Quantifying 'Apartness' in South Africa:

A General Equilibrium Estimation of the Impact of Labour Discrimination (Job Reservations)

Timothy Ngalande

September 8, 2025

Abstract

This paper quantifies the macroeconomic costs of apartheid-era labour market discrimination in South Africa's manufacturing sector from 1960 to 1985. What are the aggregate consequences of barriers that prevent talent from being allocated to its most productive use? While recent work has shown these costs to be substantial in the context of gradually eroding barriers in the United States, apartheid South Africa provides a unique laboratory to study legally institutionalized and state-enforced discrimination. I develop and calibrate a general equilibrium model with heterogeneous workers and industry-specific frictions that distort the occupational choices of black workers. The calibrated model reveals that eliminating these frictions would have increased manufacturing output by over 2% in the short run, a cost driven entirely by the misallocation of labour, not by reductions in firm-level technical efficiency. A central and novel finding is that, contrary to a narrative of gradual erosion, aggregate frictions facing black workers, after a brief decline, rose steadily from 1970 to 1985. This trend reflects a shift in the nature of discrimination from explicit statutory prohibitions to de facto exclusion from newly emerging skilled occupations in a modernizing economy. These findings provide a structural quantification of apartheid's economic drag and reconcile the persistence of large allocative inefficiencies with prior historical research pointing to the weakening of specific job reservation statutes and narrowing racial wage gaps.

1 Introduction

The extent to which discriminatory barriers hinder economic development is a central question in economics. Systems that prevent individuals from applying their talents to the most productive sectors not only perpetuate inequality but also depress aggregate output and productivity. While theoretical work dating back to Becker (1957) has explored the mechanisms of discrimination, recent advancements in quantitative general equilibrium modeling have enabled economists to measure its aggregate costs with new precision. The seminal work by Hsieh and Moretti (2019a) demonstrated that the decline in barriers for women and black men in the U.S. labour market accounted for a significant portion of aggregate productivity growth since 1960. Their findings underscore the immense economic potential unlocked by improving the allocation of talent.

This paper applies this powerful quantitative framework to one of history's most explicit and legally-enforced systems of labour market discrimination: apartheid South Africa. The policy of "job reservation", also known as the colour bar, created a legal framework through which skilled and semi-skilled jobs were primarily reserved for the white minority. Formalised in the Industrial Conciliation Act of 1956, this policy was the culmination of decades of practices aimed at protecting white workers from competition (Mariotti, 2012a). While a rich historical and qualitative literature has documented the injustice and social consequences of apartheid's labour market policies(Lipton, 1985; Feinstein, 2005), a quantitative estimate of their direct economic cost to aggregate output has remained elusive. Was apartheid merely an oppressive social system, or was it also a significant drag on economic efficiency? If so, how large was this drag?

In answering these questions, I develop and calibrate a general equilibrium model of the South African manufacturing sector for the period 1960-1985, the height of the apartheid era. The model features two racial groups (black and white) and multiple industries.[1] Workers possess heterogeneous talents and choose the industry where their income is maximised. Critically, black workers face industry-specific frictions, modelled as a tax on their wages, which captures the effect of job reservation policies that limited their entry and progression in certain sectors. Using detailed manufacturing census data, I calibrate the model to recover these unobserved frictions, the relative average talent between groups, and the economy-wide talent dispersion.

[1] I use black loosely in reference to all non-whites in the labour market. These include the Coloureds, Asians and the Africans/Bantus

This methodology allows the data to reveal the magnitude and evolution of discriminatory barriers across different industries and over time.

I use the calibrated frictions in a counterfactual analysis to assess the impact of eliminating black worker barriers from the labour market on output. I find that over the period of study, eliminating the frictions would induce re-allocation of labour in equilibrium result in aggregate gains in output. I further use the calibrated frictions and relative average skill ratios to examine their relationship with aggregate productivity. I find a significant negative aggregate productivity elasticity of both race-specific frictions and relative average skill. I decompose aggregate productivity into technical efficiency and allocative efficiency following Hornbeck and Rotemberg (2024) to identify the source of change in aggregate productivity. I find the entire magnitude of aggregate productivity elasticity of discrimination is attributed to changes in allocative efficiency rather than technical efficiency.

The paper makes three primary contributions. First, it provides a novel, quantitative estimate of the economic costs of apartheid's labour market restrictions. Similar efforts by Pellicer and Ranchhod (2023) estimate the causal effect of white racial classification on labour market outcomes during apartheid South Africa, finding a fourfold increase in income from white men. Mariotti and van Zyl-Hermann (2014) also assess the impact of job reservations determinations in South Africa and find that their impact was limited in practice, affecting only a smaller percentage of the labour force. Similarly, Giliomee (2012) suggests that job reservations were merely symbolic than of actual significance. The counterfactual analysis in paper however, suggests that removing the race-specific job reservation related frictions would have increased manufacturing output by 2-4% annually. I argue that this figure is a lower-bound estimate. It does not account for the dynamic effects of discrimination on human capital accumulation, adjustments in capital and inputs to shifts in labour from removal of frictions, and it is based on only 10 static years of Apartheid. At a more general level, the paper also joins Mariotti and Fourie (2014); Fourie and Herranz-Loncán (2015); Hazlett (1988); Knight and McGrath (1985); Moll (2000, 1992) in an empirical and quantitative understanding of the effects of apartheid policies.

Second, the paper contributes to the South African economic history literature by mapping the evolution of these frictions over time. Mariotti and van Zyl-Hermann (2014) discusses the impact of job reservations and how ite limited efficacy and progressive irrelevance led to its suspension in 1977. Likewise, Moll (2000) and Knight and McGrath (1985) also argue for a decline in discrimination over time during apartheid. Contrary to these narratives of gradual reform, this paper contributes an extra perspective of the progression of discrimination. The estimated frictions show that after a brief decline in the 1960s, there was a marked increase from 1970 to 1985, a period of significant political and social unrest. This trend occurred even as the relative average skill gap between white and Black workers was narrowing. It thus reflects a critical shift in the nature of discrimination: from explicit, statutory prohibitions in low-skill jobs to more subtle but potent de facto exclusion from the newly emerging skilled occupations in a modernizing, capital-intensive economy.

Third, the paper serves as an important case study for the broader economics literature on misallocation and discrimination. It contributes to an evolving literature on the economics of discrimination pioneered by Becker (1957). Becker posited that discrimination arises from a "taste" or prejudice, leading employers and/or; in this case, government, to perceive a cost from interacting or engaging a race group in economic activity. This leads to wage differentials that are not derived from productivity. Subsequent work, following Becker (1957) explored statistical discrimination, where group averages are used to make inferences about individual productivity in the face of uncertainty (Phelps, 1972; Arrow, 1973).

More recent contributions in the literature have applied general equilibrium in identifying and assessing the impact of discrimination and how barriers distort wages, employment, and sorting in the labour market (Hsieh and Moretti, 2019a; Restuccia and Rogerson, 2008). In the same theme, contributions in literature have linked discrimination and labour barriers such as spatial and gender discrimination to misallocation of resources in production (Lee, 2024; Hsieh and Moretti, 2019b). This paper demonstrates the applicability of modern quantitative models to historical settings with legally-enforced discriminatory regimes, providing a clear and powerful illustration of how allocative inefficiency can arise from such policies and harm an entire economy.

In the rest of the paper, I discuss the baseline general equilibrium model then calibrate the model using South Africa manufacturing census. I proceed to conduct a counterfactual analysis of eliminating frictions and then analyse the effect of frictions on aggregate productivity.

2 Historical Background

The political economy of Apartheid as institutionalised after the victory of National party in 1948 was not incidental. It was a culmination of a history of segregation of non-whites and protection of whites and poor whites mostly in mining and manufacturing. The political and social environment was designed from early on in the early years of the Union of South Africa to engender segregation and ensure that whites maintained their economic well-being. The institutionalisation of this saw the development of legal frameworks such as the population registration act of 1950 that classified the population into four distinct race groups: Whites, Bantus, Coloureds and Asians (Crankshaw, 1996). For the purposes of this paper, all the non-whites are henceforth referred to as blacks. This classification formed part of the bedrock of differentiated policy by race. One among these frameworks was the formalisation of job reservations in the industrial conciliations act of 1956. Furthermore, racially Bantu education act of 1953 was one of the cementing mechanisms of job reservations concept (Feinstein, 2005). These legal apparatus, institutionalised an already prevalent ideology that created labour market frictions.

The most direct real-world analogue of the race-specific barriers-to-entry parameter in labour market models is the policy of job reservation, commonly known as the colour-bar. Although informal racial hierarchies in the workplace were long-standing, apartheid formalised them into law. The Industrial Conciliation Act of 1956 was the cornerstone of this policy. It excluded Africans from the legal definition of an employee, thereby denying them access to formal trade union representation and an official system of collective bargaining Coetzee (1976). This exclusion had far-reaching consequences: it enabled racially segregated white trade unions to negotiate industrial council agreements that legally and explicitly reserved skilled and semi-skilled occupations for white workers. The Act also authorized the Minister of Labour to issue work-reservation determinations, allowing any job to be reserved for a specific racial group following an investigation by a government-appointed tribunal (Horrell, 1969).

An example of the application of this ministerial authority on statutory job reservation was a major determination under Section 77 in the clothing industry in 1957. The Minister of Labour decreed that four major categories of work, then occupied by 4,500 white and 35,000 black workers, were to be reserved for whites only Coetzee (1976). This meant that 35,000 black workers were to be dismissed and replaced. This was however resisted and was never implemented. Similarly, another determination to reserve skilled jobs was made in 1958 in the iron, steel and engineering industry which would affect all blacks within the industry. However, the eventual growing demands of the industry on the labour market led to a declaration of exemption of the determination in 1968 to allow for non-whites to take up semi-skilled work (Coetzee, 1976).

This system reveals that job reservation was not a static set of rules but a flexible and contested boundary. The friction it created was not uniform across the economy but varied by industry and over time. The law created a mechanism and a framework for reservation, not a fixed list of jobs. The eventual growing demands for skilled and semi-skilled workers in the labour market allowed for the evolution of the intensity of the discriminatory concept. This also indicates the significance of apartheid policy in education.

In the presence of a large pool of highly skilled black workers, the job reservation mechanism would have crumbled. Instead, discrimination and wage differentials were prevalent throughout apartheid. The Bantu Education Act of 1953 was one of the formal institutions that made enabled job reservation and related frictions. The policy was explicitly designed to create a semi-literate workforce suited for manual labor and subservience, thereby perpetuating the supply black unskilled labour (Moll, 1992). As a result, growing demand for skilled labour from mechanisation in mining, manufacturing and construction would primarily be filled by whites, maintaining a segregated labour force.

This paper focuses on the apartheid period of 1960 to 1985 because this is the period following the formalisation of both job reservation in 1956 and education act in 1953. The paper aims to identify the evolving frictions prevalent in the labour market during this period using a general equilibrium framework and asses their impact on output and productivity.

3 Baseline model

I use a static general equilibrium model framework with heterogeneous utility maximising workers. The worker chose where to supply their manufacturing labour across 18 different industry groups. Their choice of industry is a function of the wages they receive for their labour, the affinity of their fellow race in the industry and the level of frictions in the industry's labour market which include job reservation. The firms in the general equilibrium model aim to maximise their profits. So they employ labour at its marginal cost at most and likewise minimise costs of capital and materials in production. In the apartheid market, Firms also choose their labour composition of black and white workers with respect to both profit maximising objectives of labour productivity and their racial preference or obligation. The firm labour composition, given profit maximising objectives therefore reveals its labour preferences and I use this to identify frictions in the market.

3.1 Labour Supply: Preferences and Endowments

The economy comprises a continuum of individuals of measure one. Part of the population is of european or white ethnicity why the rest of the populations consists of blacks, asians and coloureds, all referred to as black or black in this model. Effectively the economy has two groups of individuals ($j \in \{\mathcal{B}, \mathcal{W}\}$) who differ in race, productivity in respective industries and their utility or disutility of supplying labour. I follow Restuccia and Rogerson (2008); Ohanian et al. (2008) and Lee (2024) in setting individual's utility separable in consumption and leisure. An individual i from group j derives utility from the consumption of goods from 18 industry groups g and from leisure, l_i:

$$U_i = \sum_g \nu_g \log(c_{ig}) - \psi_j \log(l_i) \tag{1}$$

Where c_{ig} is individual i's consumption of a good from industry g. The parameter ν_g is the taste for the good from industry g while ψ_j captures the race-specific preference for leisure. Each individual is endowed with one unit of time, which can be allocated between work (h_i) and leisure (l_i), such that $h_i + l_i = 1$.[2] Crucially, each individual i of race j is also endowed with a vector of idiosyncratic productivities, $\boldsymbol{\varepsilon}_i = \{\varepsilon_{ijg}\}_g$, where ε_{ijg} represents the individual's productivity in efficiency units of labour in industry g and follows a fréchet distribution.

The individual chooses industry to supply with respect to the wages and the frictions in the industry then supplies h_i amount of labour to that industry. The worker's income $\mathcal{I}_i$ is therefore a function of their hours of work, productivity, and the race specific labour frictions τ_{jg}.

[2] Since observing individual work hours may not be plausible, the average working time for each race serves as a proxy for aggregate labour force participation.

$$\mathcal{I}_i = (1 - \tau_{jg}) w_g h_i \varepsilon_{ijg} \tag{2}$$

I consider some standard assumptions regarding the distribution of productivities and the value of frictions

Assumption 1 *(Race-Specific Frictions): Only black workers experience non-zero frictions in the respective industries:* $\tau_{gW} = 0 \quad \forall g$ *and* $\tau_{gB} \neq 0 \quad \forall g$*. Frictions vary by industry.*

As discussed in the historical setting in Section 2 of this paper, white workers face no labour market frictions ($\tau_{gW} = 0 \quad \forall g$), while black workers may face non-negative, industry-specific frictions ($\tau_{gB} \neq 0 \quad \forall g$). These frictions are specific to the industry modelled. Thus, frictions will vary depending on industry as was the case during apartheid where some industries were more inclined to job reservations and discrimination than others.

Assumption 2 *(Distribution of Productivity): Productivities are drawn from multivariate fréchet distributions:*

$$F_j(\varepsilon_g) = \exp\left(-\sum_g (T_{jg}\varepsilon_s^{-1})^\theta\right) \tag{3}$$

Following Hsieh and Moretti (2019a); Eaton and Kortum (2002) and Lee (2024), an individual workers vector of idiosyncratic productivities, $\{\varepsilon_{ijg}\}_g$, is drawn from multivariate Fréchet distributions which is characterised by parameters T_{jg} and θ. T_{jg} is a race and industry specific scale parameter that governs the average skill of group j in industry g. A higher T_{jg} implies a systematically higher skill draw for group j in industry g. θ is a shape parameter that governs the dispersion (or variance) of talent. A lower value of θ implies greater heterogeneity in skill, implying a society of specialised workers and many workers of low skill. A high θ means the distribution of skill is more uniform and therefore there is high substitutability among workers in any given industry. This is a crucial identifying parameter for the South African economy in apartheid.

With these assumptions, the individual worker maximises their binding income constraint. They chose to supply labour in an industry that increases their income and hence utility.

3.2 Production Technology

In each of the 18 sectors in South Africa's manufacturing, a representative firm produces a unique good, Y_g, using capital, K_g, intermediate materials, M_g, and an aggregate labour input, L_g. Consider a Cobb-Douglas production function:

$$Y_g = A_g(K_g^{\alpha_g} M_g^{\beta_g} L_g^{1-\alpha_g-\beta_g}) \tag{4}$$

Where, A_g is the exogenous industry-specific total factor productivity (TFP), and α_g and β_g are the output elasticities of capital and materials, respectively. The aggregate labour input, L_g, is the sum of efficiency units of labour supplied by all workers employed in industry g:

$$L_g = \sum_{j\in\{B,W\}} \int_{i\in g} h_{ijg}\varepsilon_{ijg}\, di \tag{5}$$

Firms operate hire labour and rent capital and materials to maximise profits. Profit maximization implies that factors are paid their marginal products. The wage per efficiency unit of labour in industry g, denoted w_g, is therefore given by:

$$w_g = p_g(1-\alpha_g-\beta_g)A_g\left(\frac{K_g}{L_g}\right)^{\alpha_g}\left(\frac{M_g}{L_g}\right)^{\beta_g} \tag{6}$$

Where p_g is the price of the good from industry g. For analytical tractability, Lee (2024) simplifies this and assume a linear production function, $Y_s = A_g L_g$, which simplifies the wage to $w_g = p_g A_g$. The Cobb-Douglas specification is more realistic and therefore the specification of this paper in the quantitative implementation.

3.3 Occupational Choice with Race-Specific Frictions

To maximise their utility, the workers' choice is reduced to identifying an industry of employments that yields the highest potential income and supply labour.

The central mechanism of the model is the presence of race- and industry-specific labour market frictions. These frictions are modelled as an iceberg cost or a tax, τ_{jg}, on the wages earned by a worker of race j in industry g (Hsieh and Moretti, 2019a). This wedge represents the monetized cost of various barriers, such as taste-based discrimination, exclusionary networks, or biased evaluation processes. The after-friction income an individual i of race j can earn by working h hours in industry g is the specification in equation 2. The individual's occupational choice problem of worker i of race j, given the race and industry specific iceberg cost, is therefore to select the industry g^* that maximises their potential income per hour:

$$g^* = \underset{g}{\operatorname{argmax}}\{(1 - \tau_{jg})w_g\varepsilon_{ijg}\} \tag{7}$$

Given the assumption that there are no frictions for white workers $\tau_{gW} = 0 \quad \forall g$ and that black workers face non-negative frictions $\tau_{gB} \geq 0 \quad \forall g$. This formalizes the idea that any observed distortions in labour allocation arise from barriers faced by black workers, not by white workers.

3.4 Equilibrium

The equilibrium in this economy consists of a set of goods prices $\{p_g\}$, wages $\{w_g\}$, and individual allocations $\{c_{ijg}, h_{ijg}\}$. The workers take prices of goods and wages as given and choose am industry to supply labour to maximise their income and hence their utility. Similarly, given prices and wages, a representative firm maximises profits by employing labour and other inputs in production. The market clears when the labour demanded by the firms is fully met by the supply of labour by the workers. The resolution of the equilibrium is further explained in appendix A.4.

3.5 Theoretical Implications of Talent Misallocation

For analytical results of this model assumptions 1 and 2 allow for closed-form expressions for occupational choice probabilities and average productivity levels. These are essential for both understanding the model's mechanics and for its empirical calibration. I henceforth follow Hsieh and Moretti (2019a) and Lee (2024) closely in deriving three propositions for related to their first three respective propositions. The derivations are shown in detail in appendix A.

Proposition 1 *(Occupational Choice): Given the Fréchet distribution of talent (Assumption 2), the probability, π_{jg}, that a randomly chosen individual of race j selects industry g is given* *by the following logistic formula:*

$$\pi_{jg} = \frac{(T_{jg}(1-\tau_{jg})w_g)^\theta}{\sum_k (T_{kj}(1-\tau_{kj})w_k)^\theta}$$

This proposition provides a clear and intuitive expression for sectoral sorting. The share of workers from a given race choosing a particular industry increases with their group's average talent in that industry (T_{jg}), the industry's wage rate (w_g), and decreases with the friction they face in that industry (τ_{jg}). If increasingly more skilled workers of race j are choosing an industry g, then there is a higher probability that more workers of that race chose to supply their labour to that industry. Conversely, the existence of positive frictions will deter entrance by black workers to the industry. This is however also positively dependent on the industry wages and the heterogeneity of the distribution of skill in the economy. Higher skill dispersion means higher substitutability within the industry and hence higher likelihood of representation of the subject race.

Proposition 2 *(Average Productivity and the Superstar Effect): The expected productivity of an individual from group j conditional on them choosing to work in industry g, is:*

$$E[\varepsilon_{ijg}|chooses\ g] = \Gamma\left(1-\frac{1}{\theta}\right)\cdot(\pi_{jg})^{-1/\theta}\cdot T_{jg}$$

where $\Gamma(\cdot)$ is the Gamma function. This proposition mathematically formalises the "superstar effect."

It shows that the average productivity of those who select into an industry is inversely related to the probability of selecting that industry, π_{jg}. When a high friction τ_{gB} reduces the share of black workers entering industry g (a lower π_{gB} via Proposition 1), the average talent of those who do enter is pushed higher. This is because the selection criterion becomes more stringent; only individuals with a very high idiosyncratic talent draw ε_{isB} will find it optimal to enter despite the friction. Observing high average wages for a small group of black workers in a given industry should therefore not be mistaken for an absence of barriers; the model shows it is may represent a direct symptom of their presence.

Proposition 3 *(Identifying Frictions from Data): From Propositions 1 and 2 we can identify unobservable frictions from two expressions linking it to observable data on wages and* *employment shares.*

First, the ratio of the average wages of white to black workers in industry g can be expressed by combining the definition of wages with Proposition 2:

$$\frac{AvgWage_{gW}}{AvgWage_{gB}} = \frac{T_{gW}}{T_{gB}} \left(\frac{\pi_{gW}}{\pi_{gB}}\right)^{-1/\theta}$$

Second, from Proposition 1, we can write the ratio of employment probabilities as:

$$\frac{\pi_{gW}}{\pi_{gB}} = \left(\frac{T_{gW}}{T_{gB}(1-\tau_{gB})}\right)^{\theta} \cdot \frac{\sum_k (T_{kB}(1-\tau_{kB})w_k)^{\theta}}{\sum_k (T_{kW}w_k)^{\theta}}$$

These two equations form the basis of a system that can be solved to identify the unobservable industry-specific frictions, τ_{gB}, and relative average talents, T_{gW}/T_{gB}, from observed relative wages and employment shares.

4 Data and Calibration Results

To calibrate the model, I use manufacturing census data for South Africa, digitised from government publications. Manufacturing censuses were conducted almost every three years after 1960 and recorded principal statistics for all private enterprise. The data for this paper covers the 1960, 1963, 1967, 1970, 1972, 1975, 1979, 1982 and 1985 censuses which report nominal values of revenue, capital stock at year-end, intermediate inputs, wages, and labour employed by race. Census records beyond 1985 do not report disaggregated labour statistics by race which is crucial for the analysis and calibration of the model this paper.

The census statistics are disaggregated into 143 four-digit International Standard Industrial Classification (ISIC) sectors and 23 three-digit ISIC sectors across the period of the study Since Industry classifications in South Africa changed in 1970 from 104 four-digit sectors and 19 three-digit sectors to 143 four-digit sectors and 23 three-digit sectors, I cross-walk all the census data after 1970 to their 1960 classification. Table C.1 summarises all the cross walked categories to the 1960 industry groups. New industry groups that could otherwise not be identified into a 1960 classification are removed from the sample. Consequently, the later three-digit classifications and an earlier industry group that is only reported in 1960, are not included in the study, remaining with 18 three-digit industry groups.

I deflate the values using the official deflator from South Africa Reserve Bank (SARB) to approximate their real values. I also weigh the capital stock in each year by the respective year's SARB bank rate as an approximation of the rate of capital to construct a measure of capital expenditure in production. I use these data to calibrate the input elasticities $\{\alpha_g, \beta_g, \phi_g\}$ for capital, materials, and labour respectively. I use national input cost shares of the respective industries:

$$e_{gt}^k = \frac{\sum_i \Xi_{git}^k}{\sum_{gk} \Xi_{git}^k} \tag{8}$$

Where e_{gt}^k is the input elasticity of input k in major industry group g and year t. Ξ_{git}^k is the total expenditure on input k in four-digit industry i, major industry group i and year t. Table 1 shows the weighted annual average elasticities for the duration of the study period. The overall average elasticities $\{\alpha_g = 0.02, \beta_g = 0.6, \phi_g = 0.15\}$ show that intermediate materials were the most important input such that frictions relating to materials will have more impact on output than frictions in labour and capital shares. These elasticities are not far from estimations in literature by Hornbeck and Rotemberg (2024) whose estimates for United States manufacturing elasticities are similar.

Table 1: Input elasticities

	1960	1963	1965	1967	1970	1972	1976	1979	1982	1985	Total
Capital	0.011	0.006	0.013	0.016	0.015	0.016	0.018	0.012	0.032	0.042	0.018
	(0.004)	(0.002)	(0.004)	(0.006)	(0.005)	(0.006)	(0.007)	(0.006)	(0.012)	(0.021)	(0.014)
Materials	0.575	0.593	0.581	0.565	0.571	0.568	0.611	0.653	0.623	0.580	0.592
	(0.112)	(0.112)	(0.101)	(0.105)	(0.104)	(0.105)	(0.099)	(0.146)	(0.099)	(0.162)	(0.119)
Labour	0.147	0.151	0.150	0.148	0.150	0.156	0.151	0.128	0.143	0.142	0.146
	(0.055)	(0.054)	(0.051)	(0.049)	(0.053)	(0.059)	(0.053)	(0.080)	(0.050)	(0.070)	(0.059)

Notes: This table presents the weighted average input elasticities across 18 major industry groups. This is computed using South Africa manufacturing census data for the corresponding period as described in equation 8. Standard errors in parentheses.

I also use the census data to estimate employment shares:

$$\{\pi_{gB}, \pi_{gW}\} = \pi_{jgt} = \frac{\sum_{ij} N_{ijgt}}{\sum_{ijgt} N_{ijgt}} \tag{9}$$

Where the N_{ijgt} is the count of workers of race j in four-digit industry i, major group g and in the year t. Table 2 presents a summary of the employment shares by industry across the 10-year period. The shares indicate that the share of blacks is significantly high (over 10%) in clothing, food and metal products that are not machinery. Out of these three whites also have a significant share in metal products and relatively less significant share (over

8% but less than 10%) in food. This suggests that the metal industry was more attractive to both blacks and whites which reduces the likelihood of frictions present in the industry. Similarly, the food industry which also has a higher share of whites can be considered to have a low likelihood of frictions. Industries with significant black employment share but minimal white employment sate such as clothing, minerals and textiles have an even higher likelihood of lower or no frictions. On the other hand industries with high white employment share and very low black employment such as basic metal, chemicals, machinery, and transport equipment have a high likelihood of frictions.

Table 2: Employment shares

	Basic metal	Beverages	Chemicals	Clothing, footwear	Electrical	Food	Furniture	Leather	Machinery
π_B	0.056 (0.004)	0.023 (0.002)	0.058 (0.005)	0.144^{b**} (0.004)	0.038 (0.007)	0.146^{b**} (0.010)	0.028 (0.003)	0.008 (0.001)	0.049 (0.006)
π_W	0.118^{w**} (0.012)	0.020 (0.002)	0.099^{w*} (0.025)	0.048 (0.018)	0.070 (0.006)	0.086^{w*} (0.008)	0.017 (0.003)	0.003 (0.000)	0.111^{w**} (0.014)
	Metal	Mineral	Paper	Printing	Rubber	Textiles	Tobacco	Transport	Wood
π_B	0.106^{b**} (0.006)	0.082^{b*} (0.014)	0.029 (0.002)	0.019 (0.003)	0.016 (0.002)	0.085^{b*} (0.015)	0.004 (0.001)	0.061 (0.012)	0.051 (0.006)
π_W	0.115^{w**} (0.011)	0.046 (0.005)	0.028 (0.003)	0.071 (0.004)	0.019 (0.005)	0.029 (0.004)	0.005 (0.001)	0.106^{w**} (0.015)	0.017 (0.004)

Notes: This table presents the weighted average employment shares for whites and blacks across 10 years in the data. This is computed using South Africa manufacturing census data the 18 industries represented, using identity in equation 9. A full description of the industries is presented in table C.1. Standard errors in parentheses. ^{j**} ($\pi_j > 0.1$ for $j \in \{W, B\}$) ^{j*} ($\pi_j > 0.08$ for $j \in \{W, B\}$)

For the shape parameter θ which measures talent dispersion, It is recovered from residuals of a wage regression on race and industry attributes. I regress log of wages on race, industry dummies and year fixed effects to isolate a wage variation that is stripped of these factors. I use the idiosyncratic wage variation from the residual ϵ_i and its relationship with θ for a Fréchet distribution $[\sigma(\epsilon_i) = \frac{\pi^2}{6\theta^2}]$ to recover the value of θ. I find $\theta = 4.69$ in my estimation which is higher than the US value of $\theta = 3.5$ estimated by Lee (2024) and a value of $\theta = 2$ estimated by Hsieh and Moretti (2019a). Relatively, it implies that the South African economy in this period had a specialised labour force with a low θ, it was more homogenous than the current US labour market. This suggests that eliminating frictions will have a re-allocative effect on the labour market, workers switching occupations to maximise their income.

4.1 Equilibrium Calibration

Using the baseline model and the parameters calibrated from the data in this section, I solve the equilibrium wages of the respective sectors. Since the baseline model is static, the equilibrium computation solves for the wage that clears the markets in the respective year across all industries. Figure B.4 presents the evolution of the observed average wages of whites and blacks relative to the equilibrium across the study period. The average wage for whites in each sector was clearly above the equilibrium wage, imposing inefficiencies in the market. The frictions in the labour markets also allow for the disparity in the respective average wages.

The model also solves for the friction parameter τ_g in each industry across the years using propositions [1-3] in equilibrium. Each industry's frictions are computed for each year and are summarised in figure 1. This figure presents the evolution of the average frictions across the industries for the 1960-1985 period under study. The trajectory of the frictions indicates an initial slow decline leading up to 1970 when a progressive increase in frictions is observed for the remainder of the period.

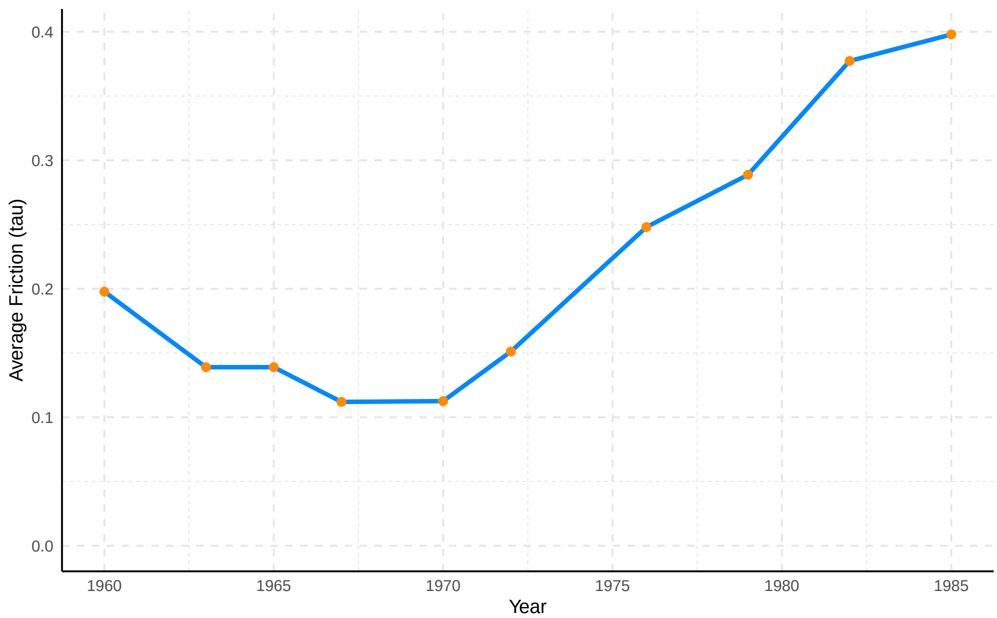

Figure 1: Evolution of Average Frictions ($\bar{\tau}_g$)

This figure presents the evolution of average frictions across the 18 industries in the census data. These frictions were calibrated in equilibrium using propositions 1-3.

A more disaggregated picture of the evolution frictions by industry presented in figure B.1

shows the contribution of each industry to this evolution. The figure shows that the industries with high black employment share as discussed in table 2 had lower and declining frictions over the period. black worker frictions in the clothing industry were consistently declining throughout the period as was the case in leather and leather products. Wood, on the other hand, with not as significant a share of black employment in table 2 but significantly hire than black employment share, had zero frictions throughout the period. Other industries with significant overall black employment such as Basic Metal, Textiles, and Mineral products initially had very low or no black worker frictions until the dawn of the 1970's. Another group of industries present progressively increasing frictions for black works from the start of the period to 1985. These include Chemicals, Beverages, Electrical Machinery, and Machinery.

The underlying common factor in the trends of the black worker frictions across all the industries is the level of skill or education required by each industry. With the color bar in effect, there was a preference for white workers in technically demanding jobs prevalently in Chemicals, Electricals, Printing, and Machinery (Mariotti, 2012b). It is also noted by O'Meara (1996) that most whites had already started switching jobs from low skill industries such as clothing. In the 1970s, the skill requirement for manufacturing rose significantly. This was a consequence of Intense mechanisation following modernisation of mining and construction alongside the Apartheid governments push for import substitution at the heels of international sanctions. Industries such as Basic Metal, Tobacco, Paper Products and Metal products became increasing technical and therefore increased the black worker frictions.

As a consequence of these increases in skill requirements and in frictions, the calibrated T-ratio (Relative average skills/talents) shown in figure 2 likewise began to decline after 1970. The preference of white workers to fill semi-skilled jobs declined significantly (Mariotti, 2012b). As of 1969, 86% of semi-skilled job vacancies were filled by whites which went down to 62% by 1981. Consequently, the blacks taking up the high skilled jobs, raised the average skill of the group, which is depicted by the decline in the T-ratio. However, the increasing mechanisation of industries further entrenched the frictions for black workers.

5 Counterfactual Analysis

Calibrating the frictions faced by black workers during apartheid using this model presents the unique advantage of adjusting the frictions to assess the impact they had on output.

H

Figure 2: Evolution of Average Relative Talent (T-ratio)

I consider a counterfactual scenario to quantify the economic consequences of the identified frictions. In this scenario I resolve the model's general equilibrium under the assumption that there is no discrimination in the labour market and di

The static general equilibrium model in this paper presents the opportunity to analyse the impact of removing the frictions in the short run. Thus it assesses the short adjustment of the subject variable, holding all else equal. In my analysis, similar to Lee (2024) and Hsieh and Klenow (2009), I set the calibrated frictions to zero, implicitly removing frictions for all worker types in the labour market.

Figure 3 shows the cumulative impact of setting the race-specific frictions for all industries to $\tau_{gB} = \tau_{gW} = 0$. The figure shows the cumulative short-run impact of removing the frictions in the census years of the data in the period of study (1960-1985). The results show that removing the frictions gains over 2% in output of the census years. Given that the census years are at two to three-year intervals, and in the medium short-run, inputs could adjust, the impact could be cumulatively more than the resolved 2%+ shown in figure 3.

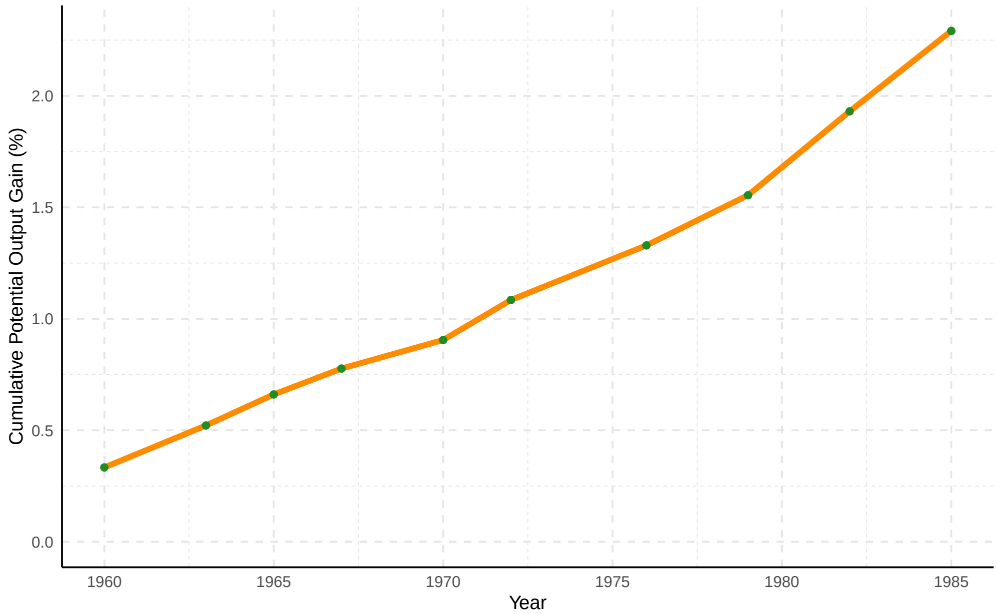

Figure 3: Cumulative Short-Run GDP Impact of Frictions (1960-1985)

Thus figure shoes the cumulative impact of isolating pure efficiency gains setting race-specific frictions to zero $\tau_{gB} = \tau_{gW} = 0$. These are short rain gains in output for each year from 1960-1985. Note that census years are at two to three-year intervals.

Furthermore, figure B.2 presents an industrial decomposition of the gains in output. These are industrial cumulative efficiency gains from the re-allocation of black labour in the short-run as shown in figure B.3. The effect of eliminating black worker barriers has a significant impact on output gains in the mildly technical, industries with a higher semi-skilled labour force such as Furniture, Printing, and publishing and Tobacco. Industries with higher skilled labour profiles such as Electrical machinery, machinery, Chemicals, Metal products and Beverages experience some mild gains from removal of frictions. The highly low skill labour profile industries of Textiles, Mineral Products[3], Wood, and Food experience efficiency losses. This is mainly because black workers, given no barriers, will re-allocate labour from the occupations with high black employee shares but low wages to occupations with previously low employee shares but high wages to maximise their income as shown in figure B.3.

5.1 Impact on Productivity

Another advantage of the static general equilibrium model in this paper is that It identifies frictions for each sector in every census year. This allows the analysis to examine the

[3]Refer to table C.1 for detailed description of these industry groups

relationship between the race-specific barriers and aggregate productivity. Consider the representative firm production function in equation 4. I adapt Hornbeck and Rotemberg (2024) and define industry aggregate productivity as:

$$\mathscr{P}\mathscr{r}_g = \mathscr{R}_g - \sum_k \Xi_g^k \tag{10}$$

Where aggregate productivity $\mathscr{P}\mathscr{r}_g$ is estimated as net total output revenue $\mathscr{R}_g$ of the input expenditure Ξ_{gk} for input k. Inputs in production include capital K, materials M, white labour W and black labour B. Since worker income in equation 2 is a function of frictions and idiosyncratic productivities, the total industry expenditure on labour will likewise be a function of the same $[\Xi_g^j = \sum_{ij}(1-\tau_{jg})w_g h_i \varepsilon_{ijg}]$. To examine the relationship between these frictions and aggregate productivity, consider the marginal effect of a change in frictions on log of productivity in equation 10:

$$\begin{aligned}
\frac{\partial \ln \mathscr{P}\mathscr{r}_g}{\partial \tau_g} &= \frac{\mathscr{R}_g}{\mathscr{P}\mathscr{r}_g}\left[\frac{\partial \ln \mathscr{R}_g}{\partial \tau_g} - \sum_k \frac{\Xi_d^k}{\mathscr{R}_g}\frac{\partial \ln \Xi_d^k}{\partial \tau_g}\right] \\
&= \phi_g\left[\frac{\partial \ln \mathscr{R}_g}{\partial \tau_g} - \sum_k \mathscr{s}_g^k \frac{\partial \ln \Xi_d^k}{\partial \tau_g}\right] && (11) \\
&= \phi_g\left[\frac{\partial \ln \mathscr{R}_g}{\partial \tau_g} - \sum_k e_d^k \frac{\partial \ln \Xi_d^k}{\partial \tau_g}\right] && \text{TFPR} \\
&\quad + \phi_g\left[\sum_k (e_g^k - \mathscr{s}_g^k)\frac{\partial \ln \Xi_d^k}{\partial \tau_g}\right] && \text{AE} \qquad (12)
\end{aligned}$$

Where $\phi_d = \frac{\mathscr{R}_g}{\mathscr{P}\mathscr{r}_g}$ is the ratio of district revenue to its productivity, which gives in this case scales growth in revenue into growth in productivity. $\mathscr{s}_g^k = \frac{\Xi_g^k}{\mathscr{R}_g}$ is the revenue share of the respective inputs in every district. Equation 12 shows that the marginal change in aggregate productivity in the presence of labour frictions can be disaggregated into Revenue Total Factor Productivity (TFPR) and Allocative Efficiency (AE). Improvements in aggregate productivity in a distorted market can either be a consequence of changes in TFPR or from re-allocation of resources within the market(Baqaee and Farhi, 2020).[4]

Table 3 presents the productivity elasticity of race-specific frictions τ_{gB} as well as relative average skill ration (T-ratio). The results show that a percentage increase in black worker

[4] A more detailed explanation and derivation of this is available in chapter 3 of the dissertation

barriers is associated with a 2% decline in aggregate productivity. This decline or conversely increase in productivity in the case of reduced frictions is mainly coming from changes in allocative efficiency. Thus a decline in race specific barriers allows for labour to re-allocate to industries and occupations that it is most productive and consequently increase aggregate productivity. The reduction in Frictions has no significant relationship with technical efficiency as the capital and material inputs are not affected by racial barriers. Similarly, a percentage increase in relative average skill ratio (T-ratio= T_{gW}/T_{gB}) of the race groups is associated with 0.3% reduction in aggregate productivity or conversely, if the average skill of whites relative to the average skill of blacks declines, this change is associated with a gain in productivity. Likewise, the change in aggregate productivity is channelled through the re-allocation of labour resources unlike change in input efficiency.

Table 3: Relationship between black labour barriers and productivity

	(1) Productivity	(2) TFPR	(3) AE
Frictions [$\tau_{gB} * 100$]	-0.205***	0.013	-0.218**
	(0.055)	(0.068)	(0.096)
Relative Skill [T-ratio*100]	-0.02982***	0.00447	-0.03429**
	(0.907)	(1.128)	(1.587)
Industry FE	Y	Y	Y
Year FE	Y	Y	Y
Controls	Y	Y	Y

Notes: This table presents the productivity elasticity of the race specific frictions τ_{gB} and relative average skill ratio between whites and blacks (T-ratio= T_{gW}/T_{gB}). The Frictions and the T-ratios have both been calibrated in the general equilibrium model of the paper. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$. Standard errors in parentheses.

This result suggests that changes in average skill ratio, though significantly associated with productivity and hence output growth, they did not have as much a magnitude of elasticity with productivity as did race-specific barriers. Thus, in the context of the discussion in literature regarding the significance of the black level of education as an important factor to their participation in skilled and semi-skilled jobs;[5] this result suggests that the average skill level was relatively less important compared to race-specific barriers. This suggests that Job reservation and related labour market policies posed a significant tax on black workers and the economy.

[5] Feinstein (2005); Mariotti (2012a)

6 Conclusion

This paper has modelled the South African labour market during apartheid years in a general equilibrium framework. This has allowed for a calibration of race and sector specific labour frictions in equilibrium as well as relative average skill ratios between blacks and whites. Incidentally these calibrations suggest that labour discrimination during the period of study was on average, progressively increasing. They also suggest that this happened despite the average skill ratio of whites to blacks decreasing in the course of the period.

A counterfactual analysis that eliminates the race and sector frictions shows that there were significant cumulative short-run gains in output over the study period. Furthermore, there is an indication that gains in output and aggregate productivity were channeled through efficiency gains from the re-allocation of misallocated labour.

References

Arrow, K. J. (1973). Higher education as a filter, *Journal of Public Economics* **2**(3): 193–216.

Baqaee, D. R. and Farhi, E. (2020). Productivity and Misallocation in General Equilibrium, *The Quarterly Journal of Economics* **135**(1): 105–163.

Becker, G. S. (1957). *The Economics of Discrimination*, University Press.

Coetzee, G. J. (1976). *Industrial relations in South Africa: An event-structure of labour*, Cape Town.

Crankshaw, O. (1996). Changes in the Racial Division of Labour during the Apartheid Era, *Journal of Southern African Studies* **22**(4): 633–656.

Eaton, J. and Kortum, S. (2002). Technology, Geography, and Trade, *Econometrica* **70**(5): 1741–1779.

Feinstein, C. H. (2005). *An Economic History of South Africa: Conquest, Discrimination, and Development*, Cambridge University Press, Cambridge.

Fourie, J. and Herranz-Loncán, A. (2015). Growth (and Segregation) by Rail: How the Railways Shaped Colonial South Africa, *Research Papers in Economics* .

Giliomee, H. (2012). Bantu education: Destructive intervention or part reform?, *New contree: a journal of historical and human sciences for Southern Africa* (65): 67–86.

Hazlett, T. W. (1988). ECONOMIC ORIGINS OF APARTHEID, *Contemporary Economic Policy* **6**(4): 85–104.

Hornbeck, R. and Rotemberg, M. (2024). Growth Off the Rails: Aggregate Productivity Growth in Distorted Economies, *Journal of Political Economy* .

Horrell, M. (1969). *South Africa's Workers: Their Organizations and the Patterns of Employment*, South African Institute of Race Relations, Johannesburg.

Hsieh, C.-T. and Klenow, P. J. (2009). Misallocation and Manufacturing TFP in China and India, *The Quarterly Journal of Economics* **124**(4): 1403–1448.

Hsieh, C.-T. and Moretti, E. (2019a). Housing Constraints and Spatial Misallocation, *American Economic Journal: Macroeconomics* **11**(2): 1–39.

Hsieh, C.-T. and Moretti, E. (2019b). Housing Constraints and Spatial Misallocation, *American Economic Journal: Macroeconomics* **11**(2): 1–39.

Knight, J. B. and McGrath, M. D. (1985). The erosion of apartheid in the South African labour market: Measures and mechanisms, *Applied Economics Discussion Paper Series* **35**.

Lee, M. (2024). Allocation of Female Talent and Cross-Country Productivity Differences, *The Economic Journal* **134**(664): 3333–3359.

Lipton, M. (1985). *Capitalism and Apartheid: South Africa, 1910-1985*, Gower, Aldershot.

Mariotti, M. (2012a). Estimating the Substitutability of African and White Workers in South African Manufacturing, 1950–1985, *Economic History of Developing Regions* **27**(2): 47–60.

Mariotti, M. (2012b). Labour markets during apartheid in South Africa, *The Economic History Review* **65**(3): 1100–1122.

Mariotti, M. and Fourie, J. (2014). The economics of apartheid: An introduction, *Economic History of Developing Regions* **29**(2): 113–125.

Mariotti, M. and van Zyl-Hermann, D. (2014). Policy, practice and perception: Reconsidering the efficacy and meaning of statutory job reservation in South Africa, 1956-1979, *Economic History of Developing Regions* **29**(2): 197–233.

Moll, P. (2000). Discrimination is Declining in South Africa But Inequality is Not, *Studies in Economics and Econometrics* **24**(3): 91–108.

Moll, P. G. (1992). Quality of education and the rise in returns to schooling in South Africa, 1975–1985, *Economics of Education Review* **11**(1): 1–10.

Ohanian, L., Raffo, A. and Rogerson, R. (2008). Long-term changes in labor supply and taxes: Evidence from OECD countries, 1956–2004, *Journal of Monetary Economics* **55**(8): 1353–1362.

O'Meara, D. (1996). *Forty Lost Years : The Apartheid State and the Politics of the National Party, 1948-1994*, Randburg, South Africa : Ravan Press ; Athens : Ohio University Press.

Pellicer, M. and Ranchhod, V. (2023). Understanding the effects of racial classification in Apartheid South Africa, *Journal of Development Economics* **160**: 102998.

Phelps, E. S. (1972). The Statistical Theory of Racism and Sexism, *The American Economic Review* **62**(4): 659–661.

Restuccia, D. and Rogerson, R. (2008). Policy distortions and aggregate productivity with heterogeneous establishments, *Review of Economic Dynamics* **11**(4): 707–720.

A Appendix: Derivation of Propositions

A.1 Derivation of Proposition 1 (Occupational Choice)

An individual i of race j chooses industry g to maximize their effective income, $I_{ijg} = (1-\tau_{jg})w_g\varepsilon_{ijg}$. The probability that industry g is chosen, π_{jg}, is the probability that I_{ijg} is the maximum among all 20 sectors.

$$\pi_{jg} = \Pr(I_{ijg} \geq I_{ikj} \text{ for all } k \in \{1, ..., 20\})$$

The derivation relies on the properties of the Fréchet distribution. Let's define a composite term $\Phi_{jg} = (T_{jg}(1-\tau_{jg})w_g)^{\theta}$. The idiosyncratic talent ε_{ijg} is drawn from a Fréchet distribution with CDF $F(\varepsilon) = \exp(-(T_{jg}\varepsilon^{-1})^{\theta})$. The effective income I_{ijg} is also Fréchet-distributed. Its CDF is:

$$\begin{aligned}
\Pr(I_{ijg} \leq I) &= \Pr((1-\tau_{jg})w_g\varepsilon_{ijg} \leq I) \\
&= \Pr\left(\varepsilon_{ijg} \leq \frac{I}{(1-\tau_{jg})w_g}\right) \\
&= \exp\left(-\left(T_{jg}\left(\frac{I}{(1-\tau_{jg})w_g}\right)^{-1}\right)^{\theta}\right) \\
&= \exp\left(-(T_{jg}(1-\tau_{jg})w_g)^{\theta} I^{-\theta}\right) \\
&= \exp(-\Phi_{jg}I^{-\theta})
\end{aligned}$$

The probability that an individual chooses industry g is the probability that the income from industry g is greater than the income from any other industry k. Given the independence of talent draws across sectors, I can write:

$$\pi_{jg} = \int_0^{\infty} \Pr(I_{ikj} \leq I_{ijg} \text{ for all } k \neq s | I_{ijg} = I) \cdot f_{I_{ijg}}(I)dI$$

where $f_{I_{ijg}}(I)$ is the PDF of I_{ijg}.

$$\Pr(I_{ikj} \leq I \text{ for all } k \neq s) = \prod_{k\neq s} \Pr(I_{ikj} \leq I) = \prod_{k\neq s} \exp(-\Phi_{kj}I^{-\theta}) = \exp\left(-I^{-\theta}\sum_{k\neq s}\Phi_{kj}\right)$$

The PDF of I_{ijg} is $f_{I_{ijg}}(I) = \frac{d}{dI}\exp(-\Phi_{jg}I^{-\theta}) = \theta\Phi_{jg}I^{-\theta-1}\exp(-\Phi_{jg}I^{-\theta})$.

Plugging these into the integral:

$$\begin{aligned}
\pi_{jg} &= \int_0^\infty \exp\left(-I^{-\theta}\sum_{k\neq s}\Phi_{kj}\right)\cdot\theta\Phi_{jg}I^{-\theta-1}\exp(-\Phi_{jg}I^{-\theta})dI \\
&= \int_0^\infty \theta\Phi_{jg}I^{-\theta-1}\exp\left(-I^{-\theta}\sum_{k}\Phi_{kj}\right)dI
\end{aligned}$$

Let $\Phi_j = \sum_k \Phi_{kj}$. The integral becomes:

$$\pi_{jg} = \Phi_{jg}\int_0^\infty \theta I^{-\theta-1}\exp(-I^{-\theta}\Phi_j)dI$$

This integral is the integral of the PDF of a Fréchet distribution with parameters Φ_j and θ, scaled by Φ_{jg}/Φ_j. The integral evaluates to $1/\Phi_j$.

$$\pi_{jg} = \Phi_{jg}\cdot\frac{1}{\Phi_j} = \frac{\Phi_{jg}}{\sum_k \Phi_{kj}}$$

Substituting back the definition of Φ_{jg}:

$$\pi_{jg} = \frac{(T_{jg}(1-\tau_{jg})w_g)^\theta}{\sum_k (T_{kj}(1-\tau_{kj})w_k)^\theta}$$

A.2 Derivation of Proposition 2 (Average Productivity)

This proposition relies on a known property of selection models with Fréchet-distributed heterogeneity. The unconditional expectation of a random variable ε drawn from a Fréchet distribution $F(\varepsilon) = \exp(-(T\varepsilon^{-1})^\theta)$ is given by $E[\varepsilon] = T\cdot\Gamma(1-1/\theta)$, provided $\theta > 1$.[5]

When an individual selects into industry g, they do so because their talent draw ε_{ijg} was high enough to make that industry the most attractive option. This selection process means that the average talent of those who choose industry g is higher than the unconditional average talent for that group in that industry. The distribution of talent for those selected into industry g is also Fréchet, but with a rescaled talent parameter. The new, conditional talent parameter becomes $T_{jg}(\pi_{jg})^{-1/\theta}$.

Therefore, the conditional expectation is found by replacing the unconditional talent parameter T_{jg} with the conditional one in the standard expectation formula:

$$\begin{aligned} E[\varepsilon_{ijg}|\text{chooses } g] &= \left(T_{jg}(\pi_{jg})^{-1/\theta}\right) \cdot \Gamma\left(1 - \frac{1}{\theta}\right) \\ &= \Gamma\left(1 - \frac{1}{\theta}\right) \cdot (\pi_{jg})^{-1/\theta} \cdot T_{jg} \end{aligned}$$

This result formalizes the intuition that as the probability of selecting into a industry (π_{jg}) decreases (e.g., due to a high friction), the selection becomes tougher, and thus the average talent of the few who do make it in must be higher.

A.3 Derivation of Proposition 3 (Identifying Frictions)

This proposition is derived through algebraic manipulation of Propositions 1 and 2.

Part 1: Relative Wage Ratio

The average wage for a worker of race j in industry g is their efficiency units of labour multiplied by the wage per efficiency unit,

w_g.

$$\text{AvgWage}_{jg} = w_g \cdot E[\varepsilon_{ijg}|\text{chooses } g]$$

Using Proposition 2, substitute the expression for the conditional expectation:

$$\text{AvgWage}_{jg} = w_g \cdot \Gamma\left(1 - \frac{1}{\theta}\right) \cdot (\pi_{jg})^{-1/\theta} \cdot T_{jg}$$

Now, form the ratio of average wages for white (W) and black (B) workers in industry g:

$$\frac{\text{AvgWage}_{gW}}{\text{AvgWage}_{gB}} = \frac{w_g \cdot \Gamma(1 - 1/\theta) \cdot (\pi_{gW})^{-1/\theta} \cdot T_{gW}}{w_g \cdot \Gamma(1 - 1/\theta) \cdot (\pi_{gB})^{-1/\theta} \cdot T_{gB}}$$

The terms w_g and $\Gamma(1 - 1/\theta)$ cancel out, leaving:

$$\frac{\text{AvgWage}_{gW}}{\text{AvgWage}_{gB}} = \frac{T_{gW}}{T_{gB}} \cdot \frac{(\pi_{gW})^{-1/\theta}}{(\pi_{gB})^{-1/\theta}} = \frac{T_{gW}}{T_{gB}} \left(\frac{\pi_{gW}}{\pi_{gB}}\right)^{-1/\theta}$$

This is the first equation of Proposition 2.

Part 2: Relative Employment Ratio From Proposition 1, I have the expressions for the employment probabilities for white and black workers:

$$\pi_{gW} = \frac{(T_{gW}(1-\tau_{gW})w_g)^\theta}{\sum_k (T_{kW}(1-\tau_{kW})w_k)^\theta} \quad \text{and} \quad \pi_{gB} = \frac{(T_{gB}(1-\tau_{gB})w_g)^\theta}{\sum_k (T_{kB}(1-\tau_{kB})w_k)^\theta}$$

I use Assumption 1, which states that $\tau_{gW} = 0$ for all g.

$$\pi_{gW} = \frac{(T_{gW}w_g)^\theta}{\sum_k (T_{kW}w_k)^\theta}$$

Now form the ratio π_{gW}/π_{gB}:

$$\frac{\pi_{gW}}{\pi_{gB}} = \frac{\frac{(T_{gW}w_g)^\theta}{\sum_k (T_{kW}w_k)^\theta}}{\frac{(T_{gB}(1-\tau_{gB})w_g)^\theta}{\sum_k (T_{kB}(1-\tau_{kB})w_k)^\theta}}$$

Rearranging the terms gives:

$$\frac{\pi_{gW}}{\pi_{gB}} = \frac{(T_{gW}w_g)^\theta}{(T_{gB}(1-\tau_{gB})w_g)^\theta} \cdot \frac{\sum_k (T_{kB}(1-\tau_{kB})w_k)^\theta}{\sum_k (T_{kW}w_k)^\theta}$$

The term $(w_g)^\theta$ cancels from the first fraction:

$$\frac{\pi_{gW}}{\pi_{gB}} = \left(\frac{T_{gW}}{T_{gB}(1-\tau_{gB})}\right)^\theta \cdot \frac{\sum_k (T_{kB}(1-\tau_{kB})w_k)^\theta}{\sum_k (T_{kW}w_k)^\theta}$$

This is the second equation of Proposition 2.

A.4 Solving for the General Equilibrium

The core of the counterfactual analysis is to solve for the new set of equilibrium wages, $\{w'_g\}$, after setting the frictions τ_{gB} to zero. This requires finding a wage vector that clears all 18 labor markets simultaneously.

For each industry g, there is a labor demand and a labor supply. An equilibrium requires that for all g, labor supply equals labor demand. Let's define the excess labor demand function for industry g, $Z_g(\mathbf{w})$, where $\mathbf{w} = \{w_g\}$ is the vector of wages.

1. Labor Supply (L_g^S): Total labor supply to industry g is the sum of efficiency units supplied by black and white workers who choose that industry.

- The number of black workers choosing industry g is $N_B \cdot \pi_{gB}(\mathbf{w})$.
- The number of white workers choosing industry g is $N_W \cdot \pi_{gW}(\mathbf{w})$.
- The average productivity of these workers is given by Proposition 2.
- The hours worked by each group, h_j, depends on the wage they receive.

So, total labor supply in efficiency units is:

$$L_g^S(\mathbf{w}) = N_B h_B(\mathbf{w})\pi_{gB}(\mathbf{w})E_B[\varepsilon|g] + N_W h_W(\mathbf{w})\pi_{gW}(\mathbf{w})E_W[\varepsilon|g]$$

where $E_j[\varepsilon|g]$ is the average productivity from Proposition 2, which itself depends on $\pi_{jg}(\mathbf{w})$. The choice probabilities $\pi_{jg}(\mathbf{w})$ depend on the entire wage vector $\mathbf{w}$ as shown in Proposition 1.

2. Labor Demand (L_g^D):

From the firm's profit maximization problem, the first-order condition for labor is:

$$w_g = p_g(1 - \alpha_g - \beta_g)A_g \left(\frac{K_g}{L_g^D}\right)^{\alpha_s} \left(\frac{M_g}{L_g^D}\right)^{\beta_g}$$

Solving for labor demand L_s^D gives:

$$L_g^D(w_g, p_g) = \left(\frac{p_g(1 - \alpha_g - \beta_g)A_g K_g^{\alpha_s} M_g^{\beta_g}}{w_g}\right)^{\frac{1}{\alpha_g + \beta_g}}$$

Assuming one of the goods is the numéraire ($p_1 = 1$), the other prices will adjust based on demand and supply, but for simplicity in the labor market solution, we can often solve for wages relative to a price index.

3. The System of Equations: The general equilibrium is the wage vector $\mathbf{w}^*$ that solves the system of non-linear equations:

$$Z_g(\mathbf{w}^*) = L_g^D(\mathbf{w}^*) - L_g^S(\mathbf{w}^*) = 0 \quad \forall g$$

This system must be solved numerically. I use a multi-dimensional root-finding algorithm (Newton-Raphson type method or a simpler Broyden's method, available in packages like R's 'rootSolve') to find the vector $\mathbf{w}^*$ that sets the excess demand in all markets to zero. The algorithm starts with an initial guess for the wage vector and iteratively adjusts it until the excess demand functions are all arbitrarily close to zero.

B Figures

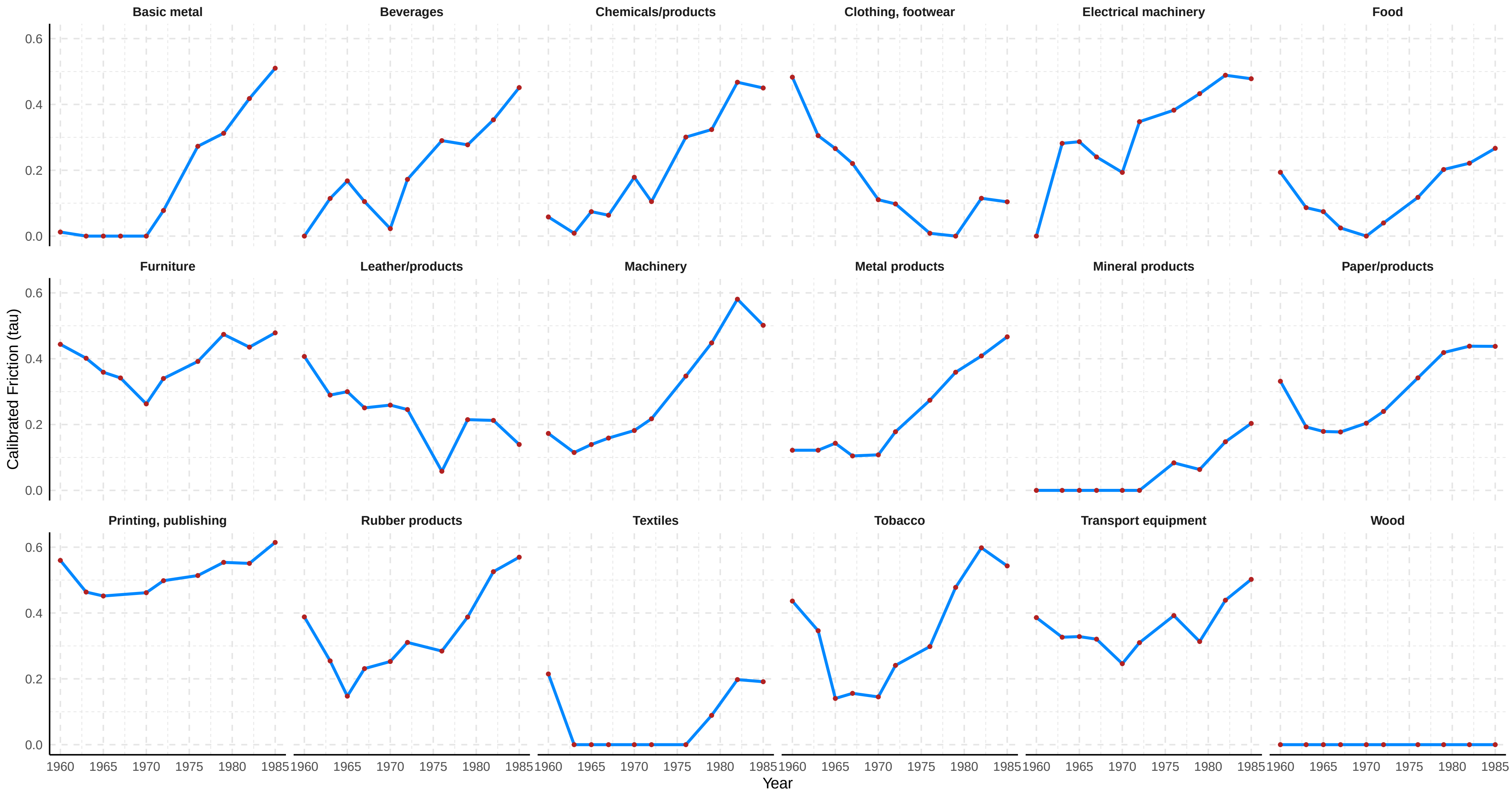

Figure B.1: Evolution of Industry-Specific Frictions (τ_g)

This figure presents the evolution of average frictions for each of the 18 industries in the census data. These frictions were calibrated in equilibrium using propositions 1-3. A comprehensive description of the industries is shown in table C.1

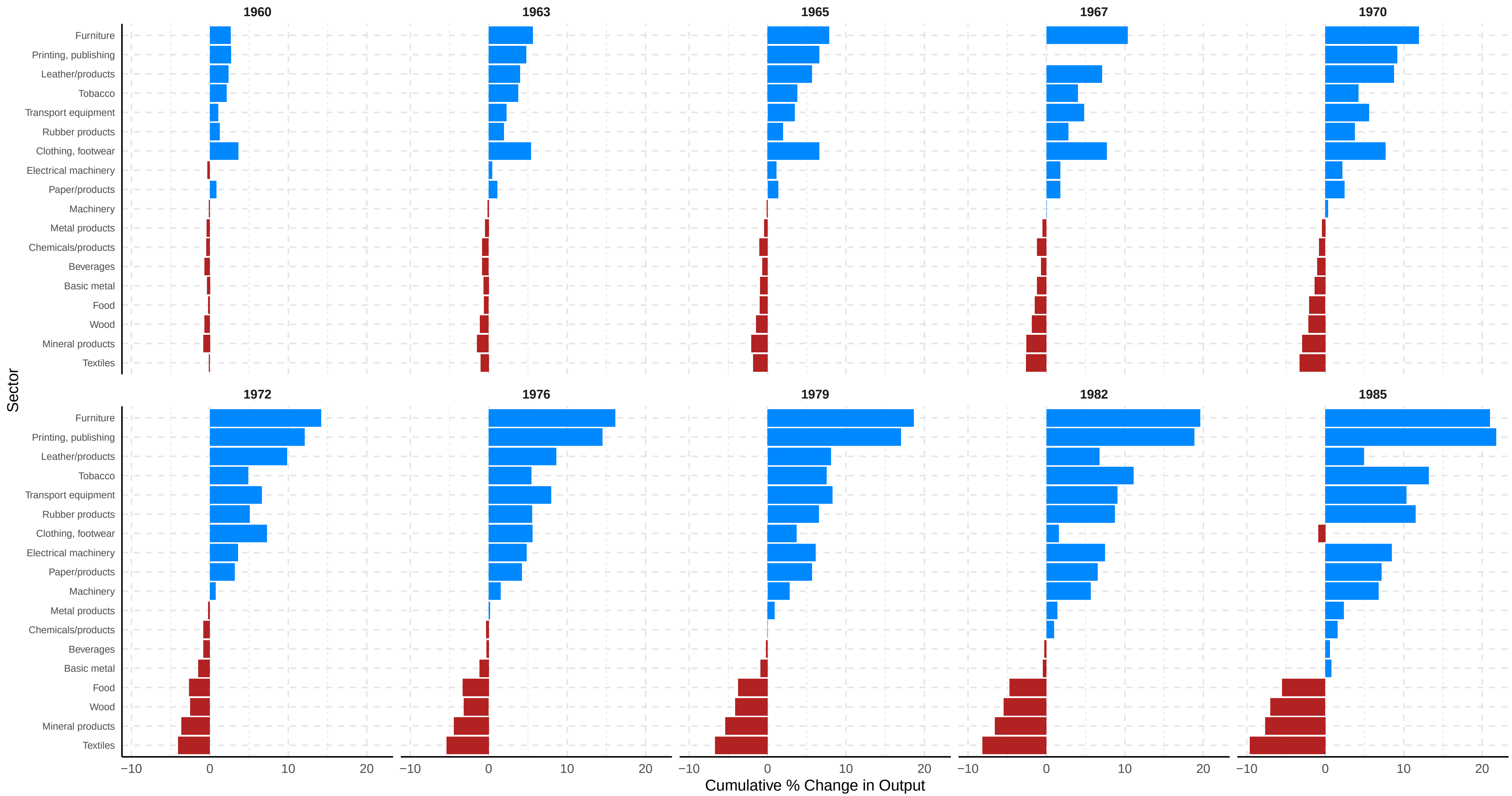

Figure B.2: Cumulative Percentage Change in Industry Output (1960-1985)

Thus figure shoes the cumulative impact of isolating pure efficiency gains setting race specific frictions to zero $\tau_{gB} = \tau_{gW} = 0$ for each industry. These are short rain gains in output for each year from 1960-1985. Note that census years are at two to three year intervals. A comprehensive description of the industries is shown in table C.1

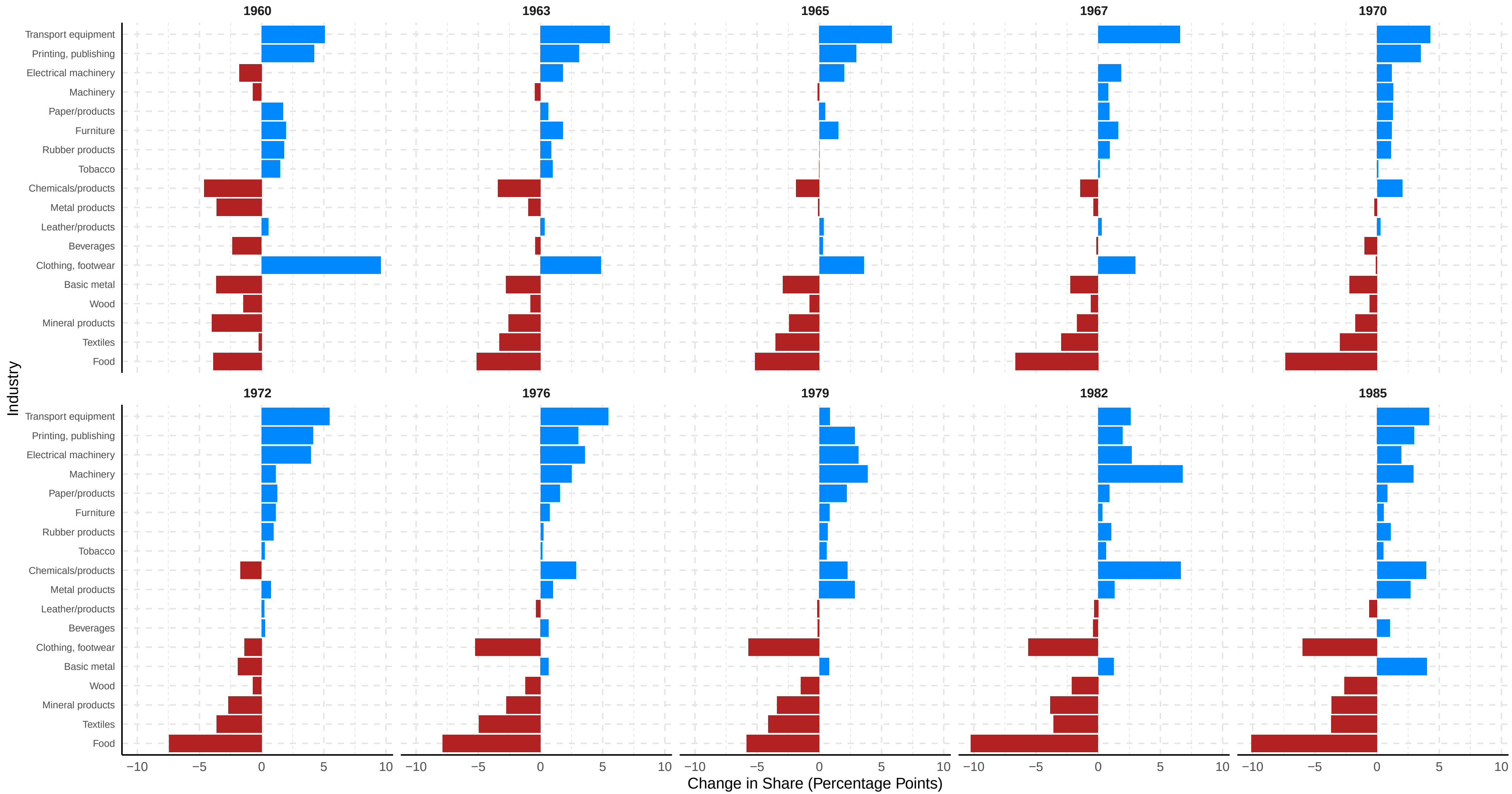

Figure B.3: Change in black Labor Share by Industry from Elimination of Frictions

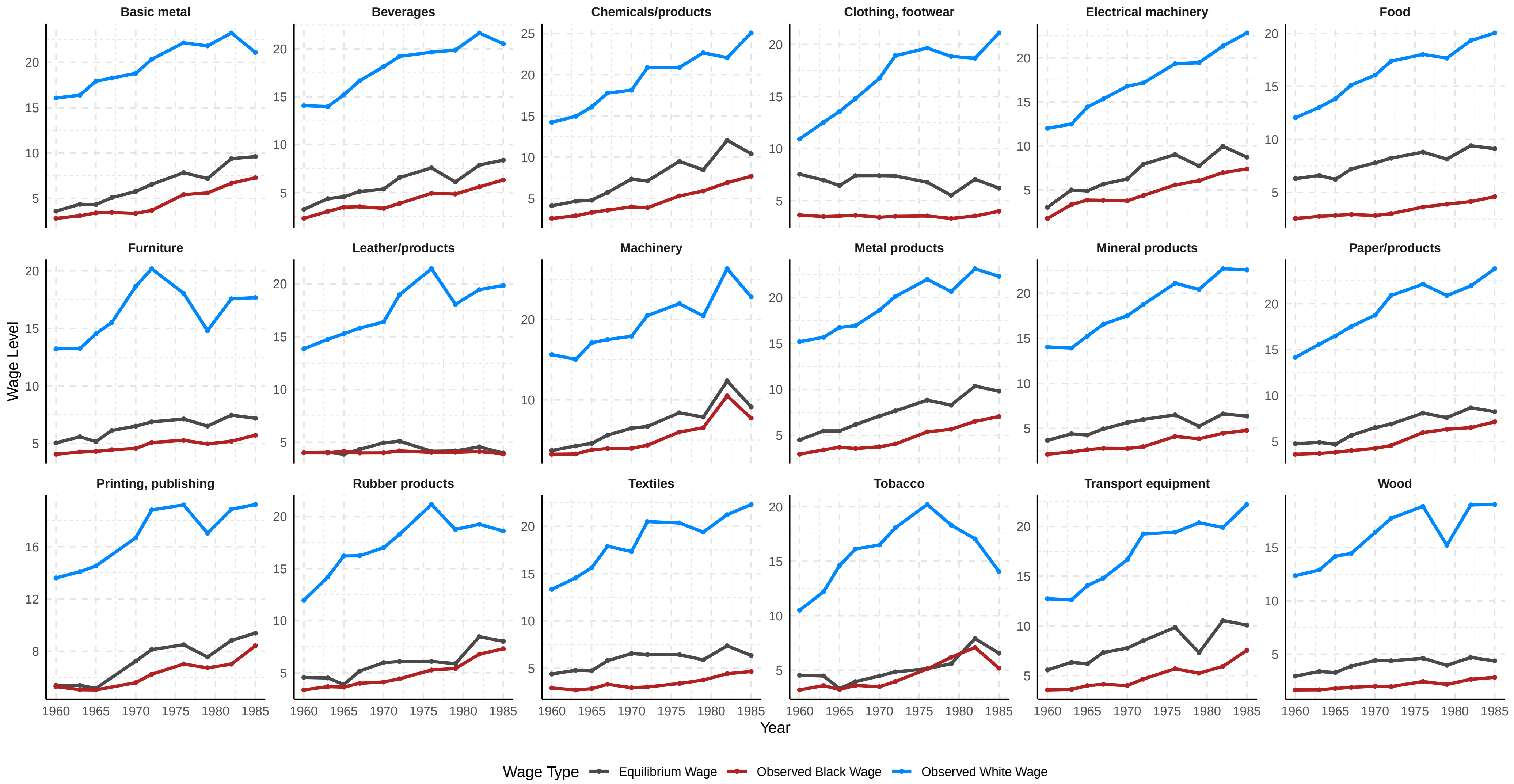

Figure B.4: Evolution of Wages by Industry: Comparing model's equilibrium wage with observed data

This figure presents a Industry-wise comparison of the evolution of average wages in South Africa's manufacturing for the period 1960-1985. It compares average wages for whites against non-whites and the calibrated equilibrium Industry wages in the paper's model. A comprehensive description of the industries is shown in table C.1

C Tables

Table C.1: International Standard Industrial Classification (ISIC) 1960

3 digit	Major Group	4 digit	Industry group
1	Food	1	Abattoirs: slaughtering, dressing and packing of livestock, including poultry and small game, for meat
		1	Canned and prepared meats and meat specialities, including meat soups, meat puddings meat pies
		1	Natural sausage casings; tallow, dripping and lard
		3	Butter and cheese
		4	Condensed milk and milk powder and other edible milk products, except ice cream, ices, etc.
		5	Ice cream, ices and other frozen milk desserts
		6	Canned, preserved and dried fruit and vegetables; fruit and vegetable juices; fresh fruit cordials and squashes; jams and jellies
		6	Pickles and sauces
		2	Canned and preserved fish, fish meal and fish oil, including such processing on factory ships
		12	Compound cooking fats, margarine and edible oils and whale oil
		7	Flour and other grain mill products, including stock dry feeds
		118	Instant breakfast foods
		8	Bread, cakes and biscuits
		7	Macaroni, vermicelli and spaghetti and dried fruit packing
		9	Manufacture and refining of sugar; golden syrup
		10	Chocolates, sugar confectionery and cocoa
		10	Roasted peanuts, other nuts and popcorn
		15	Flavouring essences
		15	Vinegar
		13	Coffee roasting, chicory grinding and tea blending and packing
		15	Yeast
		15	Other food products N.E.C (including precooked meals for resale only, tartaric materials, baking powder, jellies, custards and pudding powders and refined salt, excluding salt produced in conunction with the operation of salt pans and mines)
		11	Balanced animal feeds, chaff cutting, compressed fodder and lucern meal milling
		11	Bone-meal and blood-meal
2	Beverages	16	Distilleries and wineries
		17	Breweries, including sorghum beer breweries
		17	Malt
		18	Aerated waters and soft drinks, including syrups, but excluding establishments primarily producing fruit juices
3	Tobacco, cigars, cigarettes, snuff	19	Major group 3 - Tobacco
4	Textiles	20	Wool scouring and combing
		20	Cotton ginning; fibre working (animal and vegetable)
		20	Dyeing, bleaching, printing and finishing
		21	Blankets
		22	Spinning, weaving and finishing of woollen yarns and fabrics, except blankets, carpets and rugs
		23	Spinning, weaving and finishing of non-woollen yarns and fabrics, except blankets, carpets and rugs
		24	Garment and hosiery knitting mills
		25	Other knitting mills
		123	Carpets and rugs, mats and matting
		26	Rope, cable, cordage, twine, net and related products
		26	Linoleum and coated fabrics
		26	Pressed felt, padding, wadding and upholstery filling; tyre cord and fabric
5	Clothing, footwear and made-up textile goods	35	Soft furnishings including bias binding and embroidery
		36	Bags and sacks (from piece goods)
		37	Tents, tarpaulins, sails and other canvas goods
		38	Automotive textile goods, including seat covers, safety belts and upholstering
		29	Men's and boys' clothing factories
		29	Men's and boys' hat and cap factories
		29	Tie factories
		30	Bespoke tailoring
		31	Women's and girls' clothing factories
		32	Furriers
		33	Millinery
		27	Major group 7 - Footwear
6	Wood and cork products (excluding furniture)	39	Sawmilling from the round log and preservation of timber
		40	Board - laminated, plywood, particle, etc.
		40	Sawmilling; not from the round log; carpentry and joinery works and prefabricated wooden buildings, except on site construction from purchased materials
		40	Wattle bark grinding and compressing and other mill products - cooperage, wood - wool, etc.
		40	Wood and cane containers
		40	Woodcarving and wood turning
		40	Coffins, excluding the manufacture of coffins by funeral undertakers
		40	Picture frames and framing
		40	Other wood and cork products
7	Furniture, cabinet making, etc.	41	Major group 9 - Furniture and fixtures, except primarily of metal

Notes: This table outlines all the three- and four-digit industry classifications according to ISIC definitions in 1960. The four-digit numbers for the years after re-classification in 1970 have been cross-walked to match their definition in 1960. Thus some four-digit numbers will appear more than once within one major group since they were disaggregated in later years. Some new major groups and four-digit groups that were later introduced after 1960 are not included in the analysis for consistency and comparability of the data across years

Table C.2: International Standard Industrial Classification (ISIC) 1960 (continued)

3 digit	Major group	4 digit	Industry group
8	Paper and paper products	42	Pulp, paper, paperboard and fibreboard
		43	Manufacture of light packaging: non-corrugated, flexible, rigid and folding paper bags and boxes
		43	Manufacture of heavy packaging: paper sacks, balers and corrugated containers
		44	Stationery
		45	Other paper products
9	Printing, publishing and allied indistries	46	Printing and publishing
		46	Publishing only, as a separate business
		46	Services for printers
10	Leather and leather products	47	Tanneries - leather and fur
		47	Fellmongering
		48	Harness and saddlery
		48	Travel goods
		34	Ladies' handbags
		48	General and small goods of leather and leather substitutes
11	Rubber products	50	Tyres and tubes
		49	Rubber products not elsewhere classified
12	Chemicals and chemical products	55	Crude oil and oilseed cake and meal
		53	Tanning extract and other basic industrial chemicals
		52	Fertilisers
		59	Pesticides, insecticides, fungicides and herbicides
		145	Synthetic resins, plastic materials and man-made fibres, except glass
		57	Paints, varnishes and lacquers
		58	Medicinal and pharmacfutical preparations
		56	Soap, other cleaning compounds and candles
		58	Perfumes, cosmetics and other toilet preparations
		136	Other chemical products not elsewhere classified
14	Non-metallic mineral products (excluding products of petroleum and coal)	64	Major group 16 - Pottery, china and earthenware
		65	Sheet and plate glass, glass containers and other glassware, glass bevelling and silvering, safety glass and other glass products, not elsewhere classified
		65	Scientific and laboratory glassware, except the grinding of optical lenses
		64	Bricks, tiles, refractories, etc.
		66	Cement
		67	Plaster and other composite sheets, pipes, etc. from gypsum, cement, asbestos, etc.
		66	Cement products
		72	Stone and slate products
		72	Abrasives
		72	Other non-metallic products not elsewhere classified
15	Basic metal industries	73	Iron and steel basic industries
		74	Steel pipe and tube mills
16	Metal products, except machinery, implements and parts	125	Cutlery, hand tools and general hardware
		126	Furniture and fixtures primarily of metal, except upholstered or padded furniture
		127	Building hardware
		120	Structural steel work; prefabricated steel buildings, excluding on-site erection from purchased materials
		128	Ornamental and architectural metal work
		129	Boiler manufacture and installation, excluding installation from purchased materials
		77	Sheet metal products
		78	Tinware
		79	Cables, wire products and gates
		81	Springs (all types)
		76	Headed and threaded articles
		130	Engineering workshops, welding, fitting and turning
		119	Electroplating, anodizing, tinning, galvanising, enamelling, industrial spray painting, plastic coating and sand blasting of metal products
		82	All other mental products not elsewhere classified
17	Machinery except electrical machinery	83	Agricultural machinery and equipment, including tractors - agricultural and other
		84	Metal and woodworking machinery
		84	Special industrial machinery and equipment, except metal and woodworking machinery
		85	Office, computing and accounting machinery
		131	Refrigerators, washing machines, stoves and ovens
		132	Air conditioning and ventilation machinery and refrigeration equipment
		85	All other machinery not elsewhere classified
18	Electrical machinery, apparatus, appliances and supplies	86	Electrical industrial machinery and apparatus
		133	Radio, television and communication equipment and apparatus
		134	Electrical appliances and housewares
		87	Insulated wires and cables
		88	Dry cell and wet cell batteries
		89	Electric bulbs and fluorescent tubes
		89	Electrical products not elsewhere classified
19	Transport equipment	94	Motor vehicles
		95	Caravans, trailers and vehicle bodies
		100	Radiators
		96	Motor vehicle parts and accessories not elsewhere classified
		98	Specialised automotive engineering workshops working primarily for the trade
		92	Locomotives, coaching and goods-stock
		135	Other transport equipment not elsewhere classified

Notes: This table outlines all the three- and four-digit industry classifications according to ISIC definitions in 1960. The four-digit numbers for the years after re-classification in 1970 have been cross-walked to match their definition in 1960. Thus some four-digit numbers will appear more than once within one major group since they were disaggregated in later years. Some new major groups and four-digit groups that were later introduced after 1960 are not included in the analysis for consistency and comparability of the data across years