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Socioeconomic portraits: Leveraging the production possibilities frontier to expand coverage of inequality and economic history in principles classes

Some economists favor expanding coverage of inequality and economic history in principles classes. We argue that the production possibilities frontier (PPF) – a standard principles model -- can be easily modified to promote this goal. This is shown by providing various PPF history applications. Concurrently, we introduce the concept of "distribution boxes." This analytical tool illustrates, within a PPF context, how output is distributed across groups in an economy, which facilitates inequality analyses. In turn, this tool can transform PPFs into "socioeconomic portraits" of entire economies. We outline how these portraits could expand the efficacy of "literacy-targeted" principles classes.

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1. Introduction

Pity the lowly production possibilities frontier (PPF). Found in numerous introductory economics texts at both secondary and college levels, it plays a key role in introducing students to the basic contours of the discipline: scarcity, opportunity cost, efficiency, and comparative advantage. In most principles classes, it is then cast aside and replaced with a variety of more detailed micro and/or macroeconomic constructs. At the end of the semester, many students might vaguely recall that the first economics model they studied had something to do with producing "guns and butter."

Concurrently, some economists have recently placed many of the introductory texts alluded to above under a pedagogical microscope and have found them wanting. In particular, Bowles and Carlon (2020) and Owen and Hagstrom (2021) assert that these books spend little time assessing issues that interest many students today, such as poverty, global climate change, and especially wealth and income inequality. Partly due to this concern, starting in 2015, an open-access introductory textbook, entitled The Economy, now used by instructors at 504 colleges, was developed with the explicit goal of expanding coverage of these topics, often from a historical perspective (Carlin et al., 2025). In a similar vein, Erbil and Sanzenbacher (2020) outline a curriculum module for introducing issues of inequality in a principles class. In a sharp break with past curricula, some instructors, such as Raj Chetty at Harvard University and the faculty at Hamilton College, require students to conduct formal statistical analyses of large datasets when exploring this topic (Matthews, 2019; Owen & Hagstrom, 2021).

This paper's thesis is that the PPF – a key symbol of traditional economics pedagogy – can nevertheless be leveraged to explore inequality and economic history as well (albeit with some limitations). To convey this adaptability, we [a] present five historical analyses within a PPF context that range from the 15th to the early 21st centuries, and then [b] list follow-up discussion topics, which often address current issues, that, at the instructor's discretion, can be covered after an application is completed. When doing [a] and [b], we develop an analytical tool, denoted as "distribution boxes," which, for a given point in two-good PPF space, shows how total output is distributed across groups in an economy. When this tool is combined with a PPF, the features of the latter model – and the identities of the specific groups -- can be customized such that they are consistent with, and thus reinforce, the institutions and history that underlie the inequality data conveyed by the boxes. Under these conditions, distribution boxes can expand the curriculum coverage of PPFs: In addition to outlining basic concepts, they can become "socioeconomic portraits" of entire economies that illuminate, at an introductory level, various economic history and inequality topics. We will outline the pros and cons of this approach, which will include contrasting distribution boxes with alternative inequality measures.

Several groups of economics educators could benefit from these PPF applications:

- Teachers with an interest in "literacy-targeted" (LT) instruction could use this paper to improve their curricular delivery. This strategy uses a small number of formal models to convey a few essential core concepts in principles classes (Cohen et al., 2024). Goffe and Wolla (2024) argue that the PPF is a suitable LT model due to its analytical breadth – see their Table 2, which lists numerous topics that can be conveyed by this construct (Goffe & Wolla, 2024). This list, however, doesn't include inequality and economic history (which is understandable). This paper adds these two topics to their Table 2 by showing how they can be covered in interesting and novel ways by PPFs.
- More generally, both high school and college instructors will have additional tools to employ when increasing coverage of economic history and inequality in principles

classes. Previous course use of PPFs would facilitate this curriculum shift.

- In high schools, teachers with social science certification likely teach most economics classes. These instructors average only 4.38 college credit hours in economics, but they took 23.04 credit hours in history (Bosshardt & Walstad, 2019). Hence, greater economic history coverage via PPFs could increase both instructors' receptivity to teaching high school economics classes and their effectiveness.

We proceed in Section II by reviewing past PPF history examples and then outline "boundary conditions" for our applications. Section III employs PPFs to cover two economic history examples, absent an inequality analysis. Section IV introduces distribution boxes via a tutorial, which are then used to assess inequality in three more PPF applications. Section V contrasts this tool with alternative inequality measures and then assesses its pros and cons.

2. Previous PPF History Applications and Boundary Conditions

Previous applications

Kyer and Maggs (2021), surveying fourteen textbooks, found a "complete reliance upon hypothetical examples" (such as guns and butter, fig leaves and apples, computers and cars) when PPFs are used. That said, several non-textbook PPF history applications exist (many of which are linked to WWII). In the video "Resources and Scarcity: What's Economics All About?", from the "Economics USA" film series (Economics USA, 1984), a PPF explores wilderness vs. mineral development in Alaska and the evolution of the US economy from the Great Depression to World War II. Jenyk and Wakefield (2018) explain World War II cartoons drawn by Theodor Seuss Geisel (Dr. Seuss) using PPFs, while Chambers and Mixon (2020) use a PPF to show the 1932-45 evolution of the German economy. Finally, Kyer and Maggs (2021), while they do not draw a PPF, use WWII production data to determine years when the US was moving towards its PPF, moving along its PPF, and when its PPF shifted outward. We have not found distribution boxes in previous literature.

Discussion topic flexibility and boundary conditions

As noted earlier, applications are followed by discussion topics, often based on current issues, to be used at a teacher's discretion. We also impose these boundary conditions:

- Students already have some familiarity with PPFs.
- To minimize the complexities associated with introducing international trade into our analyses, we use "Production" instead of "Consumption" Possibility Frontiers (CPFs).
- We note that textbooks sometimes use PPFs to model input production. For recent examples, see the fourth column from the left in Table 1. We will mirror this practice and, for two of our six applications, model input production. This allows our PPFs to be more precisely "customized" so that they fit real-world economies. (Note: PPF output is often consumer products, but resources can also be allocated to the production of downstream inputs, which is "output" for upstream input industries.)
- We assume that, when needed, instructors will assign pre-class readings – some of which can be found in our sources -- that facilitate an application or discussion topic.
- Finally, our PPF applications are often combined with an illustration, a map, or photos that portray the relevant history. This allows a teacher to shift between these constructs and the PPF, such that this model reinforces the historical event.

Table 1: PPF and inequality coverage in ten prominent principles textbooks.[a]

Author	Title	Uses a PPF (Y/N)	Models Inputs with a PPF (Y/N)	Inequality Chapter (Y/N)	Reference to Gini coefficient (Y/N)
Asarta and Butters	Connect Master, Principles of Economics (2022)	Y	Y Capital goods/ Page 387	Y[c]	N
Case, Fair, Oster	Principles of Economics 13th edition (2019)	Y	Y Capital goods/ Page 30	Y	Y
Colander	Economics 12th edition (2024)	Y	Y Oil (in barrels)/ Page 188	Y	Y
Mateer and Coppack	Principles of Micro-economics 4th edition (2024)	Y	Y Capital goods/ Page 50	Y	Y
The CORE	The Econo-my 2.0, Mi-croeconom-ics edition (2024)	N[b]	NA	Y	Y
Hub-bard and O'Brien	Microeco-nomics 8th edition (2021)	Y	Y Capital goods/ Page 66	Y	Y
Mankiw	Principles of Micro-economics 10th edition (2024)	Y	N	Y	N
McConnel, Brue, Flynn	Economics 23rd edition (2024)	Y	Y Industrial ro-bots/ Page 22	Y	Y

Stevenson and Wolfers	Principles of Economics 2nd edition (2023)	Y	N	Y	N[d]
Taylor and Weerapana	Principles of Economics 9th edition (2022)	Y	Y Investment goods/ Page 25	Y	Y

[a]Source: Ihrig and Wolla (2022), which identifies six prominent post-2020 introductory texts; to this list, we added Colander (whose earlier 1993 text played in important role in providing the underlying rationale for this paper); CORE (a relatively recent text with a large international following, which attempts to expand economic history and inequality topics); Asarta and Butters (since Asarta plays a key role in surveying the economics profession on teaching techniques, see Asarta, C. J., Chambers, R. G., & Harter, C., 2021); and Taylor and Weerapana (2022)-a commonly used text among principles course which was most likely omitted from Ihrig and Wolla due to the age of the text at the time of publication.

[b]In section 3.4, at the individual person level, they use a "feasible frontier" curve in two-good space ("Hours of free time per day" on the horizontal axis, "Consumption Spending ($)" on the vertical axis) to demonstrate the concept of opportunity cost.

[c]While this text does not have a chapter dedicated to inequality, they mention issues of inequality in several chapters.

[d]In chapter 13.1 the authors include alternative methods for measuring inequality.

3. Leveraging a Traditional PPF (Absent Distribution Boxes) to Illuminate Economic History: Two Applications

The Columbian Exchange within a PPF context: Western Hemisphere vs. Europe, 1491-1750

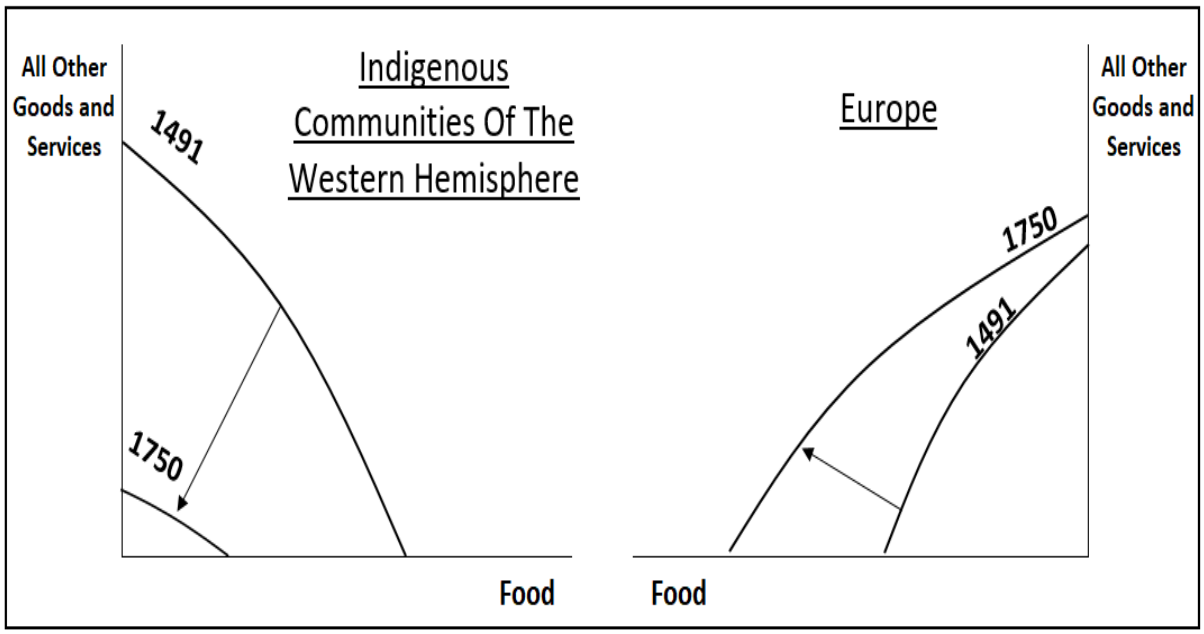
This analysis provides dramatic (and sorrowful) insights into the socioeconomic origins of the modern world. After first reviewing the Columbian Exchange – aided by a prior reading or a chart (see Figure 1A) – an instructor could use a PPF to assess how this cataclysmic event affected productive capability, which differed massively, Europe vs. the Western Hemisphere – see Figure 1B. Teachers could also provide details on these impacts. For example, note in Figure 1B that food production capability in Europe was greatly increased by the Columbian Exchange -- see the large outward shift in the European PPF, 1491-1750, along the horizontal axis. This expansion played a key role in European history. For example, Nunn and Qian (2010) estimate that the non-native potato expanded both the overall European population and urbanization during 1700-1900 by one-fourth. The disease and warfare-induced destruction of Indigenous communities throughout the Western Hemisphere, which decimated 90% of the pre-1492 population of 60 million (Koch et al., 2019), is shown by a massive (post-1492) inward PPF shift for both goods. When drawing these shifts, a teacher could move between Figures 1A and 1B, thus reinforcing the linkages between the PPFs and the relevant history.

Following this analysis, a teacher could shift to one of these discussion topics:

- Given the role of disease in the post-1492 loss in Indigenous productive capability, instructors could move to today's COVID-19 pandemic and show, via PPF shifts, how it

Figure 1A: The Columbian Exchange (Pinterest1).

Figure 1B: The economic impact of the Columbian Exchange within a PPF context: The Western Hemisphere vs. Europe, 1491-1750.



affected U.S. productive capability. Fernald and Li (2022) find that near-term potential output fell by 1¾ percent due to COVID-19. In addition, high teleworkability industries – where working remotely is feasible – increased their labor productivity (and thus their productive capability), while those with low teleworkability did not (Fernald & Li, 2022). A PPF could show these impacts by putting high teleworkability output on the horizontal axis and low teleworkability output on the vertical axis. The PPF shifts and their economic theory drivers are two-fold: [1] Labor resource reduction: the potential output fall of 1¾ percent causes a (modest) parallel inward shift for both goods; [2] Increase in technology: to reflect differing labor productivity changes, high vs. low teleworkability industries, the PPF shifts outward on the horizontal axis in a non-parallel fashion for high teleworkability output while the vertical intercept remains constant. That is, there was an expansion in virtual technology for high teleworkability output only (Fernald & Li, 2022).

- The Columbian Exchange, plus subsequent genocidal actions by European colonists and the United States Government (Dunbar-Ortiz, 2014) (DuVal, 2024), cut the United States Indigenous population from 5-15 million down to 250,000 by 1890, while U.S. acreage under their control fell from 2.4 billion to 56 million acres today (Treuer, 2021). (For a differing view of this history, see Fynn-Paul 2023.) This history, plus efforts today to enhance tribal economic and spiritual health, have prompted calls for carefully constructed land reparations (see Treuer, 2021 for a proposal on U.S. parklands; see Hassan and Healy, 2019 for a listing of previous reparation programs for both non-Indigenous and Indigenous U.S. groups). This policy direction raises complex moral, political, and administrative issues that are beyond the scope of most principles classes to assess in detail. That said, while secondary to moral issues, the potential economic efficiency impacts can be modeled by PPFs. More specifically, Indigenous groups, due to accumulating a vast array of ecological information across thousands of years (denoted as TEK, for traditional ecological knowledge per Long et al., 2020), may be highly skilled at restoring threatened species and ecosystems. For examples, often done with non-profit groups and public agencies, see Long et al. (2020) on tribal ecosystem restoration in the Western United States.; Carpenter (2022) on restoring Atlantic Salmon in Maine; and Van Leuven et al. (2023) on revitalizing the American Chestnut tree in the Eastern United States. These advantages could be shown with a PPF by placing "Production of Ecologically Restored Land" on the horizontal axis and "All Other Output" on the vertical axis, with an initial overall position – a Point X -- that is significantly inside this PPF. Land reparations, by transferring acreage to Indigenous groups, may allow them to leverage their "TEK technology" more effectively, perhaps again in concert with non-Indigenous organizations, which would push Point X to the right (closer to the PPF). That is, carefully calibrated land returns could be efficiency-enhancing (although again this effect is secondary to broader fairness concerns). Possible spillover benefits could also be discussed.

Modeling the economic impact of foreign policy with PPFs: Japan vs. USA since 1929

This PPF history application – see Figures 2A, 2B, and 2C -- links post-1929 changes in productive capabilities (= PPF shifts) for Japan and the United States to their differing foreign policy goals. Given this aim, their respective PPFs measure these outputs: [a] War Goods (vertical axis), and [b] Consumer Goods (horizontal axis).

Starting in 1929-1941, which covers the Great Depression and pre-WWII tensions, note that Japan, in contrast to the US, increased its productive capability for War Goods (Yasuba, 1996; Asia for Educators, 2023); see Figure 2B. (Due to human capital losses from high unemployment, perhaps the US 1929 PPF – see Figure 2C -- should initially shift inward.) The Japa-

nese positions – Point X in 1929 to Point Y in 1941 -- are also closer to its PPF than the 1932 U.S. position (see the inward U.S. movement from Point X in 1929 to the 1932 position in Figure 2C, and then to Point Y in 1941). Indeed, the 1932 unemployment rates for Japan and the US were 6.8% and 32%, respectively (Blumenthal, 1978). The Japanese GDP, in real terms, also expanded 63.7% during 1929-1940 (Ohkawa et al., 1979); in contrast, the US GDP grew by 19.9% (Statista, 2024). These stark differences could frame this class discussion:

- Why was the Japanese unemployment rate, relative to the United States, so much lower during the Great Depression? Why was Japan's economic growth higher? Instructors could start by noting that Japan had several advantages over the United States. First, due to pre-1930 financial crises, Japan enacted banking reforms. Hence, when the financial crisis became global in 1931, Japan was less affected than the United States due to those earlier reforms (Shizume, 2009). Second, Japanese labor unions were weaker than their United States counterparts in the 1930s, which, when combined with the higher inflation driven by a more rapid Japanese recovery, reduced the real wage rate, thus fostering Japanese worker retention (Cha, 2003). Finally, in contrast to the United States, Japan adopted expansive fiscal policies, which may have pulled Japan out of the Great Depression more rapidly (Cha, 2003; Shizume, 2009; although Nanto and Takagi, 1985 are less certain). Why did Japan adopt these policies while the United States did not? Cha (2003) lists two key reasons that in turn highlight the linkage between an economy and its underlying sociopolitical fabric: [1] Relative to the United States, Japan was less likely to regard economic intervention, such as an activist fiscal policy, with ideological suspicion; [2] A key interest group in Japan during the 1930s – the military – pushed strongly for fiscal intervention in order to expand Japan's armed forces. (And they got it: Defense spending as a percentage of public expenditures rose from 31% in 1931 to 47% in 1936, in part fueled by the 1931 Manchuria invasion Cha, 2003). In turn, this expansion promoted a key foreign policy goal of Japan: driving the foreign "interlopers" -- such as England and the United States– out of Asia, and when doing so, gaining access to resources such as oil and rubber (Morgan, 2020). Hence, the foreign policy goals of Japan crucially shaped its economy during the 1930s (see Figure 2B, which shows both greater production and productive capability for war goods). In turn, much of Japan's economic growth was attributed to the development of additional weaponry.

The 1941-45 PPF shifts during WWII for the two countries again diverge, with the United States now increasing its War Goods productive capability (see Figure 2C), while Japan's productive capability for both goods was destroyed by U.S. military actions (see Figure 2B). Differing PPF shifts continue from 1945 to 2022. This question could then be posed:

- What explains the postwar PPF shifts for the two countries? Again, foreign policy is playing a key role. For Japan, Article 9 of its new (postwar) constitution stated that "the Japanese people forever renounce war as a sovereign right of the nation... land, sea, and air forces... will never be maintained" (Asia for Educators, 2025). In turn, Japan primarily produced consumer goods (see the postwar PPF shift in Figure 2B), although it created a small defense force (Stafford, 2023). In contrast, the United States, as a superpower, expanded its productive capability for both goods (see Figure 2C).

After finishing this application, instructors could assign readings on future Japanese defense plans (Arthur, 2025) and population growth (Newsweek, 2025). This discussion question could then be posed: With low immigration, how might the Japanese PPF shift in the future? If the immigration of skilled workers instead increases, then how would this shift be modified?

Figure 2A. Left: Warship, Japanese Imperial Navy, circa WWII (Pinterest2). Right: Toyota car carrier ship (Columbia River Pilots).

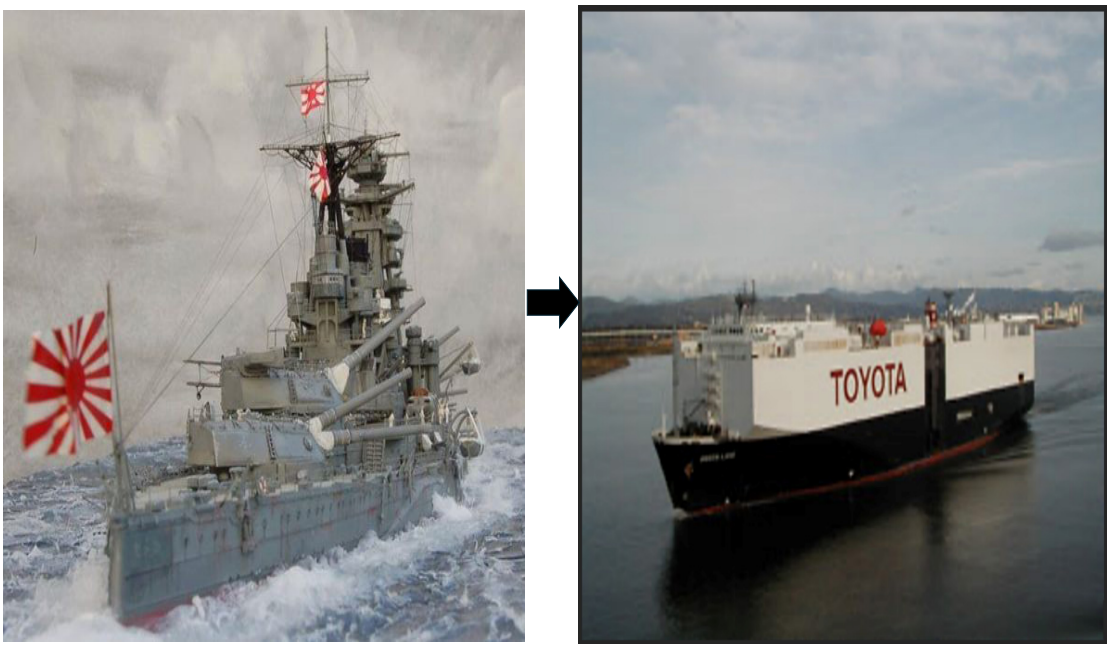


Figure 2B. The historical evolution of Japan within a PPF context: 1929-2022.

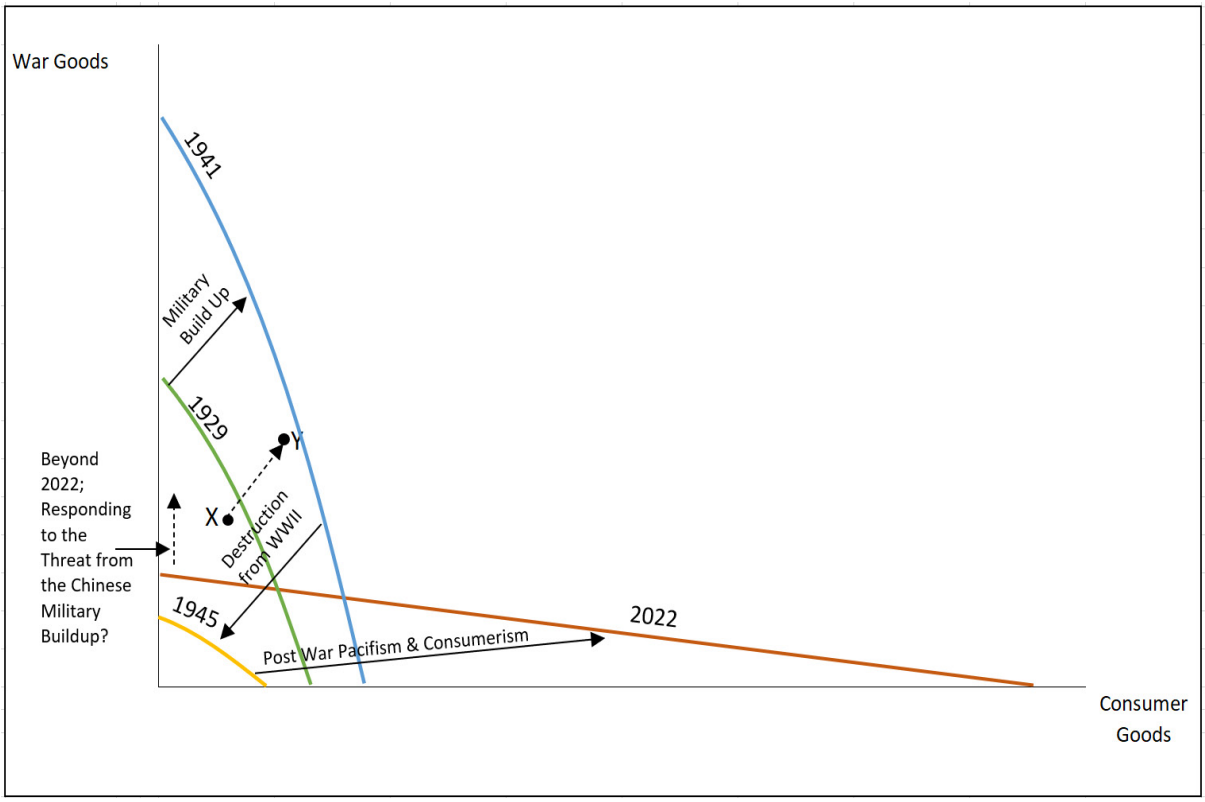
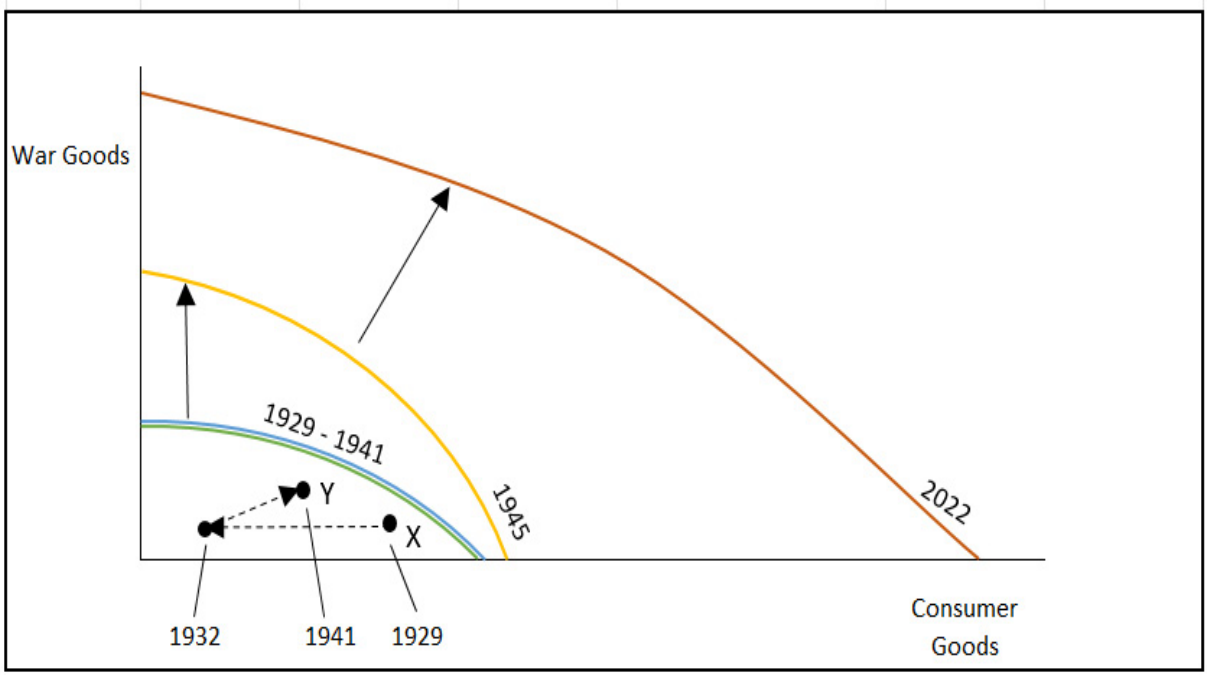


Figure 2C. As a comparison to Japan: The historical evolution of the United States within a PPF context, 1929-2022.



4. Leveraging the PPF to Explore Inequality: Introducing Distribution Boxes

A tutorial on distribution boxes, using U.S. generational inequality as a case study

We develop distribution boxes, which display how output is allocated across groups within an economy in a PPF context, via the steps listed below. (These steps could be used to convey these boxes when the "who gets the output" choice question is initially covered.) Our goal is to "customize" both the PPF and the identities of the socioeconomic groups, whose output shares will be illustrated by the boxes, so that they reinforce the institutions and politics that underlie the inequality data conveyed by this tool.

Step 1: Identify the economy, the time period, the two PPF goods, and the central issue to be addressed. We choose "Housing Benefits for Large Homes, Owned plus Rented" (which are houses and apartments with three or more bedrooms) and "Capital Production: Investor Benefits" as our two PPF goods in 2024 to explore two forms of U.S. generational inequality: housing and overall wealth -- see Figure 3A. Large homes are chosen because it is highly important for families with children. Investor benefits from capital production are chosen because the distribution of this good across generations will be based on net worth minus real estate holdings. Hence, its allocation illustrates U.S. generational wealth inequality.

Step 2: Choose an "overall PPF position" for this economy – again, see Figure 3A, with two possible overall positions: Points A (efficient) and B (inefficient). Distribution boxes can be drawn for either point; we choose B. (Note: With B, teachers could provide a few examples of U.S. regulatory-induced production inefficiencies for the housing good.)

Step 3: Divide the economy's population into groups (to minimize graphical clutter, 2-5 groups is best). Groups are defined to facilitate the application (and so could be based on age,

Figure 3A: The United States economy, 2024. Determining the two outputs and the overall PPF position (A or B).

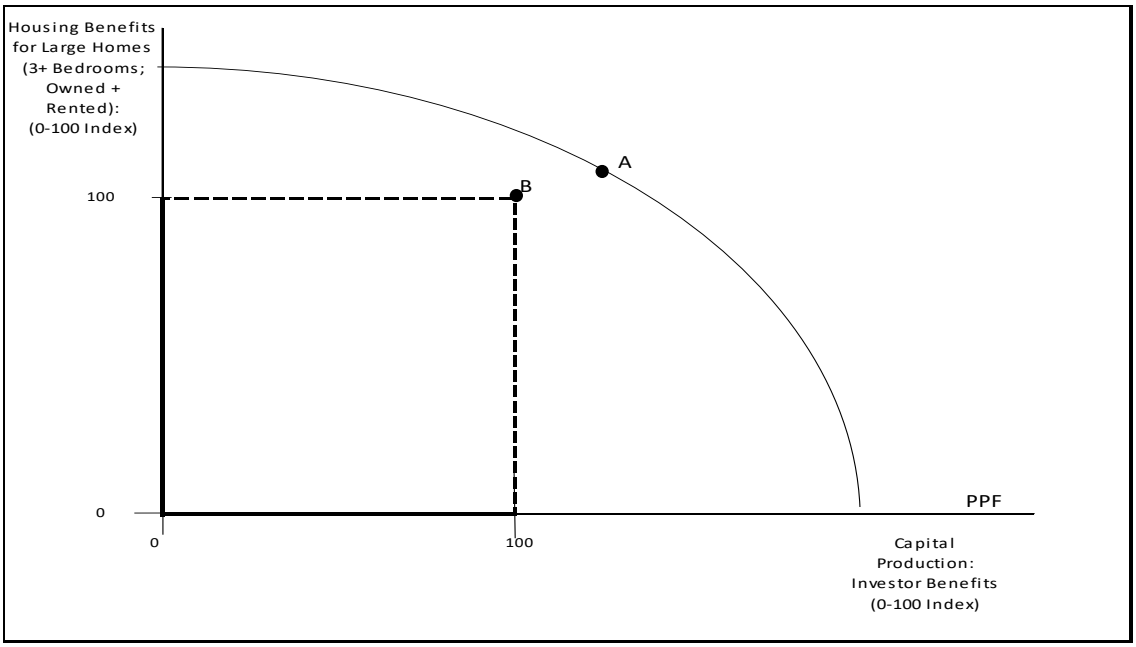
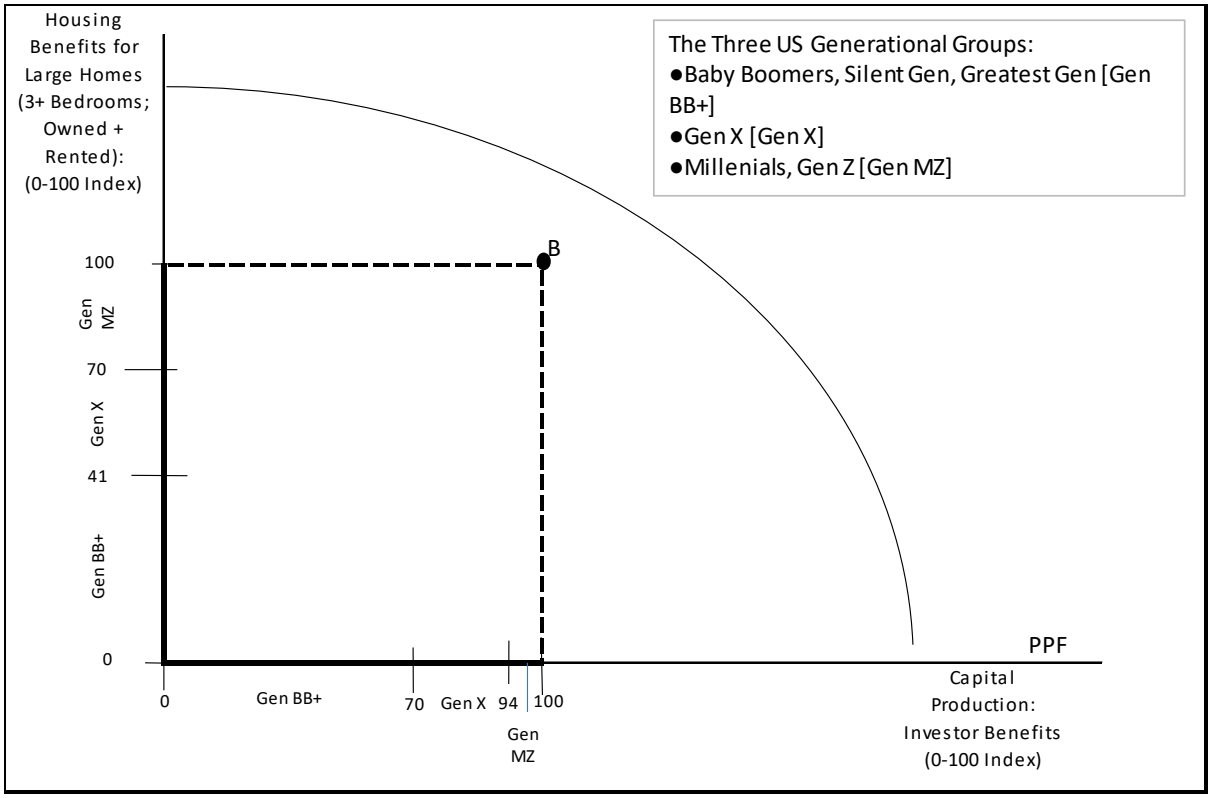


Figure 3B: Allocating output across the three generational groups.



ethnicity, religion, etc.). Since we are assessing U.S. generational inequality (see Step 1), we define three groups based on age: [1] Baby Boomers, Silent and Greatest Generations; born before 1965 (Gen BB+); [2] Generation X; born in 1965-1980 (Gen X); and [3] Millennials, adult Generation Z; born in 1981-2006 (Gen MZ). Using Hermez et al. (2024), we include minors (age 17 or less) by distributing them across the three groups based on the age of the householder they live with. (For example, if 20% of a group's households have children, then they get 20% of the children.)

With this proviso, the United States population percentages are 25%, 26% and 48% for the Gen BB+, Gen X, and Gen MZ groups, respectively (U.S. Census, 2024).

Step 4: Allocate output for both goods across groups, which can be done "plausibly" or else with statistical sources. We use U.S. Census data on large homes (three or more bedrooms) and apartments, both owned and rented, for the US in 2022 (assumed to be representative of 2024), across the three above-named groups, from Redfin (2023). Using this source, 46.7 million large homes are allocated to Gen BB+, 32.4 million to Gen X, and 33.7 million to Gen MZ. For capital goods, we assume the associated investor benefits – profits, stock value increases – are distributed across the three groups based on their ownership of wealth (= net worth – minus real estate holdings; the latter is excluded because it includes housing, which is a consumption good, and is already measured on the vertical axis). Using data on this wealth definition for the third quarter of 2024, generational wealth holdings are $78.5 trillion for the Gen BB+ group, $27.1 trillion for Gen X, and $6.2 trillion for Gen MZ (Federal Reserve, 2024). Converting shares for each good into a 0-100 index, large home benefits are 41, 29, and 30 for the Gen BB+, Gen X, and Gen MZ groups, respectively; for capital goods, they are 70, 24, and 6. (Indexing makes the output shares easier to see and then interpret in a PPF context.)

Using these values, the 0-100 line segments running along the vertical (housing) and horizontal (non-housing capital goods) axes – see Figure 3B -- are divided into three smaller segments. Each length, for a given good, equals the index points for a specific group. When doing this division, note that starting at the graph's origin, any group ordering is acceptable, but it must be the same for both goods (we use: Gen BB+, Gen X, and Gen MZ).

Step 5: Drawing distribution boxes. Turning to Figure 3C, we now construct the Gen BB+ distribution box. Note that the vertical and horizontal line segments for this group, which emanate from the origin of the graph, generate a 90-degree angle (and hence, two sides of a rectangle). The remaining two sides are added to form a "distribution box" for this group (labelled "Distribution Box, Gen BB+" in Figure 3C). The area of this box has no economic meaning. Instead, one should focus on the lengths of its horizontal and vertical sides, which denote the amounts of the two goods, in index form, going to the Gen BB+ group in 2024.

Turning to Figure 3D, the next box – for Gen X – starts in the upper right-hand corner of the Gen BB+ box, and is constructed (and interpreted) in the same way. The third box – for Gen MZ – also starts in the upper right-hand corner of the previous (Gen X) box.

Step 6: Interpreting the boxes – see Figure 3E – which is enhanced by adding, in brackets for each box, both the population percentages (see "P") and the percentage of children under age 18 (see "C"). Teachers can ask students to look directly at the boxes and associated percentages and infer what they are saying about the allocation of the two goods across generations. For example, the vertical side of the Gen BB+ box, with 25% of the population and 4% of the children, says this group owns 41% of all US large homes. Concurrently, Gen MZ, with roughly double the population size (48%) and raising sixteen times the number of children (64%) relative to Gen BB+, owns or rents roughly 3/4ths of this amount (30% vs. 41% for Gen BB+; see the vertical side of the Gen MZ box). Plausibly, is this a desirable allocation of large homes and apartments across generations?

Figure 3C: Building a distribution box for the Gen BB+ group.

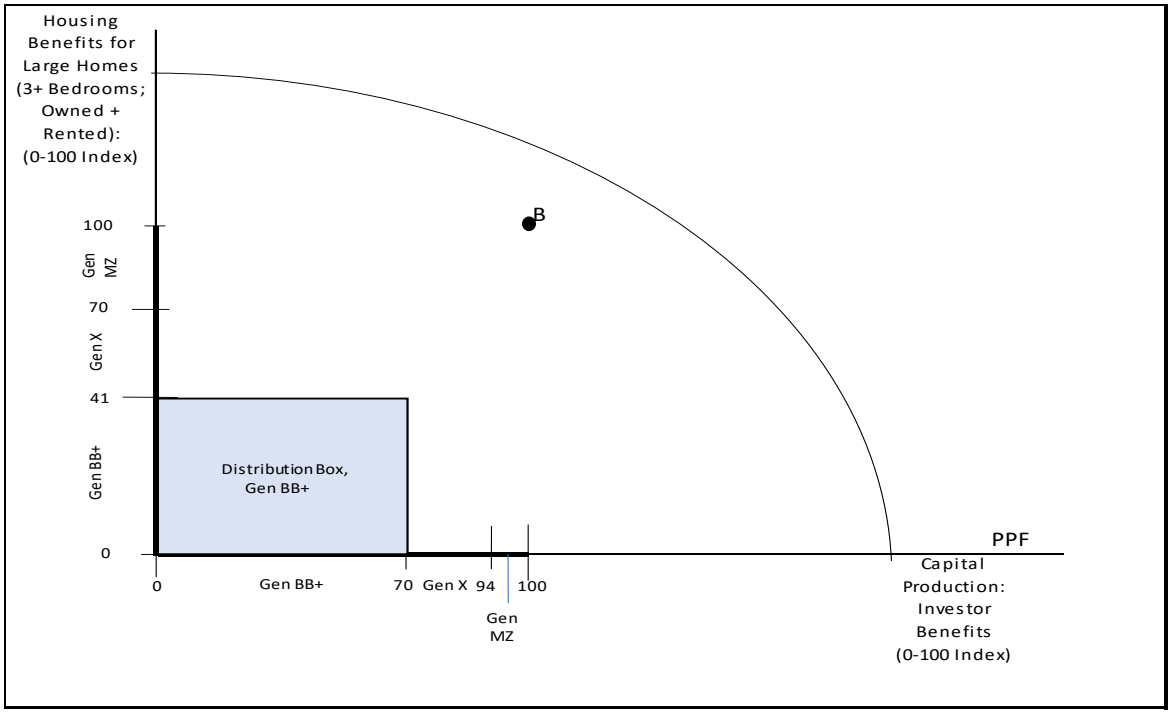
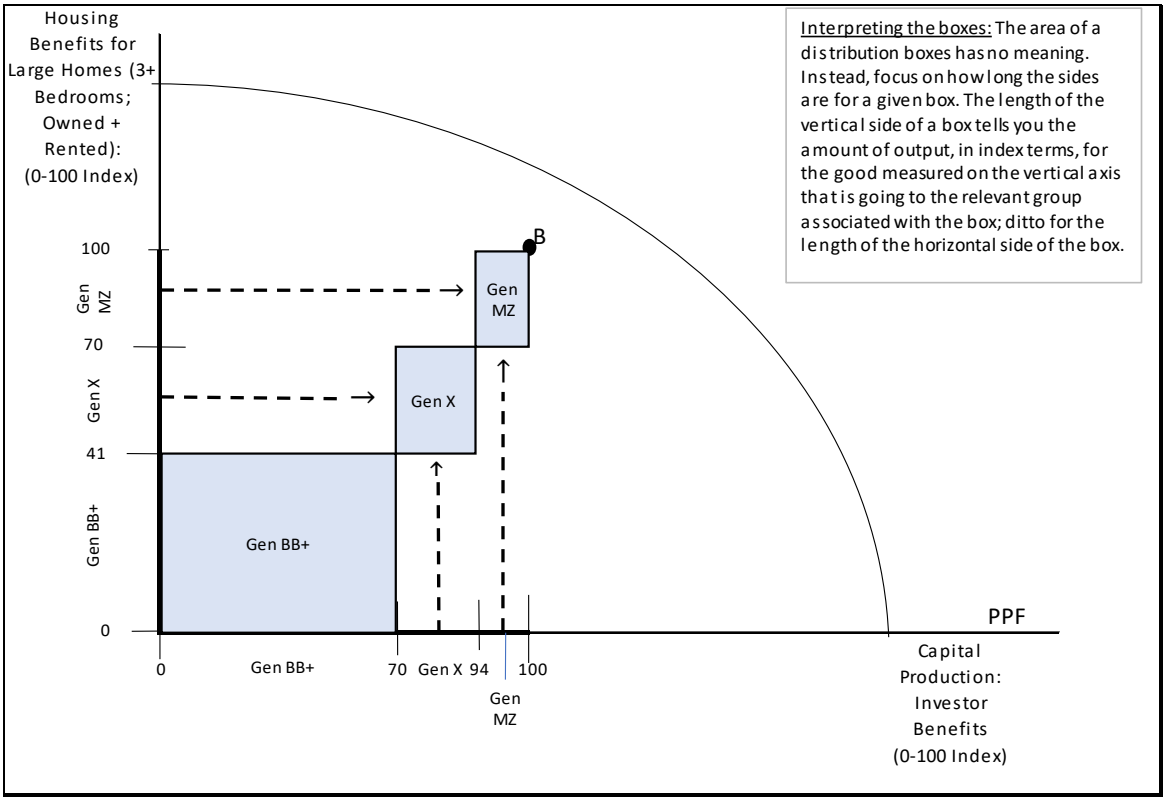
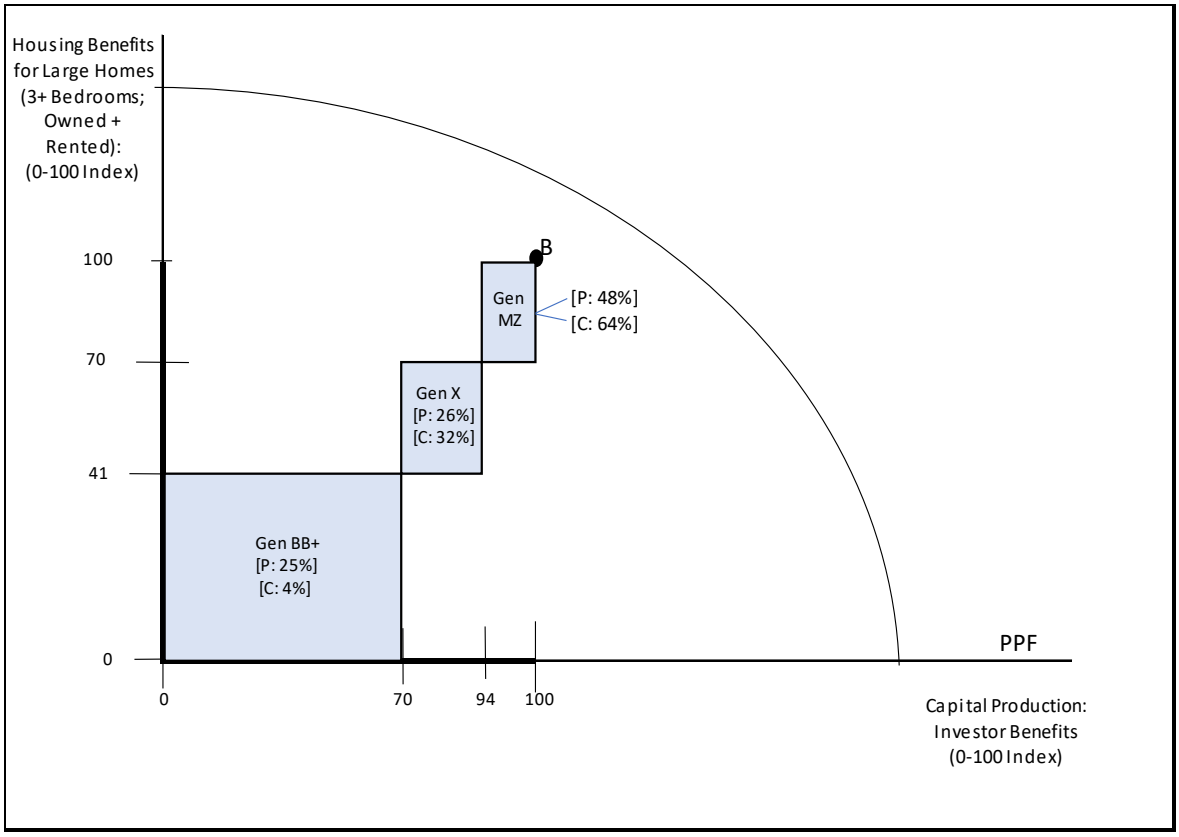


Figure 3D: Building additional distribution boxes for the Gen X, Gen MZ groups.



Step 7: Discussion topics (a possible reading is Stone, 2019). Plausibly, what might make it harder, via political activism, for Gen MZ to change this allocation? What might make it easier? Note that the Figure 3E details, such as the population sizes and the overall wealth distribution shown on the horizontal axis, Gen BB+ vs. Gen MZ, can be used to partially address these two questions. (In contrast, the Gini coefficient, a standard inequality measure – see Table 1 -- does not directly provide this contextual data.)

Figure 3E. The United States, 2024: A generational "socioeconomic portrait."



Using distribution boxes in an economic history context: Assessing the socioeconomic impact of slavery in 1860 antebellum Louisiana

We now use PPFs with distribution boxes to assess inequality in an economic history context, starting with 1860 Louisiana. We use the tutorial steps (but condense the figures). Again, the goal is to manipulate the PPF and the identities of the groups so that they reinforce the history and institutions that underlie the inequality data conveyed by the boxes.

Step 1: Identify the economy, the time period, the two PPF goods, and the central issue to be analyzed. We focus on the socioeconomic impact of slavery in 1860 antebellum Louisiana, and choose output that can be allocated across groups via the 1860 census data:

- We measure "Education" on the horizontal axis – see Figure 4A -- in order to show the nonoptimal amount (= underproduction) of this good in 1860 (which extended beyond African Americans – both free and enslaved -- to poor European Americans, see Merritt,

Figure 4A: Antebellum Louisiana, 1860: Determining the two outputs and the overall PPF position (Point X); allocating output across the five socioeconomic groups.

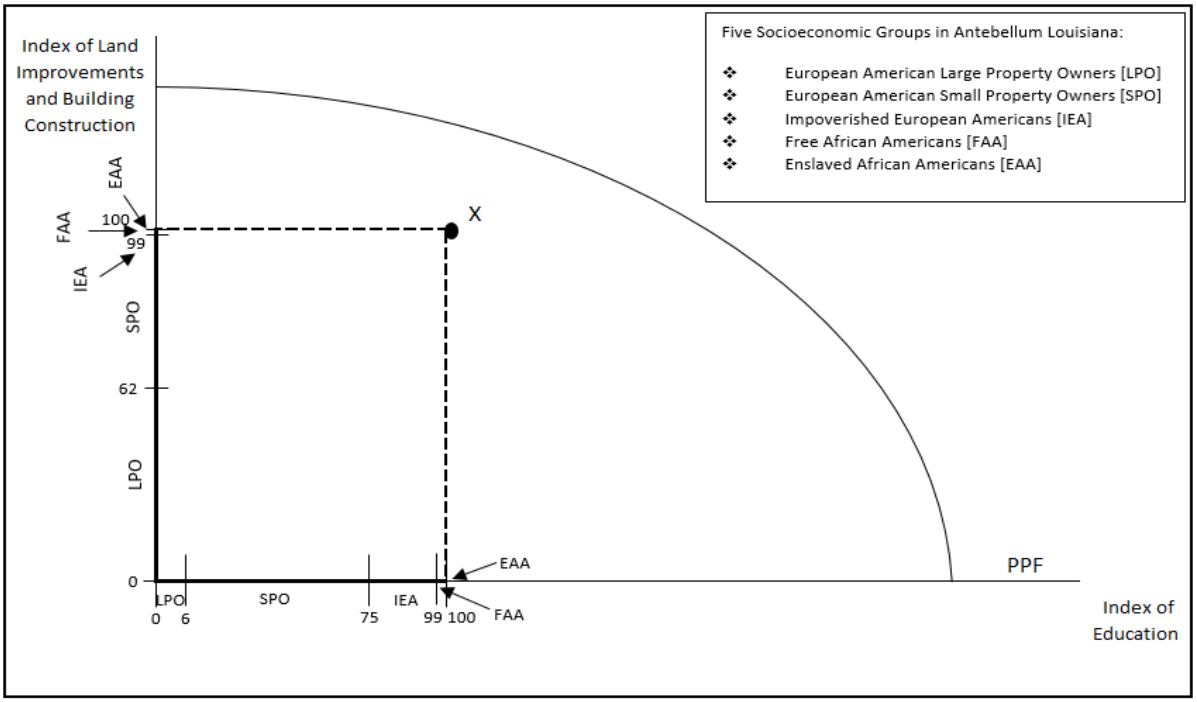
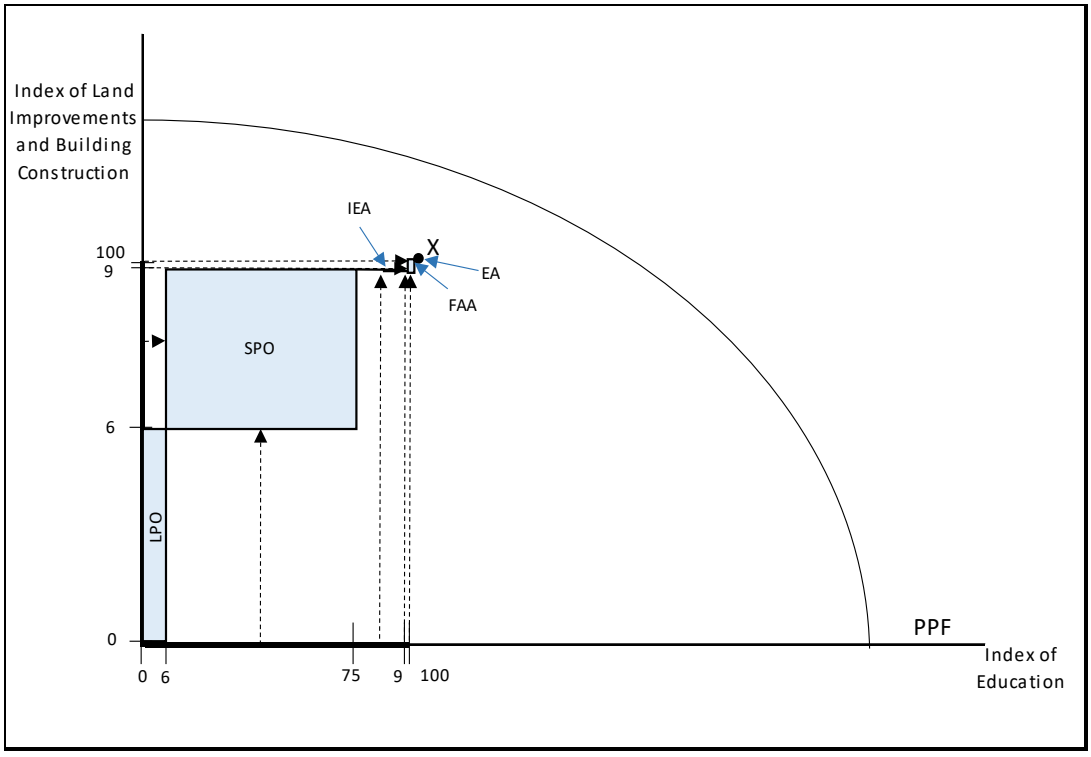


Figure 4B: Building distribution boxes for the LPO, SPO, IEA, FAA and EAA groups.



2017). An 1860 census question on whether a person attended school in 1859 is used to allocate this output across groups (U.S. Census, 1860a).

- We measure real estate output -- "Land Improvements and Building Construction" -- along the vertical axis -- again see Figure 4A. While the 1860 census did not collect annual production data for this good, it asked for total real estate holdings (U.S. Census, 1860a). This data is used to allocate real estate production increments (annual) across groups. Specifically, if a group owned 20% of the total stock of real estate, then we assume this group received, in dollar terms, 20% of annual real estate production (improved farmland and new buildings). In turn, this allocation is used to assess wealth inequality in this state. (Note: We exclude personal wealth from this good, although the 1860 census collected this data, as it includes the "illicit" value of enslaved people (U.S. Census, 1860b). Of course, certain types of land and buildings are also complicit with slavery. We do use both real estate and personal wealth data to construct our socioeconomic groups, as described momentarily.)

Step 2: Choose a plausible overall position for 1860 Louisiana. Hornback and Logan (2023) argue that slavery generated massive inefficiencies by forcing enslaved people to expand their labor effort far past its marginal cost (plausibly, this would reduce "household production" as well as leisure). There were also slavery enforcement costs, such as slave patrols (Hadden, 2003), plus long-run output losses due to intense job, education, and mobility restrictions imposed on enslaved people. Hence, we place "Point X" significantly inside the 1860 Louisiana PPF in order to reflect these inefficiencies (see Figure 4A).

Step 3: Divide the Louisiana population into the relevant groups (see Table 2):

- European American Large Property Owners (LPO), which are the top 3% of all White households in 1860 Louisiana based on wealth (real estate plus personal property, the latter category which includes the "illicit" value of enslaved persons). Shugg (1939) initially generated this 3% figure when defining his 1860 Louisiana "Upper Class," but in contrast to us, included all "free families", e.g., both European and free African Americans (instead of just White households). However, Blacks were likely a small part of his "Upper Class". For example, had we allowed Black households into our LPO group, it would have included 18 households out of 2254 (Ruggles et al., 2023). Also, using Census microfilm records, Shugg's total count of "families" in 1860 Louisiana was 74,725 (Shugg, 1939); using the same data in electronic form, our "households" count is 77,144 (Ruggles et al., 2023); the closeness of the numbers suggests that "families" were actually "households" in Shugg's analysis. Using our LPO group definition, this 3% had total wealth per household exceeding $59,185 in 1860 dollars (Ruggles et al., 2023). The 3% figure roughly matches estimates from other Southern states for this group: three percent of adult White males for the "black belt" of Alabama (Wiener, 1976); six percent of White citizens for Georgia (Inscoe, 2020), and 3 percent for this group for North Carolina (NCpedia, 2009). Translated into percentages, LPOs are 3.78% of all Louisiana European Americans and 1.90% of the state population.

- European American Small Property Owners (SPO), some of whom were enslavers, including middle-income professionals (doctors, teachers), small business owners, and "yeoman" farmers. These households either: [a] owned land (and so their real estate holdings exceeded zero), or else [b] land holdings equaled zero but personal property was greater than $200 (and so many could be enslavers). Simultaneously, their total wealth, real estate + personal property, was less than $59,185. They were 62.98% of the White population and 31.54% of the 1860 state population (Ruggles et al., 2023).

Table 2. Socioeconomic classes in antebellum Louisiana, 1860.

	European Am. Large Prop. Owners	**European Am. Small Prop. Owners**	**Impoverished European Am.**	**Free African Am.**	**Enslaved African Am.**	**Total**
Population:	13,302	221,377	116,805[a]	18,667[b]	331,726[c]	701,877
% Total State Pop:	1.90%	31.54%	16.64%	2.66%	47.26%	
Real Estate Wealth:	$214.7 mil.	$128.8 mil	$0.00	$4.6 mill	$0.00	$348.1
% Real Estate Wealth [assoc. index value]:	61.67% [62]	37.02% [37]	0.00% [0]	1.31% [1]	0.00% [0]	
# Children &Young Adults, Aged 6-25:	6,258	101,030	48,049	8,208	147,266[d]	310,811
# in School:	2,786	31,408	10,900	617	0[e]	45,711
% in School Within a Group:	44.52%	31.1%	22.7%	7.5%	0.00%	
% in School for the Entire State index value]:	6.10% [6]	68.71% [69]	23.85% [24]	1.35% [1]	0.00% [0]	

Data Source: Unless otherwise noted, all data from the Louisiana 1860 Census file is generated by Ruggles et al. (2023).

[a]May be significantly underreported; see Merritt (2017).

[b]For simplicity, 187 people who were recorded as Native Americans were classified as Free African Americans (which equals 1% of the population for the latter group).

[c]As reported in the original 1860 Census, Louisiana state returns (U.S. Census, 1860c).

[d]Estimated by computing the proportion of children and young adults aged 6 to 25 for free Louisiana African Americans, 1860 Census, and then applying this proportion to the total enslaved Louisiana population.

[e]Inferred to be zero due to the legal prohibition on educating enslaved people in Louisiana (Taylor, Undated).

- Impoverished European Americans (IEA), who were both "landless and slaveless" (Merritt, 2017). Hence, their 1860 real estate value equaled zero, while personal property value was $200 or less, and so, since the average 1860 price for an enslaved person was $800 (Williamson & Cain, 2024), this group was unlikely to include enslavers. (Note: Merritt, 2017, sets the maximum personal property value at $100, but Boulton, 1994, for several North Carolina counties, computed average personal property values ranging from $100 - $200 for this group, and so the latter number is our cut-off value.) This group was 33.23% of the European American population and 16.64% of the 1860 Louisiana population (Ruggles et al., 2023) but may have been significantly undercounted by the U.S. Census (Merritt, 2017).

- Free African Americans (FAA) of any wealth (5.32% of the Black population – for simplicity, this includes a small number of Native Americans, equaling 1% of this group (Ruggles et al., 2023); and 2.66% of the state population (Wordpress, 2015)).

- Enslaved African Americans (EAA); no schooling, wealth due to intense restrictions (Blokker, 2012); 47.26% of the state population (US Census, 1860c).

See Eisworth (2016) for an analysis of all five groups; see Bolton (1996) for data on the first three European American groups and both Glossner (2019) and Merritt (2017) for a discussion of the IEA group. For a description of free African Americans in antebellum Louisiana, who were both economically and culturally productive, see Taylor (undated); for an overview of all African Americans in antebellum Louisiana, see Blokker (2012).

Step 4: Group output allocation via 1860 Louisiana census data (Ruggles et al., 2023):

- For education, we determined the number of people aged 6-25 who attended school in 1859 for each group, and then computed their state percentage, which, converted into index values, yields this data: 6 (LPO); 69 (SPO); 24 (IEA); 1 (FAA) and 0 (EAA).

- As noted earlier, we use the 1860 census ownership data for Louisiana real estate to distribute annual real estate additions -- land improvements and new buildings -- across our five groups. Using a 0-100 index, these values are 62 (LPO), 37 (SPO), 0 (IEA), 1 (FAA), and 0 (EAA). See Table 2 for these computations.

Using these values, the 0-100 line segments that run along the horizontal and vertical axes in Figure 4A are divided into five smaller segments, with each length, for a given good, equal to the index points for a specific group. When doing this division, starting at the graph's origin, we use the following order for both goods: LPO, SPO, IEA, FAA, and EAA.

Step 5: Drawing the distribution boxes. Turning to Figure 4B, we construct the LPO distribution box, whose vertical and horizontal line segments emanate from the origin of the graph. The two remaining sides are added to complete this box. The next distribution box – for the SPO Group – starts in the upper right-hand corner of the LPO box, and is constructed (and interpreted) in the same way. The third and fourth distribution boxes – for the IEA and FAA groups – also start in the upper right-hand corners of the previous boxes. Because the EAA group receives zero output for both goods, its box converges to a single point (= X).

Step 6: Interpreting the "socioeconomic portrait" of 1860 Louisiana, which is shown in Figures 4C and 4D (with the 1860 Louisiana population percentage for each group, in brackets, added to the latter figure). Figure 4D, with the clear size difference between the LPO and IEA/FAA/EAA distribution boxes, is arresting. Given the low LPO population percentage relative to the vertical side of its box -- 2 percent of the population received 62 percent of the real estate

Figure 4C. Map of the enslaved population, 1860 U.S. Census (U.S. Census 1860d).

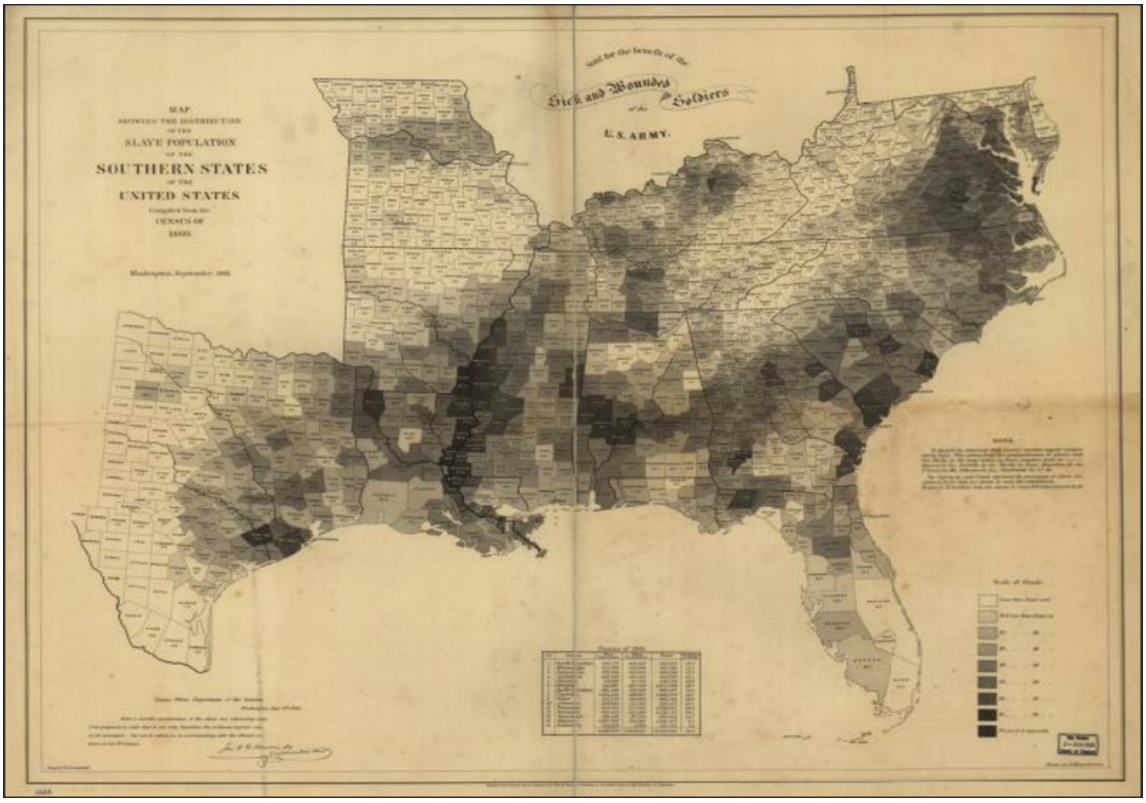
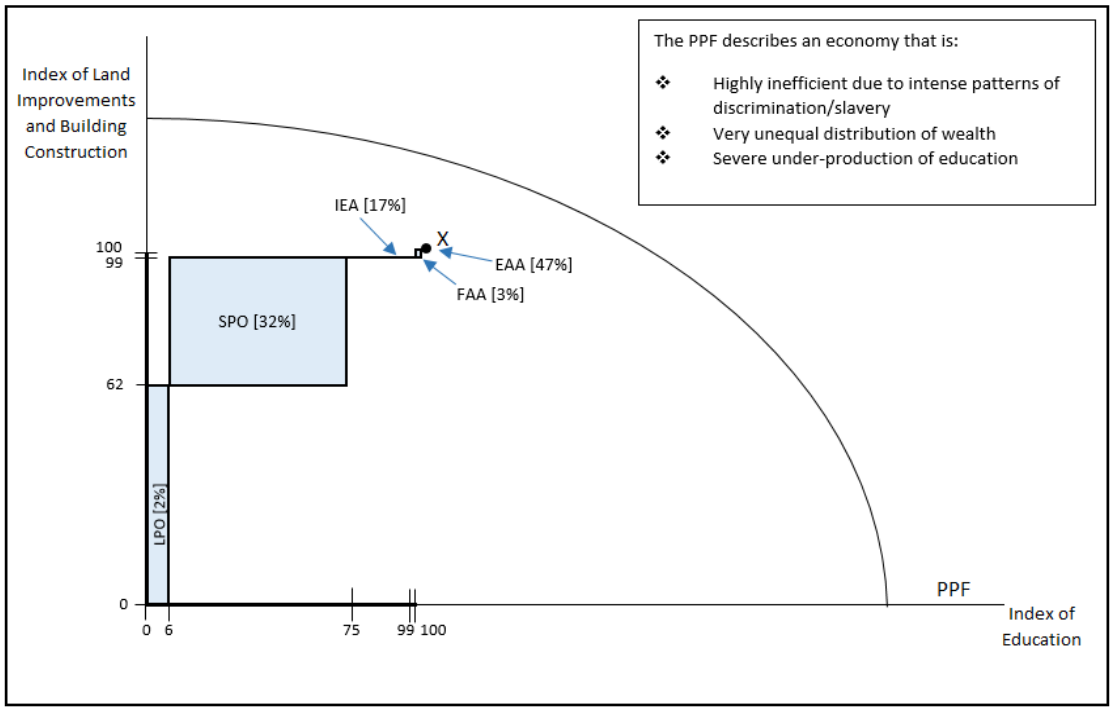


Figure 4D. Antebellum Louisiana, 1860: A "socioeconomic portrait."



improvements, the latter number which equals the overall LPO real estate ownership -- the implication is that the 1860 wealth distribution in this state was highly unequal. With X significantly inside the PPF, a second inference is that its economy was highly inefficient. A third inference, given the low amounts of Education going to the IEA, FAA, and EAA groups despite their large populations, is that this good was severely underproduced. In short, 1860 Louisiana -- and by extension, the entire antebellum South (see Figure 4C) -- was a socioeconomic powder keg that, in the long run, might have been unsustainable even if the Civil War had not intervened in the following year and triggered its explosion. (This overall conclusion might be more effectively conveyed to students via the "socioeconomic portrait" shown in Figures 4C and 4D, with its visual display and associated contextual information, relative to using pie or bar charts, or a Gini Coefficient.)

Step 7: Figures 4C and 4D could be used to transition to these discussion topics:

- While Blacks undoubtedly suffered the most under the conditions shown in Figure 4D, did poor Whites – a sizable group -- suffer losses as well? (When posing this query, teachers could ask students to compare the vertical side of the IEA distribution box to the IEA population share.) This is a controversial question, as some students may resist the idea that patterns of discrimination could generate losses extending beyond the groups being directly targeted. (See Merritt, 2017, for more information.)

- If discrimination losses extend beyond the targeted groups, then the benefits from reducing them might do so as well. Hsieh et al. (2019) address this issue by assessing U.S. efficiency gains from reduced discrimination from 1960 to 2010, finding that "roughly two fifths of growth in U.S. market GDP per person" during this time period flows from reductions in job market and (especially) education discrimination against women and Black men (Hsieh et al., 2019). The moral justification for this shift stands regardless of the economic efficiency consequences, but that said, when it occurred, the associated efficiency gains likely extended beyond those two groups.

- In Figure 4D, the eyes are drawn to the cluster of (very small) distribution boxes associated with the IEA, FAA, and EAA groups, which are collectively 67% of the Louisiana 1860 population. In the postbellum South, did these groups ever coalesce around common interests such as greater school funding? In fact, a few interracial coalitions, albeit imperfect, temporary, and fragile, did emerge in some Southern farmer organizations (Ali, 2002; Gerteis, 2007a) and industrial unions (Gerteis, 2007b). In addition, in two states – the Readjuster Party of Virginia (Barnes, 2023) and the "Fusion" movement of North Carolina (Brown, 2004) – interracial coalitions also exercised some political influence (again temporarily). Alas, these efforts ultimately failed. Why did this occur, despite the fact that, via the election of African American legislators, these coalitions sometimes increased the school enrollment and bargaining power of landless farming families, both Black and White (Logan, 2020)?

Socioeconomic portrait of the United States during the Gilded Age (1870-1900): High economic growth combined with growing inequality

For this PPF application – see Figures 5A and 5B – two goods are chosen: [a] "Manufacturing Goods" (vertical axis), since this sector was expanding during 1870-1900, and [b] "All Other Goods" (horizontal axis). We construct three groups:

- The top 1% of the population in terms of wealth (denoted as "1%");

- Rural residents, excluding any 1% members (often living on farms, denoted as "R");

- Urban residents, excluding any 1% members (blue collar/domestics, denoted as "U").

Focusing on Figure 5B, we lack output distribution data across our three groups. Hence, we use impressionistic information to show these 1870-1900 changes:

- The PPF shifted outward significantly due to an overall increase in productive capability. Indeed, in constant 1958 dollars, the U.S. GNP more than doubled from 1870 to 1900 (from 7.4 to 18.7 billion dollars), while GNP per capita doubled (from $531 to $1,011) (Campbell, 1999). This extraordinary growth was accompanied by inventions such as the telephone, the phonograph, the electric light bulb, the Kodak camera, and the automobile (Roos, 2022). Since manufacturing was expanding more rapidly relative to other outputs, the outward PPF shift in Figure 5B is larger along the vertical axis, which is driven by both technological advances and greater worker numbers (often immigrants) who worked in this industry sector (Library of Congress, undated).

- In Figure 5B, for the 1% group, the large increase in the sides of the 1900 distribution box (brown) relative to the 1870 box (green) suggests that inequality was intensifying (Siegler, 2017) (Nasaw, 2020), with this group owning 51 percent of all wealth by 1890 (O'Donnell, 2023) -- but see Geloso (2019) for an alternative viewpoint. (To avoid overlaying two sets of horizontal and vertical line segments on the same axes, which would impair visual interpretation, we place them – green for 1870, brown for 1900 – outside the two axes for easier visibility.)

- The large expansion of the vertical and horizontal sides of the "U" distribution box during 1870 to 1900 is consistent with a major population shift to, and an associated expansion of economic activity in, urban areas (Library of Congress, undated). (Note: To see this change, population shares for the R and U groups for both 1870 and 1900 in brackets, are shown in Figure 5B, see Gibson, 2010. We assume that the "1%" group lived primarily in urban areas, and so the urban shares are reduced by 1%.)

Points X (1870) and Y (1900) in Figure 5B are inside their PPFs due to inefficiencies induced by employment-based discrimination against Blacks and women that was common during this time period. In a principles class, these losses could be linked to the specialization of labor concept, where productivity is increased when workers are allocated across jobs based on their specific skills. Discrimination interferes with this allocation process by blocking at least some workers from getting jobs based on their skills, e.g., it generates "improper labor specialization" that yields inefficiencies (an economy located inside its PPF). See Harris and Lopez (2024) for a more detailed approach for principles classes.

After covering Figures 5A and 5B, teachers could transition to this discussion topic:

- The 1870-1900 period generated numerous inventions, growing inequality, and "robber barons" such as John D. Rockefeller, Cornelius Vanderbilt, and J.P. Morgan (Maryville, 2024). Interestingly, these historical conditions partially mirror the United States today: Ground-breaking inventions (smartphones, drones, self-driving cars); growing wealth inequality (Federal Reserve, 2024); and "tech giants" such as Bill Gates, Sam Altman, and Jeff Bezos. Some economists assert that a subset of recent innovations, by increasing job automation, expands inequality (Lohr, 2023). This belief has prompted calls for a "robot tax" in order to reduce automation (Ahn, 2024; Whittaker, 2023). For this question, assume that automation in fact worsens inequality. What balance, then, should be struck between innovations such as industrial robots (which may promote economic growth) vs. income equality? Suppose, for example, that a robot tax – carefully set to minimize regulatory costs -- is imposed on the Amazon company. This reduces their robot purchases, which modestly increases product shipment times, plus a 5% price increase for Amazon products. However, the tax also reduces automation at Amazon, its labor force expands by 10%, and U.S. income inequality falls. Is this an acceptable trade-off? (The goal here is to show students that reducing inequality is not costless.)

Figure 5A: Left: Vanderbilt family photo, the Biltmore Estate (Vanderbilt, undated). Right: Child working in a North Carolina cotton mill (Tenement Museum, undated).

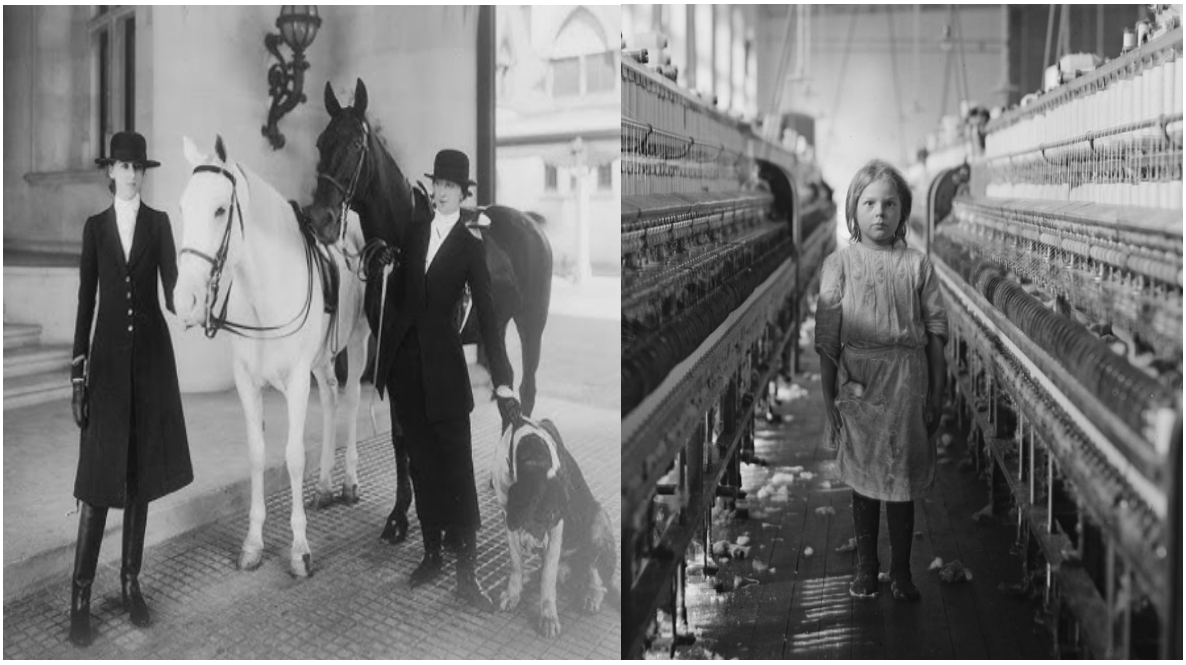
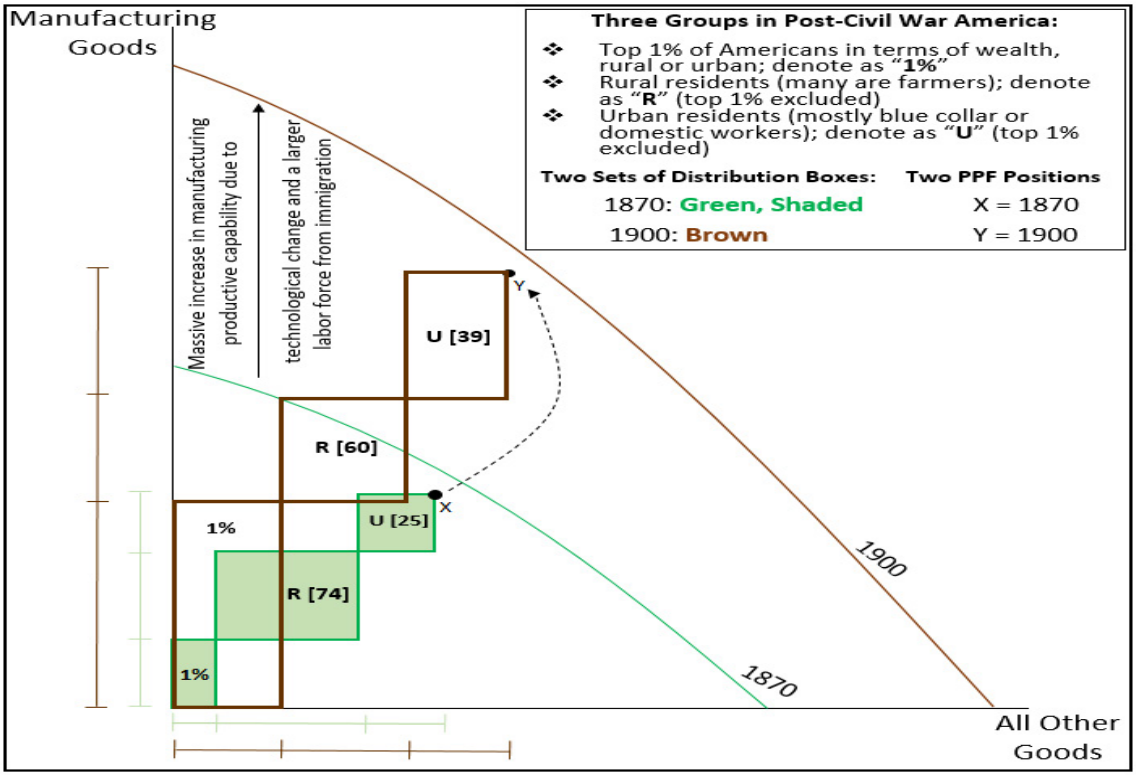


Figure 5B. A "socioeconomic portrait" of the United States during the Gilded Age (1870-1900): High economic growth combined with expanding income and wealth inequality.



- If this is an acceptable trade-off, then will the political arena – in the presence of intense lobbying efforts by a host of special interest groups on this issue, plus sophisticated attempts by firms to evade this tax (such as robot equipment modifications) -- be able to determine what a "robot" actually is (in terms of equipment characteristics); then correctly calculate the tax; and then sucessfully implement it? (Here the basic point is that political institutions, like markets, are also imperfect, and so our real choice is not between imperfect markets vs. perfect government, but rather between imperfect markets vs. imperfect government.)

Socioeconomic portrait of the Chinese economy, 1990-2040: Intergenerational tensions

This application displays the 1990-2040 evolution of the Chinese economy in order to highlight intergenerational tensions between workers (W) and retirees (R). The two goods are: "Health Care and Housing for Older People (Workers + Retirees)" (vertical axis) and "All other Goods and Services" (horizontal axis) -- see Figure 6B. Note that Points X and Y, which are plausible overall positions for China in 2015 and 2040, respectively, are both placed inside their PPFs due to economic inefficiencies generated by employment discrimination against Chinese women (Brussevich et al., 2021), which are assumed to continue up to 2040.

Starting with the period from 1990 to 2015 in Figure 6B, the outward shift of the PPF to 2015 (colored green) is substantial. This shows the gains from the "Demographic Dividend": A falling birth rate plus an expanding labor force can supercharge economic growth (Lee & Mason, 2006). Because the population share for Chinese retirees (aged 65+) was a modest 9.1% in 2015 (United Nations, 2017), both the horizontal and vertical sides of the 2015 "R" distribution box (colored green) are short, while the horizontal side of the 2015 "W" distribution box (also green) is much longer relative to its R counterpart. In turn, Point X for 2015 favors the production of "All Other Goods and Services" (instead of "Housing and Health Care for Older People").

Moving to the period from 2015 to 2040 (colored purple), the latter PPF shift is now smaller than the shift from 1990 to 2015. That is, by 2010, the Chinese population growth was slowing. Combined with rapid aging (Cai, 2013) – also see Figure 6A -- this led to reduced growth forecasts (Rajah & Leng, 2022). This fits the "Middle Income Trap": Rising Chinese labor costs will reduce exports, but it has not yet developed a large sector in higher value-added output – ergo, future growth will slow (Long, 2022). Second, Point Y for 2040 shows a larger output of the "Housing and Health Care for Older People" good relative to 2015. This change is due to a rapidly expanding R group, whose population share will be 24.8% in 2040 (United Nations,2017) (or two and a half times its 2015 level). Not surprisingly, both sides of the R distribution box for 2040 are now much longer relative to its 2015 R box, while the horizontal side of the W box for 2040, for "All Other Goods and Services" output, is much shorter than its 2015 length (although this is only a plausible outcome; we lack formal 2040 forecasts). The W group population, in fact, is declining in absolute as well as percentage terms (with people aged 16-64 falling from 982 to 856 million during 2015-2040 (United Nations, 2017)). An additional detail is the Chinese social security system is underfunded and will run dry by 2035 (Liu, 2023).

With the 2015 (green) and 2040 (purple) constructs displayed side-by-side in Figure 6B, the dilemma faced by China is now clear. Beyond 2015, a shrinking number of workers will be forced to financially contribute to an expanding array of retiree pensions and services while simultaneously their own wages are growing more slowly due to a cooling economy. (Note that when making this point, an instructor could shift between Figures 6A and 6B in order to highlight the interdependence between the demographic and economic changes.) An increase in intergenerational tensions appears to be unavoidable. This tension has been labelled the "4-2-1" problem in China (Campbell, 2019): In the presence of slowing growth, a single young adult may have to support their two aging parents, plus up to four grandparents.

How could these tensions be reduced? One option is to reduce work discrimination

Figure 6A. Chinese population pyramids, 2015 vs. 2040: UN Population Division estimates & projections, medium variant (Eberstadt, 2019).

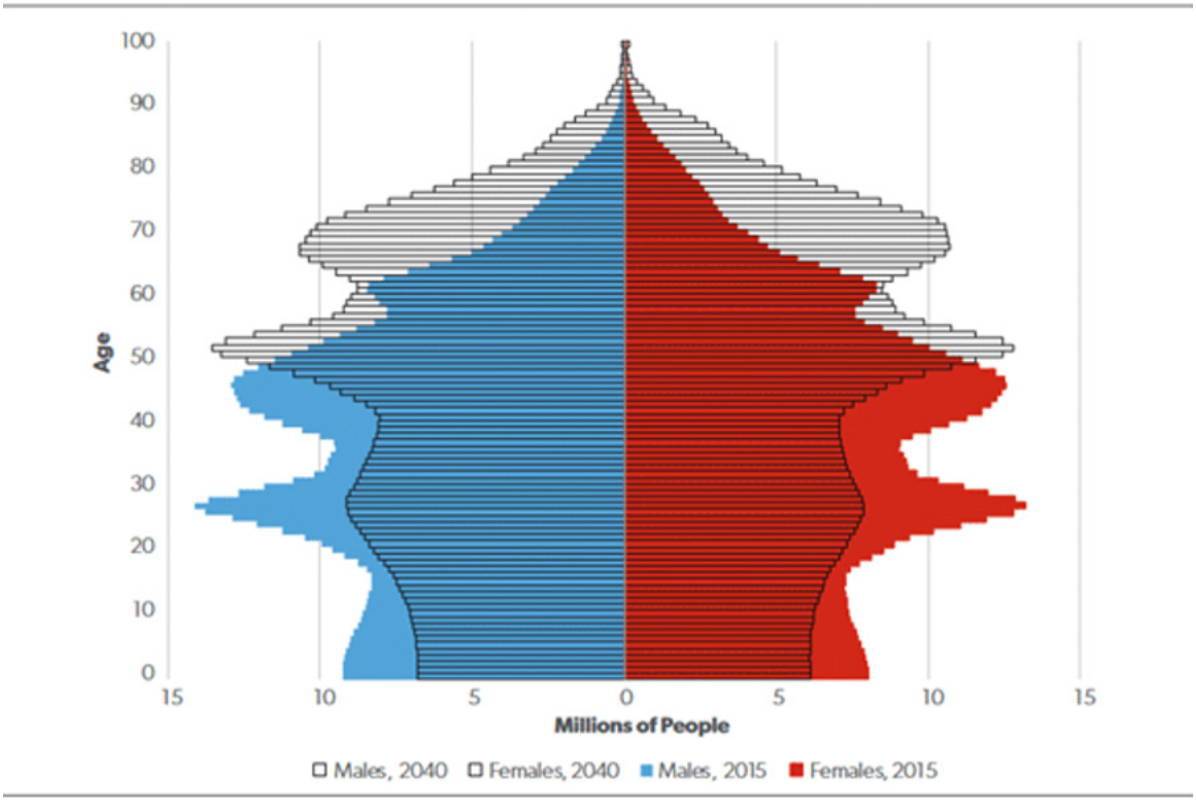
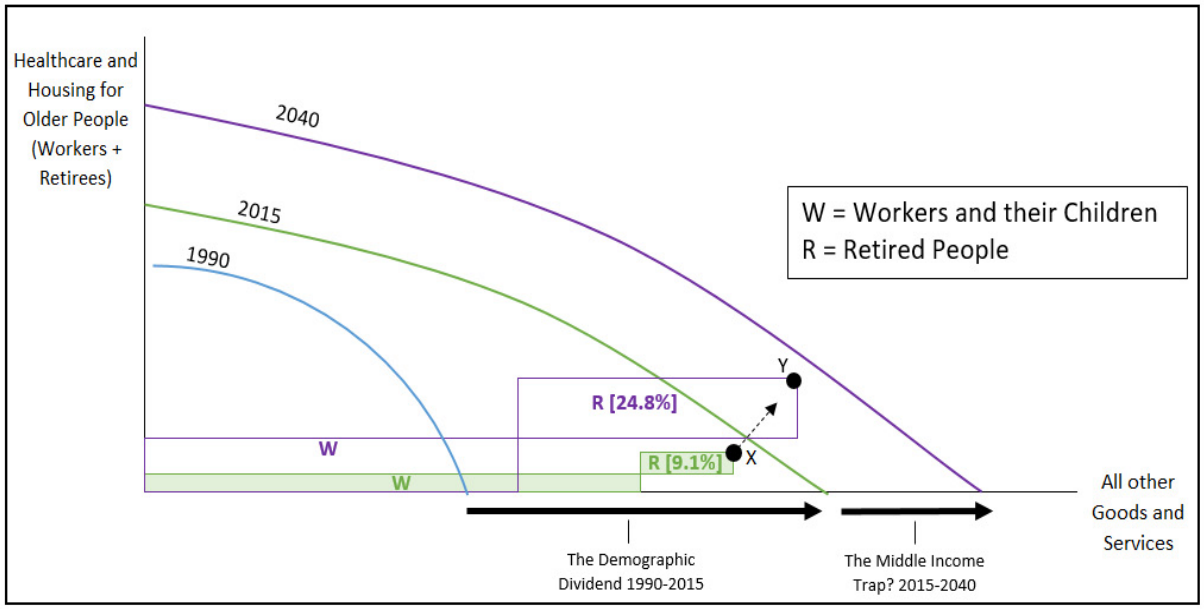


Figure 6B. A "socioeconomic portrait" for China, 1990-2040: Intergenerational tensions.



against Chinese women, which, as stated in Brussevich et al. (2022), would increase economic growth (and thus make it easier for workers to afford retiree services and pensions).

Drawing from Figures 6A and 6B, instructors could transition to the following topic:

- Could this analysis, broadly, also apply to the United States? (See the earlier analysis on U.S. generational inequality.) If yes, then how might the United States intergenerational conflict be diffused? Would higher immigration foster future growth and thus more funds for pensions? Or: Should Social Security taxes be increased for higher-income workers?

5. Discussion

Alternative tools for teaching inequality in principles classes: The Gini Coefficient, the Palma Ratio, and Data-Driven Visualization

The Gini Coefficient often appears in textbooks (see Table 1, far-right column) and is comparable across countries. Nevertheless, it is subject to criticisms:

- Different income distributions can generate the same value (Blesch et al., 2022);
- It emphasizes the middle portion of the income distribution, but analysts may want to focus on the "tails" (lowest versus highest income groups) (De Maio, 2007);
- Beyond the values of zero and one, it is difficult for non-technical audiences, which would likely include principles students, to interpret it (Floyd & Potters, 2022).

In contrast, the Palma ratio exploits this "stylized" fact: The income share of the 40% to 90% income range is stable across most countries (equaling 45-55%). This ratio focuses on income shares above and below this range, and equals the income percentage of the top 10% divided by the bottom 40% (Cobham & Sumner 2013). This generates two advantages: The ratio focuses on the "tails" of an income distribution, an interest of many analysts, and it can be easily interpreted, e.g., a value of five means that the top 10% of the population receive five times more income relative to the bottom 40% (Cobham & Sumner, 2013).

Finally, Truong and Barreto (2023) outline a "Data-Driven Visualization" (DDV) technique, which they believe is easily interpreted by non-technical audiences. After adjusting for income differences across U.S. states from 1976 to 2019, they sort this data into ascending decile groups by state. They then display, in 3D maps, this adjusted decile data, in order to show income inequality changes across time by state (Truong & Barreto, 2023).

Contrasting distribution boxes with the Gini, Palma, and DDV constructs

Distribution boxes have these advantages relative to the three inequality measures:

- As stated previously, the features of a PPF can be manipulated so that the data in the boxes are displayed within a historical/institutional context. For example, for China from 2015 to 2040 (see Figure 6B), the increase in health and housing services going to retirees (note the expanding vertical side of the retiree distribution box, 2015 vs. 2040) is visually juxtaposed with slowing economic growth (the smaller outward PPF shift, 2015-2040 vs 1990-2015). This makes it harder for workers to fund these services; therefore, intergenerational conflict intensifies. The three alternative inequality measures, in contrast, cannot provide this context on their own.
- Concurrently, instructors can manipulate the group identities linked to the distribution boxes to illuminate inequality. Inequality tensions can run along a multitude of

dimensions, such as ethnicity, religion, age, and gender, which cannot be easily seen in a single inequality statistic. These nuances are more effectively illustrated by dividing a population into groups based on these dimensions. For example, a Gini coefficient for wealth in 1860 Louisiana would indeed be revealing, but would this number show that the extreme poverty underlying this statistic was interracial in character? The three tiny distribution boxes clustered near Point X in Figure 4D capture this important nuance.

- Since distribution boxes are a PPF extension, prior student knowledge of this model can be leveraged to teach these boxes more quickly. Applications can also be used to reinforce previous PPF concepts. This approach fits Goffe and Wolla (2024), who favor using PPFs to connect many concepts and ideas across an entire LT course.

- Hoover and Washington (2024) note that students of color are underrepresented in principles classes, and suggest reversing it by focusing on "applications that are interesting and relevant to students' lives," such as "housing, education, trade, immigration, and especially discrimination, inequality, and race". This paper follows their advice: The overall positions for three applications – antebellum Louisiana, the U.S. Gilded Age, and China – are inside their PPFs due to discrimination; via the distribution boxes, we model inequality; and for post-application discussion topics, we suggest contemporary issues such as pandemics, immigration, land reparations, and robot taxes. When taking these steps, our goal is to convey this postulate to students: Economic history can be used to frame interesting issues that are relevant today.

That all said, the ease of constructing and interpreting the Palma Ratio makes it an attractive inequality option, and so it could be combined with distribution boxes (see below).

Limitations of PPF applications

As noted previously, our PPF applications often require assigning additional readings so that students can better grasp the relevant history. Teachers can maximize comprehension by selecting readings that best fit the "background knowledge" of students for a particular topic (Willingham, 2021). A second concern is that cutbacks in other topics – already a given when undertaking these applications – will increase to accommodate new assignments.

A third disadvantage is that the group definitions for a PPF application are often unique, and so their distribution boxes cannot be easily compared across countries. One redress is to use distribution box analyses for case studies, but revert to a standard inequality measure -- such as the Palma Ratio -- when comparing inequality across countries.

Concluding remarks

Economics educators – especially "literacy-targeted" advocates -- face the following conundrum: Since the first economics course many students take will also be their last, what topics should be taught in these classes? Assessing this query in detail is beyond this paper's scope. However, if teachers choose to increase coverage of inequality and economic history topics in these courses, then this expansion should be done in an understandable, thought-provoking, and time-conserving manner. On that score, employing PPF "socioeconomic portraits" may be a potent strategy for promoting this broader shift in curricular coverage.

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