	76	194
1849	403	217	108	14	64	186
1850	571	363	131	38	39	208

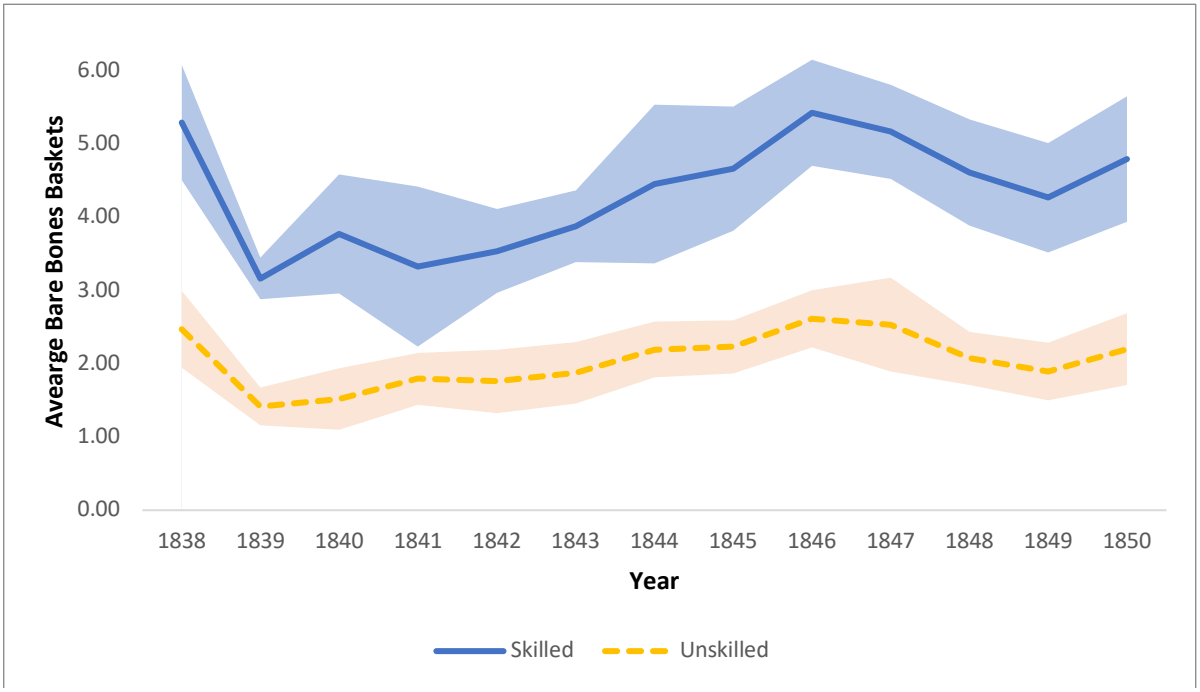
Source: Davies (1977, Appendix 5 and 13A) and Vamplew (1984). All data expressed as £1,000.

Figure 1: Average wages for skilled and unskilled workers, 1838 - 1850



Note: Shaded areas are one standard deviation from the average wage for five unskilled occupations and 15 skilled occupations.

Figure 2: Average Welfare Ratios: Bare Bones Baskets, Skilled & Unskilled workers, 1838 - 1850



Note: Shaded areas are one standard deviation from the average bare bones basket.