Using Simple Supply and Demand Models to Estimate the Impact of World War II on Female Workers

Dina Shatnawi and Price Fishback

August 2014

Please do Not Cite Without the Authors' Permission

Dina Shatnawi is an Assistant Professor of Economics at the Naval Postgraduate University, Graduate School of Public Policy, Monterey, California, 93943, dshatnaw@nps.edu. Price Fishback is the Thomas R. Brown Professor of Economics at the University of Arizona, Department of Economics, University of Arizona, Tucson, AZ 85721 pfishback@eller.arizona.edu. The paper builds on earlier work with Ryan Johnson and Alec Smith. We would also like to acknowledge helpful comments at presentations at the ASSA meetings in Denver in 2011, the University of Pittsburgh, and the University of Arizona. We thank Karen Clay, Claudia Goldin, Sonam Gupta, Taylor Jaworski, Trevor Kollmann, Derek Lemoine, Robert Margo, Ron Oaxaca,, Jessamyn Schaller, Allison Schertzer, Gary Solon, Werner Troesken, and Randy Walsh for their insights in conversations about the paper.

World War II and the Demand for Female Workers in Manufacturing

Economists and economic historians seeking to explain what happened in the recent or distant past are often faced with data that is often limited to price and quantity, At a conference honoring Claudia Goldin, Nobel laureate Gary Becker stated that economists seem to have forgotten how much you can learn from the use of simple supply and demand models. Our goal in this paper is to use the basics of simple supply and demand models to develop estimates of the size of shifts in labor demand and labor supply for female and male workers over the course of the 1940s.

The iconic image of Rosie the Riveter during World War II and later increases in female activity in the work force has long influenced how people viewed the impact of World War II on the role of women in the workplace. Historians (Chafe (1970 ???Dina who else?????) have provided anecdotal evidence on how the views of women's roles changed after they were so active during the War and have argued that the War helped set the stage for the long run expansion in women's role in labor markets. On the other hand, a series of studies of female labor participation have found relatively small changes in female labor force participation between 1940 and 1950 and suggest that the War had only short term effects that had largely gone away by 1950.

There is room for both sets of scholars to be correct. The quantitative studies of female labor force participation are largely studies of female labor supply, although Daron Acemoglu, David Autor, and David Lyle (2004) find elasticities of substitution between male and female labor and a labor demand elasticity for women when they develop econometric estimates of the relative demand for females versus males in comparisons of 1940 and 1950. Meanwhile, the historians seem to be focusing more on the demand side of the labor market. The narrative evidence suggests large increases in female labor demand and supply during the War with sharp

drops after the War, but there has been little quantitative work measuring the size of the shifts during the 1940s. Nor has there been good evidence provided about the size of the *shifts in labor demand* for different classes of female and male workers between the pre-War and post-War settings.

In this paper we develop estimates of the size of shifts in labor demand and labor supply in manufacturing during the War and following the War. Manufacturing is the focus because so much of the discussion of changing roles for women during the War was centered on women working on manufacturing production lines in a variety of industries where few had worked before. We use information for four classes of manufacturing workers: males in salaried jobs, females in salaried jobs, male wage earners, and female wage earners. To measure the raw shifts in labor demand and supply, we start with information on earnings and employment and/or hours worked and then use assumptions about elasticities of labor demand and supply from the literature. To focus further on the impact of the War, we compare the actual changes to counterfactual estimates of the changes in earnings and employment (or hours) that might have occurred in the absence of War. The counterfactuals are based on trends in earnings and employment between business cycle peaks in 1923 and 1929. To examine the shifts in demand for females relative to males, we then follow the methods used by Claudia Goldin and Lawrence Katz in *The Race Between Education and Technology* and by Acemoglu, Autor, and Lyle (2004) to develop estimates of the relative shifts in demand based on elasticities of substitution. Finally, we take one further step and use panel data for nine manufacturing sectors from 1941 to 1948 to estimate reduced-form equations for earnings and employment (hours) while controlling for changes in value of product per worker, union density, racial mix, and the earnings of other classes of workers and other factors. We then walk back through the process using the year fixed

effects in place of earnings and employment to estimate the shifts in residual demand between the pre-War and post-War period.

The heart of the analysis is derived from annual surveys of all manufacturers in Pennsylvania for all four types of workers reported by the Pennsylvania State Department of Internal Affairs between 1923 and 1950. They asked the same survey questions each year during the period and sought complete coverage of the firms in the same way that the U.S. Census did for firms in their manufacturing and mining surveys. Pennsylvania was probably the state that most closely matched the industrial structure of the United States as a whole; thus, the findings in Pennsylvania might reasonably be considered representative of what was happening in U.S. industry as a whole.

The qualitative findings for demand shifts are remarkably robust to a large range of labor demand elastictities. The raw employment and earnings figures show that the demand for both salaried and wage female workers boomed by more than 50 percent between 1941 and the War peak in 1944. Following the War the demand for each type dropped, but the demand still remained 25 percent above the 1941 demand. Comparisons to the counterfactual trend suggest that the demand for both types of labor remained at least 16 percent above the level that might have been expected without the war. After netting out the effects of several factors that might have shifted labor demand or supply, the analysis of the fixed effects show that the residual demand for female production workers was more than 50 percent larger in 1948 than it would have been in the absence of the war. On the other hand, the residual demand for female salaried workers was no higher than the counterfactual demand. The contrast in residual demand shifts makes some sense because women commonly were employed in salaried jobs before the War but not in the production jobs paying wages in a number of industries. Thus, there were more

opportunities for employers to learn new information about women working in the wage jobs. The experiences of men during the War and after were quite different from those of women. As a result, measures of the demand shifts for women relative to men in both salaried work and wage work reveal a substantial rise in the relative demand for women related to the War.

PRIOR STUDIES OF WORLD WAR II AND THE LABOR MARKET FOR WOMEN

The early literature on women's work and World War II emphasized the war's transformative effect.[1] Prior to 1940, women—particularly married women—faced substantial obstacles to paid work: segregation into low-wage occupations, legal constraints on daily and weekly hours, limited access to union membership, firm personnel policies that barred work for married women, and a workplace ideology dismissive of women.[2] The increased demand for labor due to mobilization for World War II and the sharp decline in the number of men available for civilian work pushed the female labor force participation rate from 27.8 percent in 1940 to 33.8 percent in 1945. As the story goes, the disruptive change led many women to not only enter the labor force *en masse* during the war, but dramatically altered attitudes toward women in the workplace; thus, the war was the impetus for the continued increase in women's labor force participation throughout the second half of the twentieth century.

However, the view that the war led to sweeping changes in employment opportunities and attitudes toward women faces challenges. Female labor force participation increased over the entire twentieth century, steadily until 1930 and more rapidly thereafter. Despite the desire of many women who joined the workforce during the War to remain at work, women were laid off in large numbers as employers and unions ignored seniority rules and gave preference to men in

---

1

2 Claudia Goldin, *Understanding the Gender Gap: An Economic History of American Women* (New York: Oxford University Press, 1990).

retention and hiring. More broadly, women also faced pressure to return to their prewar role as homemakers.[3]

Several quantitative studies also raise doubts about a large impact of the War on female labor activity (Acemoglu et. al (2004), Goldin (1991), Finegan and Margo (1994)). T. Aldrich Finegan and and Robert Margo (1994) link the increased labor force participation among women during WWII to their reduced labor force participation induced by the Works Progress Administration during the Great Depression. Using census data from 1940, they find that in addition to reduced product demand, the work relief program reduced the number of women joining the labor force. They hypothesize that some of the women who entered during WWII would have entered prior to the war in the program's absence.

Claudia Goldin (1991) looks specifically at the WWII period and uses individual level retrospective surveys (Palmer Survey) from 1940, 1944, and 1951 in conjunction with census data to infer whether WWII encouraged the rise of female employment. She finds that even though the war was associated with a large increase in the number of women employed, the war-time rise was smaller than the rate of increase of female employment from 1944 to 1950. Many women who were working in 1950 had been working in 1940, and many others had begun work after the War. Ultimately, wartime entrants comprised only one-fifth of white married women at work in 1950. Goldin (1991) suggests that long run factors such as the rise of the clerical sector along with increased education may have influenced the changing economic role of women more than the war.

---

[3] Karen Anderson, *Wartime Women: Sex Roles, Family Relations, and the Status of Women During World War II* (Westport: Greenwood Press, 1981); D'Ann Campbell, *Women at War with America: Private Lives in Patriotic Era* (Cambridge: Harvard University Press, 1984); Ruth Milkman, *Gender at Work: The Dynamic of Job Segregation by Sex During World War II* (Urbana: University of Illinois Press, 1987).

Daron Acemoglu, David Autor, and David Lyle (2004) use military mobilization as an instrument to study the effect of the war on female labor supply and on the demand for women relative to men. Their idea is that military mobilization rates are independent of women's past choices to enter the labor market, but the mobilization itself led to an increase in their labor supply. They use Integrated Public Use Microdata Series (IPUMS) of the decennial censuses for 1940 and 1950. Assuming a constant elasticity of substitution (CES) production function, Acemoglu et al. (2004) find that women in states with greater mobilization of men during WWII worked more immediately after the war and in 1950, but not in 1940, compared to women in states with less mobilization. Their estimates of the demand for women relative to men indicate that female and male labor inputs were imperfect substitutes. However, men and women were closer substitutes at the middle of the skill distribution. [4] Building on this study, Claudia Goldin and Claudia Olivetti find that employment gains were concentrated among women with at least a high school degree.[5] Moreover, women with no children during World War II were the most affected by manpower mobilization in 1950. Meanwhile, women with children were the most affected in 1960.

In earlier work, Mary Schweitzer showed that the increase in women's labor force participation during the war was responsive to their household duties.[6] Single women accounted for half of those working in 1940 and continued to comprise the largest share during the war. In contrast, women with young children were the last group to enter in large numbers: only in the second half of 1943 after firms together with local, state, and federal governments helped to

[4] Since data does not exist for intra-census years, Acemoglu et al (2004) use the Current Population Survey (CPS) Social Security Earnings Records Exact Match file for adults interviewed for the CPS in March of 1978. This employment data is only available starting in 1947.

[5] Claudia Goldin and Claudia Olivetti, "Shocking Labor Supply: A Reassessment of the Role of World War II on US Women's Labor Supply," NBER Working Paper 18676.

[6] Mary Schweitzer, "World War II and Female Labor Force Participation Rates," *Journal of Economic History* 45 (1980): 89-95.

provide child care and other housekeeping services. This infrastructure disappeared at the end of the war and so too did many working mothers.

A case study by Sherrie Kossudji and Laura Dresser using employment records from Ford Motor Company supports the findings of Goldin and Schweitzer. These authors document a pattern of postwar layoffs that is consistent with targeting women over men. As a result, by the start of 1946, only two of the women in their sample of roughly 300 were still working at Ford. This level of attrition does not comport with the generally high job performance ratings received by these women during the war. To explain this pattern, Kossudji and Dresser point to the unwillingness of management and unions to offer the wage and benefits packages perceived as necessary to maintain women in the workplace. Thus, from the vantage point of the late 1940s, the war's contribution to female employment gains was modest.

There is growing evidence that World War II played some role in changing attitudes towards women's work and women's expectations about their lifetime prospects in the labor market. A 1947 report by the Women's Bureau presents evidence that women's work during the war altered family roles, for example with respect to childcare, meal preparation, and other household responsibilities.[7] However, the study provided no additional information on the attitudes of men and whether altered household responsibilities lasted into the postwar years. Raquel Fernandez, Alessandra Fogli, and Claudia Olivetti show that World War II had lasting effects on women's labor force participation through likely changes in the attitudes toward working women of the sons of working mothers. The sons of women more likely to have worked during the war were also more likely to have a working wife.[8]

---

[7] US Women's Bureau, *Women's Wartime Hours of Work: the Effect on their Factory Performance and Home Life* (Washington: Government Printing Office, 1947).

[8] Raquel Fernandez, Alessandra Fogli, and Claudia Olivetti, "Mothers and Sons: Preference Formation and Female Labor Force Dynamics," *Quarterly Journal of Economics* 119 (2004): 1249-1299.

The Historical Context

By 1941 it is not unreasonable to believe that the economy had recovered to a position somewhere near the long run trend. Real GDP per capita was 27 percent above its 1929 peak, which implies that it had reach a level equivalent with a trend growth rate of 2 percent per year since 1929. The number employed as a share of the population had reached 39.4 percent, 1.4 percent above the pre-Depression peak in 1929 and the unemployment rate had fallen to 5.99 percent. The labor markets were still influenced by the presence of emergency work relief agencies like the Works Progress Administration, which provided work for poor families and paid for poor families at roughly half pay. The employment and unemployment rate figures above treat such workers as employed. If they are treated as unemployed, the employed as a share of population is 37.7 percent, 0.3 percent lower than in 1929 and the unemployment rate is 9.9 percent.[9]

Although the U.S. had begun a military buildup to aid the allies through programs like Lend Lease and in anticipation of entering the War, the attack on Pearl Harbor on December 7, 1941 led the U.S. to declare war. The result was a tremendous shift in the entire structure of the economy. By 1944 roughly 17 percent of the labor force was serving in the military, roughly 40 percent of GDP was devoted to fighting the War, the military with some civilian oversight through the War Industries Board was controlling the allocation of all materials necessary to

[9] Real GDP is series Ca11 (p. 3-25), the information on employment and unemployment came from series Ba470, Ba474, Ba475, and Ba777 (pp. 2-82, 2-83), population is series Aa7, pp. 1-28, 1-29. In Pennsylvania in 1941 hourly earnings on the WPA were 49 cents per hour compared with 69 cents on Public Roads Administration projects and 85 cents for Public Works Administration projects that were not required to hire many relief workers (Federal Works Agency 1941, 263, 305, 437. The NICB average hourly earnings for males in cotton manufacturing in the North, the lowest paying industry was 67 cents per hour. Average annual earnings for the entire country for the rest of the 25 industries they surveyed ranged from 78 cents in paper and pulp to $1.20 in automobile manufacturing (NICB

fight the War. Large amounts of the manufacturing in the country had shifted almost entirely from consumer goods to the production of war goods. The large-scale induction of men into the armed forces led a large number of women to be drawn into the labor force into both salaried and production jobs in manufacturing and other sectors. Wage and price controls were in place and there was extensive rationing.

Wage and salary ceilings were adopted in September 1942 and lasted until 1946. When the war ended in 1945 the demobilization of the men and women in the armed forces was performed relatively quickly. Once the wage controls were ended in 1946, labor markets were released to reach market equilibria. The potential for floors on wages driven by union bargaining were weakened after the Taft-Hartley Act was adopted in June 1947. By 1950 the U.S. was back on a peace time footing with an unemployment rate of 5.2 percent, real GDP per capita was 29.1 percent higher than in 1941, implying an annual average trend growth rate of 2.9 percent since 1941. We do not push farther into the 1950s to avoid the military expansion and limits on markets associated with the Korean War.

ESTIMATING THE SIZE OF SHIFTS IN SUPPLY AND DEMAND WITH INFORMATION ON EARNINGS AND EMPLOYMENT

The focus of our analysis is on the changes in manufacturers' demand for female workers associated with the war experience. This involves examining the changes from the pre-War period to the wartime peak and then the demobilization, and then the changes between the pre- and post-War period. Part of our goal in the paper is to see how robustly we can infer the size of the demand and supply shifts related to the war from annual information on average earnings and employment for different classes of workers over a broad range of labor demand and supply elasticities of employment with respect to earnings..

Part of the problem scholars face during the World War II decade is that much of the action of interest occurred during periods when detailed individual level data are unavailable. The Palmer Report used by Goldin (1991) covered 1940, 1944, and 1950, but she focused on female labor participation. Acemoglu, Autor, and Lyle (2004) and Goldin used individual level data from the 1940 and 1950 population censuses to estimate elasticities of substitution and of employment with respect to earnings in female/male relative demand estimation, but the timing is not good. The data on earnings and weeks worked are from 1939 and 1949. The year 1939 is problematic because it was still a Depression year in which real GDP per capita had just managed to reach its 1929 level and was still well below the long run trend. The unemployment rate was 11.3 percent, or 17.2 percent if people on emergency work relief are counted as unemployed. Thus comparisons between 1939 and 1949 hours and earnings will likely overstate the rise in demand associated with the War.

Even if we had individual level data during the middle of the 1940s it would not necessarily be a solution to studying the change in demand because we would not likely have all of the information on factors influencing demand that would be necessary to say how much it shifted. One of the key factors described in the narratives is changes in employers' attitudes toward a woman's ability to handle jobs, particularly on some production lines. Empirically, measuring the impact of changing attitudes and other unobservables is necessarily going to lead to a focus on residuals or on year fixed effects as we do later in the paper. Therefore, the analysis will still need to rely on inferences about shifts in supply and demand.

The data available consistently throughout the 1940s consist of information on the number employed and the earnings they received for different types of workers. As a starting point we can draw simple conclusions about the relative size of shifts in labor demand and

supply by assuming a downward sloping demand and upward sloping supply and then comparing the change in earnings and employment. As an example if we see that earnings and employment rise, we can assume that a rise in demand dominated all other shifts. An earnings rise but no change in employment implies that demand rose but supply fell enough to keep employment the same. Table 1 summarizes the implied dominant changes in supply and demand associated with different combinations of changes in earnings and employment.

The analysis can be more specific about the size of changes in labor demand and supply, if one is willing to make assumptions about the elasticities of employment (E) with respect to earnings (w) for the labor demand and labor supply curves. Consider the log linear demand and supply functions plotted in Figure 1. The starting equilibrium is point A where demand line D1(-0.8) intersects with Supply line S1(3), ln(earnings) equal 7.8 and ln(employment) is 10.8. After demand rises to D2(-0.8) and supply falls to S2(3) the new equilibrium is at point B where ln(earnings) equal 8 and ln(employment) is 11.2. The values in parenthesis are the elasticities used to draw the supply and demand lines.

We define the size of the demand change as the associated difference in ln(employment) between points on the new and old demand curve measured at a specific level of ln(earnings). In practice the measurement is either made at the original ln(earnings) or the new ln(earnings). In the empirical analysis associated with Figure 1 ln(employment) rose from 10.8 at point A to 11.2 at point B. To find the change in ln(employment) caused by the demand shift we need to subtract the change in ln(employment) associated with the change in ln(earnings) from the actual change in ln(employment) between points A and B. The equation takes the form

$$DD = [\ln(E_B) - \ln(E_A)] - e_D\,[\ln(W_B) - \ln(W_A)]. \qquad 1)$$

DD is the demand shift measure, E_B and E_A are employment at locations A and B, W_A and W_B are earnings at points A and B, and e_D is the demand elasticitiy, which is assumed to be negative. Thus, the shift measure can be rewritten using the absolute value of the demand elasticity $|e_D|$ as

$$DD = [\ln(E_B) - \ln(E_A)] + |e_D| [\ln(W_B) - \ln(W_A)]. \quad 2a)$$

A mathematical derivation of the equation is shown in Appendix 1.

To measure the change in demand associated with this change in equilibrium in Figure 1, pick a level of ln(earnings) and then measure the gap between ln(employment) at that level. Pick ln(earnings) of 8 at the new equilibrium B and the gap to be measured is the horizontal difference between points C and B. That difference is the known horizontal gap between A and B of 0.4 minus the change in ln(employment) from A and C, which is the reduction along the original demand D1(-0.8) curve associated with the 0.2 rise in ln(earnings). In the figure a demand elasticity of -0.8 is assumed for the original demand D1(-0.8). The rise in price from 7.8 to 8 caused the ln(employment) to fall from 10.8 at point A to 10.64 at point C along D1(-0.8). This -0.16 reduction is the change in ln(earnings) of 0.2 multiplied by the elasticity of -0.8. The demand shift measure using ln(earnings) of 0.8 is therefore the horizontal gap between A and B of 11.2-10.8 = 0.4 minus the horizontal gap between B and C of -0.16 for a total of 0.56.

The demand change also can be measured at the original ln(earnings) of 7.8. In this case the demand change is the horizontal difference in ln(employment) between points A and E. If ln(earnings) had stayed fixed at 7.8 when demand rose to D2(-0.8), ln(employment) would have risen from 10.8 at point A to 11.36 at point E. To move from there to the new equilibrium at point B, ln(earnings) rose by 0.2 from 7.8 at point E to 8 at point B. Assuming an elasticity of -0.8, this caused ln(employment) to fall back along the new demand D2(-0.8) to point B, leading to a change in ln(employment) of -0.8*0.2=-0.16. Here again, the difference in ln(employment)

between A and B is known to be 0.4 and we subtract the estimated change in ln(employment) from E to B of -0.16 to find the 0.56 difference in ln(employment) between points A and E.

Notice two features of this analysis. First, when one equilibrium ln(earnings) is used to measure the demand change, the elasticity assumption is applied to the other demand curve. Thus, measuring the demand change at the new equilibrium ln(earnings) at B means applying the elasticity assumption to the original demand D1; measuring the demand change at the old ln(earnings) at A means applying the elasticity assumption to the new demand D2. Second, the measures will be the same if the same elasticity is applied to the two curves.

Equation 2a) shows that the measurement of the demand shift differs with the elasticity assumed. If we assume a perfectly inelastic new demand D(0) with an elasticity of 0, the demand line would be the vertical line D2(0) at ln(employment) of 11.2. We are still comparing equilibriums at points A and B because D2(0) passes through the new equilibrium at point B. When the demand shift is measured at the original ln(earnings) of 7.8, it is the horizontal gap between A and F. The elasticity of 0 for D2(0) implies no change in ln(employment) associated with the rise in price that leads to the new equilibrium at point B. As a result, the horizontal gap between A and F is the same as the horizontal gap between A and B and equals 0.4. The demand shift with this more inelastic demand is smaller than when we had a more elastic demand elasticity of -0.8. In general, if both ln(earnings) and ln(employment) rise a more elastic demand assumption will lead to a larger measured rise in demand. The impact of the demand elasticity assumption on the size of the demand shift is shown for all combinations of changes in ln(earnings) and ln(employment) in Table 2. As another example, if ln(earnings) fall and ln(employment) rises, a more elastic demand will lead to a rise in demand.

There is one other feature to note here. When the equilibrium moves from point A to point B and we measure the demand change, we are always making an assumption about the elasticity of only one of the demand curves. Thus, if the elasticity of the original and the new demand curves are different, we will get different estimates of the demand shift depending on which elasticity is used. It is important to provide a range of estimates of the demand shift if it is probable that the demand elasticity had changed. [10]

The measurement of a supply shift follows the same process. The supply shift SS is calculated as the actual change in ln(employment) minus the change in ln(employment) associated with the change in earnings between the two equilibrium points.

$$SS = [Ln(E) - Ln(E^*)] - b1\,[Ln(w) - ln(w^*)] \qquad 2b)$$

On Figure 1 the measure of the supply shift from S1(3) to S2(3) when using the new ln(earnings) of 0.8 is the horizontal distance between G and B. We know ln(employment) at points A and B. Finding point G requires an assumption about the supply elasticity of ln(employment) with respect to ln(earnings). S1(3) assumes a supply elasticity of 3. The 0.2 rise in ln(earnings) between points A and B would have led to a rise in ln(employment) A along S1(3) from 10.8 at point A to 11.4 at point G. The difference of 0.6 can be found by multiplying the rise in ln(earnings) of 0.2 by the supply elasticity of 3. Using equation 2b the measure of the change in supply is the actual change in ln(employment) from point A to B of 0.4 minus the change in employment from A to G associated with the ln(earnings) rise) of 0.6, which is a reduction in supply by -0.2.

If we were to measure the supply change at the original ln(earnings) of 7.8 the supply reduction would be measured as the horizontal reduction between points A and H, which would

[10] A pure change in demand elasticity with no demand shift, would be a rotation of the demand curve around point A in Figure 2. It is not possible to mistake a demand shift for a pure change in the elasticity of demand.

be the actual gap in ln(employment) between A and B of 0.4 minus the estimated gap in ln(employment) between B and H of 0.6 along the new supply curve S2(3). If the elasticity is assumed to be 3, the reduction in supply will again be -0.2.

As with the demand shift measure, the assumed elasticity determines the size of the supply shift. Table 2 shows how the assumed elasticity influences the size of the shift with different combinations of changes in ln(earnings) and ln(employment). For example, most of the changes related to the War are associated with increases in both ln(earnings) and ln(employment). In such a situation an increase in the supply elasticity would lead to a more negative estimate of the supply shift.

Measuring Shifts when Wage Ceilings Are in Place

The measurement of supply and demand shifts moving into and out of World War II is complicated by the wage and salary controls imposed by the federal government between September 1942 and 1946. Figure 3 shows the implications of the controls for measuring the shifts. Narratives describe a rise in both labor demand and supply for women during the War, so we show the impact of a rise in demand from D1(-0.8) to D2(-0.8) and a rise in supply from S1(3) to S2(3). Had there been no wage controls, the changes would have led to a move from point A to point B, ln(earnings) would have rise from 7.85 to 7.95, and ln(employment) would have risen from 10.7.5 to 11.25. An effective wage ceiling at 7.9 caused the actual change to be a move from point A to point C, limiting the rise in ln(earnings) to a move from 7.85 to 7.9 and the rise in ln(employment) to a move from 10.75 to 11.1. As a result, the measure of the rise in demand is underestimated; using a demand elasticity of -0.8 the true measure would have been the gap of 0.56 between points E and F, while the actual measured gap is lower at 0.38, the distance between C and F at the ceiling of 7.9.

If the assumed supply elasticity is correct, we still can find the true change in labor supply using equation 2b at the new ln(earnings) of 7.9 at point C. With a supply elasticity of 3, the 0.5 rise in earnings would have caused a move up the original supply curve S1(3) from A to D, which is a rise in ln(employment) of 10.9-10.75=0.15. This leaves the remaining gap between C and D as the measure of the supply shift, 11.1-10.9= 0.2. Had the wage control not been in place the supply shift measure would have been the gap between G and B, 11.28-11.08=0.2, which is the same as the gap at the wage ceiling. Had the wage ceiling been set at the starting point ln(earnings) of 7.85 at point A, there would have been no change in ln(earnings) and the supply shift would have been the change in ln(employment) between points A and H, which again is 0.2.

Measuring the Effect of the War By Comparing to a Counterfactual Trend

The demand and supply shifts measured above are the raw changes associated with the War. They describe the impact of the War if we believe that the situation would have stayed the same as in 1941 without the war. Goldin (199??? Book???) notes that there were substantial changes in women's roles in the 1920s and 1930s that likely would have continued had the War not been fought. We therefore develop a counterfactual trend set of predictions of what would have happened had the War not been fought. The additive native of the log linear demand and supply shift equations allow us to subtract the counterfactual predictions from the actual changes to get estimates of the sizes of the actual demand shift relative to the counterfactual shift (ΔDD) and the actual supply shift relative to the counterfactual shift (ΔSS).

$$\Delta DD = [\Delta \ln(E_A) - \Delta \ln(E_C)] + |e_D| [\Delta \ln(W_A) - \Delta \ln(W_C)]. \quad 3a)$$

$$\Delta SS = [\Delta \ln(E_A) - \Delta \ln(E_C)] - e_S [\Delta \ln(W_A) - \Delta \ln(W_C)]. \quad 3b)$$

where $\Delta\ln(E_A)$ is the actual and $\Delta\ln(E_C)$ is the counterfactual change in ln(employment), and $\Delta\ln(W_A)$ and $\Delta\ln(W_C)$ are the actual and counterfactual changes in ln(earnings). This difference provides a more likely estimate of the change in demand related to the war experience by subtracting out changes that likely would have occurred without the war.

The counterfactual trend is based on the average annual growth in earnings and amount of labor between 1923 and 1929. We chose that period for several reasons. It was the only extended noncrisis period for which data are available on a consistent basis prior to 1950. The years 1923 to 1929 were both business cycle peaks and there were minor fluctuations in the economy in between. These were boom years for the economy with substantial growth in new technologies like automobiles, radios, and electricity, a rise in leisure activity, expansions in internal labor markets, increases in the access to high school and more advanced education, and changed political roles for women after they obtained the right to vote. The period 1923 to 1929 also led to expansions in labor market activity by Pennsylvania women. The average annual growth rate in the number of female salaried employees was 2.45 percent per year and their real salaries grew at 1.6 percent per year. Meanwhile, employment by female wage workers rose 1.4 percent per year and their real average annual earnings rose 1 percent per year.

We did not want to choose a trend line from the recovery from 1933 because that would have led to unusually large growth rates because the economy was coming out of a trough during the Great Depression that was extraordinarily deep. Between 1929 and 1933 total hours worked by female production workers dropped more than 30 percent and employment for female salaried workers fell by more than 28 percent. The troughs were so deep that growth in hours worked for female production workers and employment for female salaried workers each exceeded 4.8

percent per year between 1933 and 1939, yet the level of their activity still had not reached the levels of 1929.

Because we have to make assumptions about labor demand and labor supply elasticities and choose a counterfactual trend, we will not be able to obtain precise estimates of how much labor demand changed for female workers. On the other hand, the changes in employment and earnings for female workers from before the start of the War to the War peak to the post-war period are quite large. As will be seen below, these changes lead to demand shift estimates that are quite large over a broad range of elasticity choices.

Choosing Labor Demand and Supply Elasticities

A key to the analysis is choosing appropriate labor demand and labor supply elasticities of employment (or hours) with respect to earnings. We searched the recent literature for short run elasticities for the manufacturing sector of the economy but could not find elasticities specific to manufacturing. Daniel Hamermesh (1993, 270-273) summary of demand elasticities for males suggests that the demand is generally inelastic and the estimates range from 0 to minus 1. Acemoglu, Autor, and Lyle (2004) estimate that the demand elasticity for women workers of all types was more elastic and ranged between -1 and -1.5.

The range of supply elasticities in the literature is much larger and has been debated extensively (Keane and Rogerson 2012; Chetty, Guren, Manoli, and Weber 2011). Part of the debate is based on differences in the level of aggregation in estimation. Studies of individual data often find small elasticities that are well below 1, while macroeconomists focusing on aggregate data use elasticities ranging from 1 to 3. Keane and Rogerson (2012) argues that the small estimates from individual data imply the larger elasticities with aggregate data, but Chetty, et. al. (2011) still argues for aggregate elasticities below one. Neither the micro nor the macro

elasticities fit the context we are examining exactly because the macro estimates are for the entire economy and the micro estimates are for individuals.[11]

Our solution is to use a broad range of elasticities for three reasons.. One, there is likely to be a great deal of uncertainty about the true elasticities for demand and supply for the four different classes of workers in manufacturing because relatively few scholars estimate these elasticities. Second, endogeneity problems make it difficult to estimate the elasticities and it is difficult to find satisfactory instruments to resolve endogeneity issues in many settings. It is particularly difficult in a setting like this where we have data from only one state. One of the goals here is to determine as much as we can from a limited amount of information. Third, we wanted to show how robust the findings are to different elasticities under specific settings. Given equations 2a) and 2b) for measuring the demand and supply shifts, it is clear that the demand and supply shifts will be measured with more robustness when the difference in earnings are smaller.

DATA

To determine the changes in labor demand and supply, we joined Ryan Johnson in compiling a gender-specific industry level employment data set from the "Report on Productive Industries, Public Utilities and Miscellaneous statistics of the Commonwealth of Pennsylvania" and the "Annual Report of the Secretary of Internal Affairs of the Commonwealth of Pennsylvania: Industrial Statistics." The data were collected annually and span the years 1916 to 1950 for over 300 industries in Pennsylvania. We aggregated the industries into several broad

[11] There are also a profusion of elasticities estimated for hours worked, decisions about accepting employment, and intertemporal elasticities of both types.

categories to eliminate problems with plant information being reported in one subcategory in one year and another category in other years. We then focused on aggregating information for the entire state in the following broad manufacturing categories: chemicals and allied;, clay, glass, and stone; food and beverages; rubber and leather; wood products; metal products (including machinery); paper and printing; textiles; and tobacco products. Information was reported for these industries in all years. We left out miscellaneous manufacturing because of problems with reporting on the smaller miscellaneous categories. We also did not include mining because very few women worked as wage workers before, during, and after the war. The following description of the data is from a revised version of Ryan Johnson's Ph.D thesis (2004) and further details can be found in his data appendix:

> "These reports were compiled from annual reports from manufacturing and mining industries by the Department of Internal Affairs. The Department of Internal Affairs had a team of field workers who conducted surveys and also kept in close contact with chambers of commerce to ensure that the department collected data on all relevant firms (Pennsylvania Department of Internal Affairs 1941, p. xvi). There were about 315 industry classifications each year. The industrial classifications are so fine that some firms produced products that should be classified in multiple industries. In cases like this the data were coded by the Pennsylvania Department of Internal Affairs according to the classification of the product that represented the firm's largest value of manufacture (see the forward of the 1926 report). In some years there was construction industry data reported also."

We also did extensive cross-checking of the data with a 1964 report by the Statistics staff of the Pennsylvania Department of Internal Affairs (1964). In the 1964 report they carefully restructured the data on total employment and total wage and salaries for the entire period from 1916 to 1962 to meet the SIC codes of the time period but did not report separate information for the categories. The correlations across time between 1920 and 1950 for total wage and salary information between the annual reports and the 1964 reported information were over 0.99 for all but three industries. The correlations for

those three were 0.95. 0.88, and 0.91. We also cross-checked the data with the Pennsylvania data in the manufacturing censuses and the correlations across time between the data reported by the state and the data reported by the U.S. Census was 0.99 for average annual earnings for wage workers, 0.91 for total wage earners and 0.97 for total wages paid.[12]

The variables of interest for this study cover the four categories of workers: male wage earners. female wage earners, male salaried workers, and female salaried workers. We have information on the number of workers and the total annual payments spent on each of the four labor inputs. Later in the paper we will also incorporates information on the value of the product, extent of unionization, racial mix, and ethnic mix.

Given the nature of wage payments for salaried workers, who are not paid by the hour, the average salary is a good estimate of the wage that workers consider when choosing between firms. For production workers, who are typically paid by the hour or the piece, the annual earnings are influenced by hours worked, which are a component of the labor supply. Therefore, we obtained measures for male and female production workers of hourly earnings and average hours per week in 25 industry classifications between 1920 and 1948 from the National Industrial Conference Board (NICB)[13] This information was collected from the National Industrial Conference Board monthly reports titled *Personnel Management Record* for the years between 1939 and 1950.[14] We obtain the same information for the years 1920-1939 from Ada

[12]None of the alternative sources had the detail by male and female wage and salary workers or the annual coverage that the data set we have compiled has.

[13] The industries listed in the NICB records are: agriculture implement, automobile, boot and shoe, chemical, cotton, electrical manufacturing, furniture, hosiery and knit goods, iron and steel, leather, lumber, meat packing, paint and varnish, paper and pulp, paper products, printing books, printing news and magazines, rubber, silk and rayon, wool, foundries and machines. We have aggregated these industries to match the Pennsylvania industries. In most cases the matches were obvious. In a few cases we matched information from some industries with proxy industries for which we have information from other sources that the industries paid similar wages.

[14] The hourly earnings are not wage rates because they may include overtime and other monetary compensation.

Beney (1938) who also collected them from the same source. The data are reported monthly and we convert it into annual averages so that we can match and merge the national wages to the annual Pennsylvania data. The NICB data cover the entire country, but Pennsylvania accounted for 13 percent of the firms surveyed (National Industrial Conference Board 1930, 34-35). We have looked at other sources of hourly earnings and hours worked by state for the years 1933, 1935, 1937, and 1939 and for later years, and Pennsylvania's hourly earnings seem to track reasonably closely to the national hourly earnings over time in those sources. [?????go and double check this??????]

DEMAND AND SUPPLY SHIFTS IN THE ACTUAL DATA AND RELATIVE TO THE COUNTERFACTUAL

The information in Table 3 shows the information on the natural logs (ln) of real average annual salaries and average employment that is used to calculate the actual shifts in demand and supply for the period 1941 through 1950. The shift calculations are shown for female workers in Table 4 and for males in Table 5. Both tables show the size of the demand shifts associated with these changes over a broad range of demand elasticities of employment (or hours) with respect to earnings of -0.3 -0.8 and -1.5. The supply shifts are shown for elasticities ranging from 1 to 5.5. In the discussion we will focus on a labor supply elasticity of 3 and a demand elasticity of -0.8 to ease the exposition.

Female Salaried Workers

Female salaried workers were typically clerks and administrative assistants and administrators during the 1940s. Women had been in many of these positions in the 1920s and 1930s even in industries where they were not working on production lines. Between 1941 and the peak of the War effort in 1944 ln(salaries) for female salaried workers had grown by 0.089

log points and ln(employment) had boomed by 0.570 log points. These changes imply a rise in demand of 0.641 log points if there had been no salary controls. This is an understatement of the true rise in demand because the salary controls in place after September 1942 prevented the full effects of the demand rise on salaries and employment from occurring. We can get a more accurate estimate of the size of the labor supply shift. At our baseline supply elasticity of 3 it the supply shift was 0.303 log points, although it was much smaller at 0.081 log points with an elasticity of 5.5.

The War demobilization began with the end of the War in 1945 and the wage ceilings were removed in 1946. Between the War peak in 1944 and 1950 employment declined and real salaries increased each year except 1946. By 1950 ln(employment) had fallen by -0.179 log points and ln(salaries) had risen by 0.067 ln(points). The changes imply a drop in demand by -0.13 log points or more because the salary controls prevented us from measuring the full rise in demand to 1944. It also implies a drop in supply of -0.379 log points from the war time peak. This drop in demand matches the narratives of layoffs for female workers after the War and the replacement of female workers by the returning male workers in manufacturing.

One of the key comparisons in analyzing the change in labor demand and supply is between the pre-war and post-war era because it allows for comparisons of peace-time production of similar goods. This comparison is particularly important because so much of the manufacturing during the War was focused on military production, which was replaced by the production of goods normally provided during peace time. Despite the sharp drop-offs in employment after the War, the ln(employment) for female salaried workers in 1950 was 0.391 log points above the level seen in the strong economy of 1941, while ln(salary) was 0.156 log

points above. This implies a large demand rise between 1941 and 1950 of 0.62 log points and a much smaller supply fall of -0.08 log points.

Since the long run path in the U.S. is one of growth and change, it is important to go beyond just comparing the actual situations in 1941 and 1950. We therefore compare the changes to a counterfactual path based on the average annual growth rates in earnings and employment between the two business cycle peaks 1923 and 1929. The counterfactual trend paths for the natural logs of employment and average salaries start with the actual values in 1941 and then allow each series to grow at the trend pace between 1923 and 1929. During that period real salaries grew at an average annual pace of 0.016 log points per year and female salaried employment grew .024 log points per year. If they had grown at the same pace between 1941 and 1950, ln(employment) would have been 0.22 log points higher and ln(salaries) would have been 0.146 log points higher in 1950 than in 1941. These changes imply a counterfactual demand rise of 0.337 log points and a supply reduction of -0.216 log points.

The differences between the actual 1941-1950 changes and the 1941-1950 counterfactual changes give a better estimate of the impact of World War II on the demand and supply. Table 4 shows that the actual change in ln(salary) between 1941 and 1950 was 0.010 log points higher than the counterfactual change, while the actual change in ln(employment) exceeded the counterfactual change by 0.171 log points. This implies that demand rose more than the counterfactual demand by 0.18 log points and labor supply rose more than counterfactual labor supply by 0.14 log points. These differences between the actual and counterfactual demand shifts are robust to a broad range of assumptions about the elasticities.[15]

[15] The mathematical reason for the relatively small range of the relative demand shift measure over a large range of elasticities is that the ln(salary) change, which is multiplied by the absolute value of the elasticity in equation 7a, is relatively small, so that the ln(employment) change is the

Female Wage Workers

Rosie the Riveter had a strong effect on the American imagination because women working on production lines in long male-dominated industries were an unusual feature that came with the War. Our sense is that it was changes in opportunities for production work that was the predominant influence of the Wartime experiences. Between 1941 and the war-time peak in 1944 ln(hours) exploded by 0.521 log points while the wage controls held the rise in ln(hourly earnings) to 0.115 log points. Had this been a situation with no wage controls, the rise in demand would have been 0.613 log points, but the presence of the wage controls makes this an underestimate of the true increase. Meanwhile, female labor supply rose by 0.176 log points, although it should be noted that a supply elasticity of 5.5 implies a decline in labor supply in Table ?? by -0.111 log points.

Both demand and supply for female wage workers declined after the wartime peak. Between 1944 and 1948, ln(total hours) declined by -0.293 log points, while ln(hourly earnings) remained virtually the same. This combination implies a reduction in both demand and supply by around -0.29 log points.

Comparisons of the pre- and post-War settings shows that ln(total hours) rose by 0.228 log points between 1941 and 1948 and ln(hourly earnings rose by 0.115 log points. These changes imply an increase in labor demand by 0.32 log points and a reduction in supply by -0.118 log points. A better measure of how labor demand and supply changed as a result of the War is to compare the actual change to the counterfactual change. After subtracting these counterfactual changes in demand and supply from the actual changes, the demand for female

---

primary determinant of the size of the shift. The same holds for the relative supply shift measure in equation 7b.

wage earners rose by 0.19 log points more than the counterfactual at an elasticity of -0.8, with a range of 0.16 to 0.23 over the range of demand elasticities described. Relative to the counterfactual the labor supply of women between 1941 and 1950 fell barely at all with a supply elasticity of 3, but the direction of the supply shift varies from a rise of 0.1 to a fall of -0.14 over the span of supply elasticities.

Male Workers

The standard narrative for the War is that the mobilization expanded the demand for male production workers, just as large numbers were drawn into the military. After the war the demand for male workers fell back some, while the supply expanded again. We know that the wage distribution became more compressed between 1940 and 1950, but we do not know much about how the changes in demand and supply relative to a counterfactual trend for male workers between the two periods.

Male Salaried Workers

Comparisons of Tables 3, 4, and 5 show that male salaried workers had a quite different experience from female salaried workers and somewhat different experience from the narrative. In contrast to the experience for salaried females, their employment continued to rise after the war time peak while their real salaries fell. Between 1941 and the War peak ln(salaries) rose 0.102 log points and ln(employment) rose 0.074 log points. The presence of the salary ceilings imply a rise in demand of greater than 0.156 log points. Meanwhile, the mobilization contributed to a reduction of supply of -0.231 log points. Both changes are consistent with the narratives of large numbers of men pulled out of the workforce into the military and the rise in demand for professionals, technical workers, administrators, and clerks with the war effort.

After the War real salaries in Table 3 fell below their 1941 level, then recovered some, but still remained -0.064 log points below the War Peak. Employment continued to rise in the post-war era and ln(employment) in 1950 was 0.198 log points higher than in 1944. These changes imply substantially different changes in demand and supply than the experiences of the other three groups of workers. Male salaried workers were the only ones to experience a rise in demand following the peak of the War, roughly 0.15 log points in their case. Their labor supply also grew by 0.39 log points in contrast to the drops in labor supply for female workers.

The pre- and post-War peacetime comparisons in Table show that ln(employment) in 1950 was 0.272 log points higher but ln(salary) was 0.038 log points higher than in 1941. These imply a demand shift of 0.30 log points and a supply shift of 0.158 log points. Had the economy followed the counterfactual trend from 1923 to 1929, the counterfactual demand would have risen by 0.38 log points and the supply would have fallen -0.51 log points. Therefore, the actual rise in male ln(salaries) between 1941 and 1950 was -0.196 lower than the predicted counterfactual rise, while the rise in ln(employment) was 0.083 log points higher. This implies that the actual rise in demand was -0.074 log points below the counterfactual, while the actual rise in supply was 0.672 log points higher than the counterfactual.

Male Wage Workers

Male wage earners followed the patterns of the standard narrative. Labor demand rose 0.18 log points and labor supply fell -0.11 log points between 1941 and the War peak. After the War demobilization caused labor demand to fall -0.14 log points and labor supply to rise by 0.14 log points. The rise and fall meant that there was no change in ln(earnings) and only a small rise of 0.032 log points in ln(total hours). This led to a small rise in demand and supply for male production workers. The counterfactual trend from 1923 to 1929 also implied a relatively small

change of -0.04 log points in demand and a larger decline in labor supply of -0.35 log points. Thus relative to the counterfactual, labor demand rose by 0.07 log points while labor supply rose by a very large 0.39 log points.

Change in Demand for Females Relative to Males

If the elasticities of demand and supply were the same for male and female workers, we could carry the analysis above further to make comparisons of the changes for females relative to males and then comparisons of how females fared relative to males relative to the counterfactual. But it is unlikely the elasticities were the same.

The demands for males and females are connected together by the degree to which they are can be substituted for each other in the work process. Acemoglu, Autor, and Lyle (2004) and Goldin and Katz (2008) have derived relative demand functions for different classes of workers based on the elasticity of substitution between the classes of workers. Following Goldin and Katz (2008, 297) we can write the female/male relative demand function (D_{FM}) as

$$D_{FM} = [[\ln(E_{50}^{F}) - \ln(E_{41}^{F})] - [\ln(E_{50}^{M}) - \ln(E_{41}^{M})]] + \sigma_{FM}\,[[\ln(W_{50}^{F}) - \ln(W_{41}^{F})] - [\ln(W_{50}^{M}) - \ln(W_{41}^{M})]] \quad (4)$$

where the F and M subscripts refer to females and males, the 50 and 41 subscripts refer to the years 1950 and 1941 (1948 and 1941 for production workers), E is employment (or hours), W is earnings, and σ_{FM} is the elasticity of substitution in production between females and males. In their analysis they assumed the supply elasticity was zero in the short run, which implies that the relative supply shift is equal to the difference between the change in ln(employment) for females

and males.[16] Acemoglu, Autor, and Lyle (2004) estimated an elasticity of substitution between male and female labor (σ_{FM}) that ranged from 2.4 to 4.2 for all types of labor. We provide estimates for a larger range from 0 to 4 to show the robustness of the relative demand estimates to the elasticity assumptions.

The comparisons in Table 6 show the actual and counterfactual female/male relative changes in ln(earnings) and ln(labor) between the pre- and post-war periods. The supply changes document that female labor activity increased relative to male activity using the actual numbers and relative to the counterfactual by less than 0.9 log points.

The big change is in the demand for females relative to males. The actual female demand for salaried workers grew by 0.12 log points more than the actual demand for males when the elasticity of substitution is zero. At the midpoint of the range estimated by Acemoglu, Autor, and Lyle (2004) the relative demand for workers rose by as much as 0.35 log points. After subtracting out the counterfactual change, the demand for females relative to males grew at least 0.088 log points more than the counterfactual relative demand at a substitution elasticity of zero. More likely substitution elasticities suggest that the female/male relative demand grew 0.29 to 0.91 log points faster than the counterfactual relative demand. The story was similar for production workers. Based on the actual changes, female demand grew at least 19.6 percent more than male labor demand and as much as 0.66 points more. Relative to the counterfactual the relative demand grew faster by 0.05 to 0.65 log points.

Measuring Shifts After Controlling for Several Factors in Reduced Form Estimation

[16] They were able to adjust for the quality of labor to some degree and thus used the amount of efficiency units provided by the workers employed. The counterfactual in our analysis controls for changes in efficiency units that would have occurred during peace time, but part of what remains may be due to changes in relative quality. In the next section we control for several other factors. Goldin and Katz assumed that changes in the relative labor supply of college to noncollege labor did not affect the wage premium for high school graduates relative to high school dropouts. In our case we are making the assumption that the relative supply of female and male salaried workers does not affect the relative demand and supply for female and male wage workers and vice versa. [

Thus far, we have used the counterfactual as a control for what would have happened in the absence of the War. Some of the differences driving the changes in demand and supply for a group like female salaried workers might have been driven by changes in the earnings of male salaried workers that deviated from the changes that occurred during the 1920. Another factor might have been differential changes in productivity. To some extent the estimates in Tables 4 through 6 are reasonable estimates of the impact of the War if transitions into and out of the War and the War time experiences were the driving forces behind the changes in earnings for other groups or in productivity. Controlling for these deviations might cause us to underestimate the impact of the War.

If the War was not the driving force behind those changes, however, we can use the Pennsylvania data to control for several factors and then perform the analyses above on the year fixed effects. We disaggregate the data into nine broad manufacturing categories and estimate reduced form ln(earnings) and ln(employment) regressions for each group.

$$ln(E_{it}) = X_{it}\beta + Industry_i + Year_t + \varepsilon_{it.} \quad 5a)$$

$$ln(W_{it}) = X_{it}\beta + Industry_i + Year_t + \mu_{it} \quad 5b)$$

The X_{it} is a vector of control variables that vary across industry *i* and over time *t*. The control variables are a mixture of factors that influence labor demand and labor supply. These include the percent union in the industry at the national level; the value of output per worker (including salaried and production workers), the percent black, and percent foreign-born in the Pennsylvania industry; and the natural log of earnings in the other categories. For example, in the equations for female salary workers, the natural logs of salary of male salary workers, hourly

earnings of female production worker, and hourly earnings of male production workers. $Industry_i$ is a vector of industry fixed effects that control for features of the industry that did not change over time, $Year_t$ is a vector of year fixed effects that measure factors that are common to that year across industries but vary over time. The $\varepsilon_{it.}$and μ_{it} are measures of other unobservable factors.

We estimate the models for the period 1941 through 1948. We cannot go past 1948 because hourly earnings are not available for both male and female production workers. When we estimate the models for salaried workers to 1950, the results are essentially the same. To obtain a counterfactual measure, we also estimate the models for the period 1923 through 1929. We then redo the analysis above using the estimates of the year fixed effects in place of the ln(earnings) and ln(employment). The year fixed effects capture the changes across time in Pennsylvania manufacturing over the period after controlling for a measure of overall labor productivity, the wages of other classes of workers, the racial and ethnic composition of the workforce, unionization, and unchanging features of each industry. Thus, the comparisons of the year fixed effects in the 1940s are akin to comparing wages that have been adjusted to eliminate differences in the control factors. When we compare them to predicted counterfactual fixed effects based on the 1923-1929 period, we eliminate the residual changes that normally would have occurred during peacetime. This brings us closer to finding the demand changes that were associated with changing employer attitudes associated with the wartime experience.

We chose to estimate the reduced-form equations because it was difficult to find strong and valid instruments that would be uncorrelated with the error that varied both across industry and time during the 1940s. Even had we found proper instruments, the measurement of the demand shift related to employers' attitudes and other unobservables still would have come

down to comparing the year fixed effects in the demand and supply equations. The advantage of instrumenting is that the year fixed effects could have been read directly as demand changes and supply changes. The disadvantage arises to the extent that the instruments are not strong and/or valid, which would then raise questions about whether the year fixed effects truly came from supply and demand equations. Our choice as to estimate the reduced-form ln(earnings) and ln(employment) equations that do not require us to control for endogeneity between ln(earnings) and ln(employment) to get estimates of the year fixed effects for each equation. We then use other estimates of demand and supply elasticities and these year fixed effects to infer the changes in demand and supply. We therefore have cleaner estimates of the fixed effects and use a wide range of elasticity estimates to determine the robustness of the findings.

Female Workers

The story about the pre-war and post-war comparisons for female salaried workers changes some when using the fixed effects rather than the raw information. The rise in demand between 1941 and 1948 was smaller, roughly 0.35 log points using the fixed effects and 0.64 using the raw information. Meanwhile, the counterfactual change in demand was about the same at around 0.35 in both situations. As a result, the residual demand rose the same between 1941 and 1948 as the counterfactual demand would have risen. Therefore, it appears that some of the increases in the demand relative to the counterfactual using the raw information was driven by changes in the wages of the other classes of workers. On the supply side, there was a supply increase relative to the counterfactual using both the wages and the fixed effects.

For female production workers the results are essentially the same for both the raw information and the fixed effects. Comparisons of 1941 to 1948 show a very large rise in residual demand that remains large after subtracting out the counterfactual. As with the raw

information, the estimates of residual supply changes between 1941 and 1948 are somewhat uncertain and depend heavily on the supply elasticity chosen 48.

Male workers

The story was essentially the same for male salaried workers using both fixed effects or the raw information. The actual changes show both a substantial rise in both demand and supply between 1941 and 1948. Compared to the counterfactual there was a small and uncertain demand change, while there was a large increase in labor supply.

The fixed effects analysis agrees with the raw information for male production workers in implying a substantial rise in labor supply relative to the counterfactual between 1941 and 1948. On the other hand, it implies a significant rise in residual demand relative to the counterfactual not found in the demand predictions drawn from the raw information. The difference arises because the actual change in ln(earnings) and ln(employment) was very small between 1941 and 1948, implying very small changes in demand and supply. The fixed effects analysis implies a substantial rise in residual demand and drop in residual supply between 1941 and 1948. These changes are substantially larger than the counterfactual changes implied by the fixed effects from the regression from 1923 to 1929.

Changes for Females Relative to Males

Using either the fixed effects analysis or the raw information, the comparisons of female to male workers tell the same story about the changes in the relative demand for female workers. At substitution elasticities of one or more, the relative demand for female salaried workers rose between 1941 and 1948 by a substantial amount in actual terms and relative to the counterfactual. Meanwhile, the relative demand female production workers rose substantially at every substitution elasticity that is greater than zero.

CONCLUSIONS

Our goals are two-fold. First, use the limited information available on actual employment and earnings outcomes to make statements about shifts in labor demand and labor supply and show how robust these statements are to the demand and supply elasticities of employment with respect to earnings. The shifts are measured as the change in employment (or hours worked) at a specific earnings level. Second, use the methods to examine the impact of World War II on the demand and supply of female workers in the labor market.

The methodological point is that we can develop pretty strong inferences from limited information. We do not get precise regression coefficients, but it is important to note that the regression coefficients themselves have confidence interval bounds. In our experiences and in reading many empirical papers the confidence interval bounds are as large as the ranges in estimates that we have found here. Given the endogeneity of supply and demand it is often difficult to find effective ways to control for endogeneity due to the inability to find instruments that are truly exogenous to the situation. Even then the instruments are often only capturing part of the relevant variation. In supply and demand situations often our most believable estimates come from running separate reduced form equations for the wage (or the price) and for employment (or quantity) as a as a function of factors influencing both demand and supply. Even then in the case of specific events or laws, the key results are actually captured by time fixed effects in the regressions. Then we still need to put interpretations on the fixed effects to determine what they imply for shifts in demand and supply.

Most of the quantitative work to date has focused on the labor supply of women before and after the War and found that the changes were not as large as people had thought. We find

similar results for female salaried workers with increases of roughly 12 to 13 percent. For female production workers the supply change might have gone either way and depends heavily on the supply elasticity chosen.

Our contribution comes in looking at the demand side. Our results show that no matter how you measure the change in demand—the actual change, the change relative to a counterfactual, actual and counterfactual changes after controlling for several factors, and the change relative to men—the War was associated with a substantial rise in the demand for female production workers. The actual demand boomed 50 to 70 percent between 1941 and the war time peak in 1944. It then fell substantially after the war but still remained well above the 1941 level and also well above a level that would have been predicted by trends from the 1920s. After taking into account the counterfactual trends and controls for other influences, the demand in 1948 was at least 20 percent above what likely would have occurred had the War not been fought and the gap might well have been larger.

The situation for female salaried workers is not as clear cut. Like the situation for female production workers, the actual demand and supply of female salaried workers boomed during the War and both fell after the War. The longer range impact of the War in peacetime is more uncertain. Comparisons of the raw numbers on salaries and employment to the counterfactual trend suggest that the demand and supply of labor in 1948 were about 12 to 20 percent higher than the predicted counterfactual. Once we control for several influences, the residual demand in 1948 seems to have been roughly the same as the predicted counterfactual. In many ways it is not a surprise that the demand did not shift nearly as much for female salaried workers as for their sisters on the production line. Females had long been performing office work for manufacturers in many industries while not being allowed on the production lines in those

industries. Even though the change in the level of demand for female salaried workers might not have been changed by the War, the demand for female salaried workers relative to male salaried workers rose substantially.

Male workers had quite different experiences. Following the traditional narrative, the demand rose and the supply fell sharply for male production workers between 1941 and the War's peak in 1944. Then demobilization led to a reduction in demand and a rise in supply. Similar to the production workers, the supply of male salaried workers fell during the war and rose again afterward. In contrast, however, the demand for male salaried workers grew both during the War and continued to grow after the War. In comparisons of the pre- and post-War periods therefore, the actual demand rose more than 0.26 log points for salaried workers, while there was virtually no change in the demand for production workers. The counterfactual trends from the 1920s suggest that even without the war the demand for salaried workers would have risen as much or more, while the demand for production workers would not have changed much. As a result, the effect of the War on the demand for male workers might well have been negligible. When we control for other factors and examine changes in the residual demand, the changes for male salaried workers are essentially the same as with the raw data. The residual demands for male production workers, on the other hand, imply a substantial increase in demand. On the supply side, all methods suggest that the labor supplies of males to both wage and salary work were higher in 1948 than in 1941 and also higher than what the counterfactual trend would have predicted.

REFERENCES

Acemoglu, D. Autor, D.H. and Lyle, D. (2004), "Women, war, and wages: The effect of female labor supply on the wage structure at mid-century", Journal of Political Economy 112, 497-551.

Anderson, Karen. *Wartime Women: Sex Roles, Family Relations, and the Status of Women During World War II* (Westport: Greenwood Press, 1981);

Beney, Ada. *Differentials in Industrial Wages and Hours in the United States: National Industrial Conference Board Studies: No. 238.* New York: National Industrial Conference Board, 1938.

Campbell, D'Ann. *Women at War with America: Private Lives in Patriotic Era* (Cambridge: Harvard University Press, 1984);

Chafe, William. *The American Woman: Her Changing Social, Economic, and Political Roles, 1920-1970* (New York: Oxford University Press, 1974).

Costa, D.L. (2000), "From mill town to board room: The rise of women's paid labor", Journal of Economic Perpectives 14(4), 101-122.

Federal Works Agency. *Second Annual Report for Fiscal Year Ending June 30, 1941.* Washington, D.C.: Government Printing Office, 1941.

Fernandez, Raquel, Alessandra Fogli, and Claudia Olivetti, "Mothers and Sons: Preference Formation and Female Labor Force Dynamics," *Quarterly Journal of Economics* 119 (2004): 1249-1299.

Filer, Randall, Daniel Hamermesh, and Albert Rees. 1995. *The Economics of Work and Pay, 6th Edition.* New York: HarperCollins College Publisher.

Freeman, Richard. 1980. "Employment and Wage Adjustment Models in U.S. Manufacturing, 1950-1976." *Economic Forum* 11: 1-27.

Finegan, T.A. and Margo, R.A. (1994), "Work relief and the labor force participation of married women in 1940", The Journal of Economic History 54(1), 64-84.

Goldin, Claudia. (1990), *Understanding the Gender Wage Gap: An Economic History of American Women*, Oxford University Press.

Claudia Goldin, "The Quiet Revolution That Transformed Women's Employment, Education, and Family," *American Economic Review Papers and Proceedings* 96 (2006): 1-21.

Goldin, Claudia. (1991), "The role of WWII in the rise of women's employment", American Economic Review 81, 741-756.

Goldin, Claudia. and Katz, Lawrence. (2008), *The Race between Education and Technology*, Harvard University Press.

Goldin, Claudia and Claudia Olivetti, "Shocking Labor Supply: A Reassessment of the Role of World War II on US Women's Labor Supply," NBER Working Paper 18676.

Hamermesh, Daniel .S. (1993), *Labor Demand*. Princeton, New Jersey: Princeton University Press.

Johnson, Ryan. 2002. "The Economic Progress of American Black Workers in a Period of Crisis and Change, 1916-1950." Ph.D. Dissertation, University of Arizona.

Keane, Michael and Richard Rogerson. 2012. "Micro and Macro Labor Supply Elasticites: A Reassessment of Conventional Wisdom." *Journal of Economic Literature* 50(2): 464-476.

Miriam King, Steven Ruggles, Trent Alexander, Donna Leicach, and Matthew Sobek. *Integrated Public Use Microdata Series, Current Population Survey: Version 2.0*. [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], 2004.

Ruth Milkman, *Gender at Work: The Dynamic of Job Segregation by Sex During World War II* (Urbana: University of Illinois Press, 1987).

National Industrial Conference Board. *Personnel Management Record*. New York: National Industrial Conference Board Inc., monthly issues from 1936 through 1948.

National Industrial Conference Board. *Wages in the United States, 1914-1929.* New York: National Industrial Conference Board, 1930.

Neumann , Todd, Jason Taylor, and Price Fishback. **"**Comparisons of Weekly Hours Over the Past Century and the Importance of Work Sharing Policies in the 1930s," with. *American Economic Review Papers and Proceedings* 102 (May 2013): 105-110.

Pennsylvania Bureau of Statistics. *Report on Productive Industries, Public Utilities and Miscellaneous Statistics of the Commonwealth of Pennsylvania* for the years 1916 to 1950. Pennsylvania

Pennsylvania Department of Internal Affairs. *Report on Productive Industries and Miscellaneous Statistics of the Commonwealth of Pennsylvania.* Various years from 1916 to 1950.

Pennsylvania Department of Internal Affairs. *Annual Report of the Secretary of Internal Affairs of the Commonwealth of Pennsylvania: Industrial Statistics.* Various years from 1916 to 1950.

Pennsylvania Department of Internal Affairs, Statistics. *Comparable Statistics for Manufacturing Industries in Pennsylvania: 1916-1962. Special Release No. S-14.* June 1964.

Schweitzer, Mary. "World War II and Female Labor Force Participation Rates," *Journal of Economic History* 45 (1980): 89-95.

Shatnawi, Dina. 2010. "Women and Labor Market Segregation Across Occupations and Industries." Ph.D. Dissertation, University of Arizona.

Tick, L.S. and Oaxaca, R.L. "Technological Change and Gender Wage Differentials", Working Paper, October 12, 2008.

U.S. Bureau of the Census. *Biennial Census of Manufacturing, 1937, Part 1.* Washington, D.C.: Government Printing Office, 1939

US Women's Bureau, *Women's Wartime Hours of Work: the Effect on their Factory Performance and Home Life* (Washington: Government Printing Office, 1947).

Table 1
Implications for Changes in Demand and Supply from
Changes in Earnings and Employment

Earnings	**Employment**	**Dominant Shift**
Rise	Rise	Demand Rise Dominates
Fall	Fall	Demand Fall Dominates
Rise	Fall	Supply Fall Dominates
Fall	Rise	Supply Rise Dominates
Rise	No Change	Demand Rise offset by Supply Fall
No Change	Rise	Demand Rise offset by Supply Rise
Fall	No Change	Demand Fall offset by Supply Rise
No Change	Fall	Demand Fall offset by Supply Fall

Table 2
Implications for Changes in Demand and Supply from Different Elasticities under the Combination of Potential
Changes in Earnings and Employment

Earnings	**Employment**	**More Elastic Demand Leads Demand Shift to Be**	**More Elastic Supply Leads Supply Shift to Be**
Rise	Rise	More Positive	Less Positive
Fall	Fall	More Negative	Less Negative
Rise	Fall	Less Negative	More Negative
Fall	Rise	Less Positive	Less Positive
Rise	No Change	More Positive	More Negative
No Change	Rise	No Different	No Different
Fall	No Change	More Negative	More Positive
No Change	Fall	No Different	No Different

Table 3

The Natural Logs of Average Real Annual Salaries and Employment for Male and Female Salaried Workers and of Real Average Hourly Earnings and Total Hours Worked by Male and Female Wage Workers in Pennsylvania, 1941 to 1950

	Female Salaried Workers		Female Wage Workers		Male Salaried Workers		Male Workers Production Workers	
Year	ln(salary)	ln(employment)	ln(hourly earnings)	ln(total hours)	ln(salary)	ln(employment)	ln(earnings)	ln(hours)
1941	7.868	10.807	0.362	20.164	8.878	11.764	0.716	21.352
1942	7.839	11.046	0.327	20.314	8.912	11.804	0.692	21.460
1943	7.887	11.285	0.416	20.590	8.942	11.824	0.733	21.519
1944	7.957	11.377	0.477	20.685	8.980	11.839	0.791	21.469
1945	7.979	11.365	0.475	20.594	8.976	11.850	0.758	21.398
1946	7.989	11.269	0.486	20.375	8.907	11.941	0.745	21.327
1947	7.960	11.246	0.479	20.355	8.863	11.985	0.727	21.377
1948	7.969	11.252	0.477	20.391	8.856	12.034	0.716	21.384
1949	8.024	11.202			8.883	12.029		
1950	8.024	11.198			8.916	12.036		

Sources: Pennsylvania Department of Internal Affairs (various years between 1941 and 1950), Beney (1938), and National Industrial Conference Board (various months between 1941 and 1948). Earnings and salaries are adjusted for inflation using the Consumer Price Index with 1967=1 (U.S. Census Bureau 1975, series E-135, p. 210).

Table 4
Sizes of Actual Demand and Supply Shifts for Female Salaried and Wage Workers During and After the War and Shifts Relative to the Counterfactual, 1941-1950

	Change in		Implied Change in Demand When Elasticity is			Implied Change in Supply When Elasticity is		
	ln(Salaries)	Ln(Employ)	-0.3	-0.8	-1.5	1.0	3.0	5.0
Female Salaried Workers, Salaries and Employment								
Actual Change from 1941 to 1944	0.089	0.570	0.60	0.64	0.70	0.48	0.30	0.08
Actual Change from 1944 to 1950	0.067	-0.179	-0.16	-0.13	-0.08	-0.25	-0.38	-0.55
Actual Change from 1941 to 1950	0.156	0.391	0.44	0.52	0.62	0.24	-0.08	-0.46
Counterfactual Change from 1941 to 1950	0.146	0.220	0.26	0.34	0.44	0.07	-0.22	-0.58
Actual Minus Counterfactual from 1941 to 1950	0.010	0.171	0.17	0.18	0.19	0.16	0.14	0.12
	Change in							
Female Production Workers Hourly Earnings and Total Hours	**ln(earnings)**	**ln(hours)**						
Actual Change from 1941 to 1944	0.115	0.521	0.56	0.61	0.69	0.41	0.18	-0.11
Actual Change from 1944 to 1948	0.000	-0.293	-0.29	-0.29	-0.29	-0.29	-0.29	-0.30
Actual Change from 1941 to 1948	0.115	0.228	0.26	0.32	0.40	0.11	-0.12	-0.41
Counterfactual Change from 1941 to 1948	0.063	0.079	0.10	0.13	0.17	0.02	-0.11	-0.27
Actual Minus Counterfactual from 1941 to 1948	0.053	0.149	0.16	0.19	0.23	0.10	-0.01	-0.14

Notes. Changes in the natural logs of earnings, salaries, employment, and hours are calculated from information in Table 3. The implied Changes in Demand and Supply are calculated based on equations 2a and 2b. The changes relative to the counterfactual are based on equations 3a and 3b. The counterfactual is based on the changes between 1923 and 1929 and then adjusted to match the length of time for comparisons with the 1940s data. The change in demand is measured as the change in ln(employment) (or ln(hours)) between the original demand and the new demand, holding the ln(earnings) constant. The definition is similar for the measure of the change in supply.

Table 5
Sizes of Actual Demand and Supply Shifts for Male Salaried and Wage Workers During and After the War and Shifts Relative to the Counterfactual, 1941-1950

	Change in		Implied Change in Demand When Elasticity is			Implied Change in Supply When Elasticity is		
	ln(Salaries)	**Ln(Employ)**	**-0.3**	**-0.8**	**-1.5**	**1.0**	**3.0**	**5.0**
Male Salaried Workers Salaries and Employment								
Actual Change from 1941 to 1944	0.102	0.074	0.10	0.16	0.23	-0.03	-0.23	-0.49
Actual Change from 1944 to 1950	-0.064	0.198	0.18	0.15	0.10	0.26	0.39	0.55
Actual Change from 1941 to 1950	0.038	0.272	0.28	0.30	0.33	0.23	0.16	0.06
Counterfactual Change from 1941 to 1950	0.234	0.189	0.26	0.38	0.54	-0.05	-0.51	-1.10
Actual Minus Counteractual from 1941 to 1950	-0.196	0.083	0.02	-0.07	-0.21	0.28	0.67	1.16
	Change in							
Male Production Workers Hourly Earnings and Total Hours	**ln(earnings)**	**ln(hours)**						
Actual Change from 1941 to 1944	0.075	0.118	0.14	0.18	0.23	0.04	-0.11	-0.29
Actual Change from 1944 to 1948	-0.074	-0.085	-0.11	-0.14	-0.20	-0.01	0.14	0.32
Actual Change from 1941 to 1948	0.000	0.032	0.03	0.03	0.03	0.03	0.03	0.03
Counterfactual Change from 1941 to 1948	0.096	-0.065	-0.04	0.01	0.08	-0.16	-0.35	-0.60
Actual Minus Counteractual from 1941 to 1948	-0.096	0.097	0.07	0.02	-0.05	0.19	0.39	0.63

Notes. See Table 4.

Table 6
Goldin-Katz Estimates for Changes in Relative Female/Male Demand and Supply for Salaried and Wage Workers

	Change in							
	ln(salary)	**ln(employ)**	**Supply**	**Demand When Elasticity of Substitution is**				
Salaried Workers, Salaries and Employment, 1941-1950				**0**	**1**	**2**	**3**	**4**
Actual Change	0.118	0.119	0.119	0.119	0.237	0.354	0.472	0.589
Counterfactual Change	-0.089	0.031	0.031	0.031	-0.057	-0.146	-0.235	-0.323
Actual Change Minus Counterfactual Change	0.206	0.088	0.088	0.088	0.294	0.500	0.706	0.913
Production Workers, Hourly Earnings and Total Hours, 1941-1948	**ln(earnings)**	**ln(hours)**						
Actual Change	0.115	0.196	0.196	0.196	0.311	0.426	0.541	0.656
Counterfactual Change	-0.034	0.144	0.144	0.144	0.111	0.077	0.043	0.010
Actual Change Minus Counterfactual Change	0.149	0.051	0.051	0.051	0.200	0.349	0.498	0.647

Notes. Changes in relative demand were calculated using equation 4. The change in relative supply in this situation is the same as the change in ln(employment). The change in relative demand relative to the counterfactual subtracts equation 4 with the counterfactual information from the version of equation 4 using the actual data.

Table 7
Changes in Residual Demand and Supply Between 1941 and 1948 After Controlling for Unionization, Wages of Other Workers, Racial Mix, Overall Labor Productivity, and Ethnic Mix with Comparisons to Counterfactual Estimates

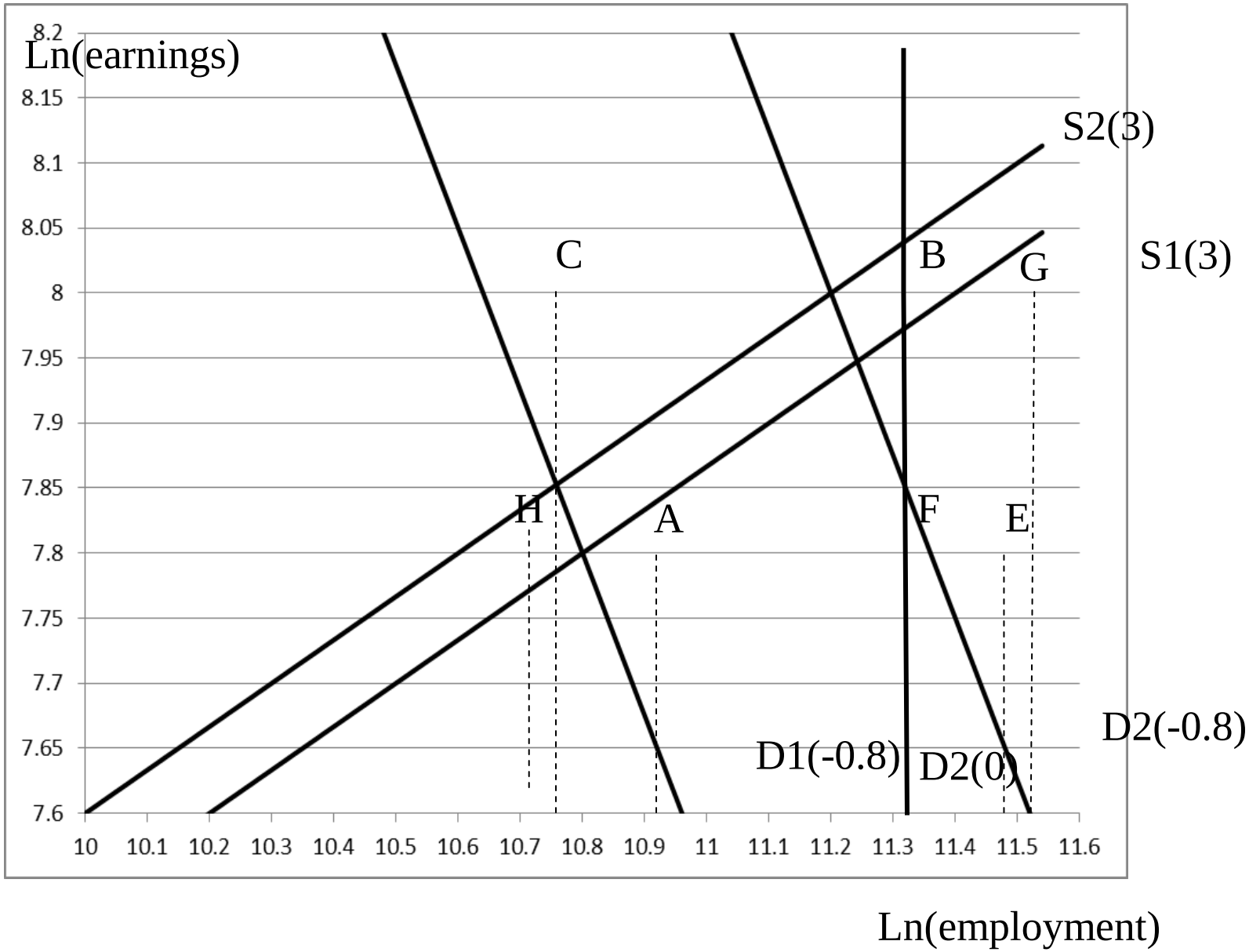
	Change in		Implied Change in Demand When Elasticity is			Implied Change in Supply When Elasticity is		
	ln(Salaries)	**Ln(Employ)**	**-0.3**	**-0.8**	**-1.5**	**1.0**	**3.0**	**5.0**
Female Salaried Workers, Salaries and Employment								
Actual Change from 1941 to 1948	0.046	0.312	0.33	0.35	0.38	0.27	0.17	0.06
Counterfactual Change from 1941 to 1948	0.079	0.282	0.31	0.35	0.40	0.20	0.05	-0.15
Actual Minus Counteractual from 1941 to 1948	-0.032	0.030	0.02	0.00	-0.02	0.06	0.13	0.21
Female Production Workers Hourly Earnings and Total Hours	**ln(earnings)**	**ln(hours)**						
Actual Change from 1941 to 1948	0.119	0.572	0.61	0.67	0.75	0.45	0.21	-0.08
Counterfactual Change from 1941 to 1948	-0.050	0.043	0.03	0.00	-0.03	0.09	0.19	0.32
Actual Minus Counteractual from 1941 to 1948	0.169	0.530	0.58	0.67	0.78	0.36	0.02	-0.40
	ln(Salaries)	**Ln(Employ)**	**-0.3**	**-0.8**	**-1.5**	**1.0**	**3.0**	**5.0**
Male Salaried Workers, Salaries and Employment								
Actual Change from 1941 to 1948	-0.075	0.243	0.22	0.18	0.13	0.32	0.47	0.66
Counterfactual Change from 1941 to 1948	0.231	0.063	0.13	0.25	0.41	-0.17	-0.63	-1.21
Actual Minus Counteractual from 1941 to 1948	-0.307	0.180	0.09	-0.07	-0.28	0.49	1.10	1.87
Male Production Workers Hourly Earnings and Total Hours	**ln(earnings)**	**ln(hours)**						
Actual Change from 1941 to 1948	0.025	0.317	0.32	0.34	0.35	0.29	0.24	0.18
Counterfactual Change from 1941 to 1948	0.113	-0.010	0.02	0.08	0.16	-0.12	-0.35	-0.63
Actual Minus Counteractual from 1941 to 1948	-0.088	0.327	0.30	0.26	0.19	0.42	0.59	0.81

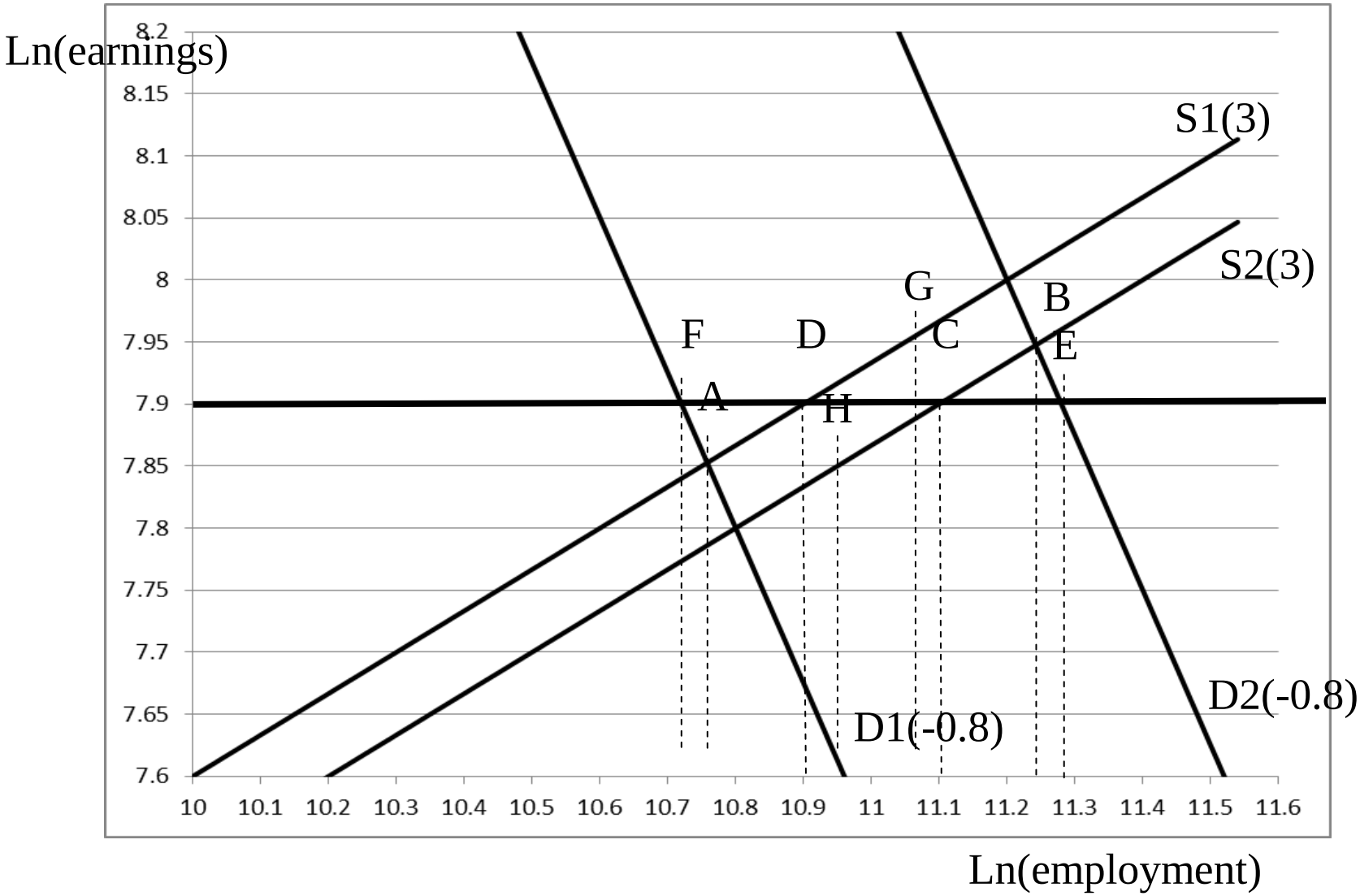
Notes. The changes in ln(earnings), ln(salaries), ln(employment) and ln(hours) are based on year fixed effects from reduced-form regressions of each separately as a function of industry fixed effects and the factors listed in the title of the table from 1941 through 1948. The counterfactuals are based on the same types of regressions for the period 1923 through 1929. The regressions were run on panels with annual data for nine industries in each time period.

Table 8
Goldin-Katz Estimates for Changes in Relative Female/Male Residual Demand and Supply for Salaried and Wage Workers

	Change in							
	ln(salary)	**ln(employ)**	**Supply**	**Demand When Elasticity of Substitution is**				
Salaried Workers, Salaries and Employment, 1941-1948				**0**	**1**	**2**	**3**	**4**
Actual Change	0.122	0.069	0.069	0.069	0.191	0.313	0.435	0.556
Counterfactual Change	-0.152	0.219	0.219	0.219	0.067	-0.086	-0.238	-0.391
Actual Change Minus Counterfactual Change	0.274	-0.150	-0.150	-0.150	0.124	0.399	0.673	0.947
Production Workers, Hourly Earnings and Total Hours, 1941-1948	**ln(earnings)**	**ln(hours)**	**Supply Change**	**Demand Change When Elasticity of Substitution is**				
Actual Change	0.094	0.255	0.255	0.255	0.349	0.444	0.538	0.633
Counterfactual Change	-0.163	0.053	0.053	0.053	-0.111	-0.274	-0.437	-0.601
Actual Change Minus Counterfactual Change	0.258	0.202	0.202	0.202	0.460	0.718	0.975	1.233

Figure 1
Measuring the Size of Demand and Supply Shifts in Different Ways and With Different Elasticities


Ln(earnings)
8.2
8.15
8.1
8.05
8
7.95
7.9
7.85
7.8
7.75
7.7
7.65
7.6
10
10.1
10.2
10.3
10.4
10.5
10.6
10.7
10.8
10.9
11
11.1
11.2
11.3
11.4
11.5
11.6
S2(3)
S1(3)
C
B
G
H
A
F
E
D1(-0.8)
D2(0)
D2(-0.8)
Ln(employment)


Ln(earnings)
8.2
8.15
8.1
8.05
8
7.95
7.9
7.85
7.8
7.75
7.7
7.65
7.6
10
10.1
10.2
10.3
10.4
10.5
10.6
10.7
10.8
10.9
11
11.1
11.2
11.3
11.4
11.5
11.6
S1(3)
S2(3)
D1(-0.8)
D2(-0.8)
A
B
C
D
E
F
G
H
Ln(employment)

Appendix 1
Mathematical Derivation of the Measures of the Demand Shifts and Supply Shifts.

The equations in the text used to measure the size of the demand and supply shifts can be derived from the log-linear labor demand and supply equations 1a and 1b respectively.

$$Ln(E) = a0 - a1\ ln(w) + a2\ ln(D). \quad 1a)$$

$$Ln(E) = b0 + b1\ ln(w) + b2\ ln(S). \quad 1b)$$

Where w is the wage, E is employment, D is a factor that shifts labor demand and S is a factor that shifts labor supply. The log-linear demands imply that the parameters a1, a2, b1, and b2 are all elasticities and they are all absolute values. For example, the labor demand elasticity of employment with respect to the wage is a1 and the negative sign in front of it implies a downward sloping short run demand for labor, while the positive sign in front of b1 implies an upward sloping supply of labor. If the demand shift factor D increases, the positive sign before a2 suggests that labor demand increases and raises earnings for every level of employment. The positive sign in front of b2 suggests that an increase in the supply shift factor S increases supply.

If we assume an equilibrium model in which the wage adjusts to equate the ln(E)s from the labor demand and supply functions, we can solve for ln(w) and ln(E) to obtain reduced form functions in which the two are functions of both the natural logs of both the labor demand shifter (D) and the labor supply shifter (S).

$$ln(w) = [(a0 - b0) + a2\ ln(D) - b2\ ln(S)]/ (b1+ a1) . \quad 2a)$$

$$Ln(E) = [b1a0 + a1b0 + a1\ b2\ ln(S) + b1\ a2\ ln(D)]/(a1+b1), \quad 2b)$$

Similarly, the ln(w*) and ln(E*) associated with a prior equilibrium can be written

$$ln(w^*) = [(a0 - b0) + a2\ ln(D^*) - b2\ ln(S^*)]/ (b1+ a1) . \quad 3a)$$

$$Ln(E^*) = [b1a0 + a1b0 + a1\ b2\ ln(S^*) + b1\ a2\ ln(D^*)]/(a1+b1), \quad 3b)$$

where the asterisks refer to the prior value.

After subtracting the equations with the prior values from the current year equations and multiplying both sides by (a1+b1), the equations become

$$(Ln(w) - ln(w^*))\ (a1+b1) = a2\ (ln(D) - ln(D^*)) - b2\ (ln(S) - ln(S^*) \quad 4a)$$
$$(Ln(E)- Ln(E^*)\ (a1+ b1) = a1\ b2\ (ln(S) - ln(S^*)) + b1\ a2\ (ln(D) - ln(D^*)) \quad 4b)$$

The amount that a factor shifts supply (SS) relative to the trend is the product of the change in the shifter and b2, its impact on the supply curve, such that

$$SS = b2\ [ln(S)-ln(S^*)]. \quad 5a)$$

Similarly, the amount that a factor shifts demand (DD) is the product of the change in the shifter and its impact on the demand curve (a2), such that

$$DD= a2\ [ln(D)-ln(D^*)]. \quad 5b)$$

After substituting DD and SS from equations 5a and 5b into equations 4a and 4b, and rearranging terms, the equations become.

$$[Ln(E)- Ln(E^*)]\ (a1+ b1) = a1\ SS + b1\ DD \quad 6a)$$
$$[Ln(w) - ln(w^*)]\ (a1+b1) = DD - SS \quad 6b)$$

Solve equations 6a and 6b for SS and DD to get equations that show the size of SS and DD as a function of the changes in employment and the wage.

$$SS = [Ln(E)- Ln(E^*)] - b1\ [Ln(w) - ln(w^*)] \quad 7a)$$
$$DD = [Ln(E)- Ln(E^*)] + a1\ [Ln(w) - ln(w^*)] \quad 7b)$$

When the model is constructed this way SS measures the change in log(employment) caused by the shift in supply *while holding the wage constant*, and DD measures the change in log(employment) caused by the shift in demand *while holding the wage constant*.[17] As in the discussion of the text, we are assuming a single elasticity for demand and supply. If there is the possibility that the elasticities might have changed, it would be important to calculate the estimates of the supply and demand shifts over a range of elasticities to establish potential bounds for the size of the shifts.

[17] If the equations 1 and 2 were set up with ln(w) on the left side and ln(E) on the right to match up with the way labor supply and demand are typically graphed, the parameters multiplied by ln(E) in both equations would be inverse elasticities, and SS and DD would measure the size of the differences caused by shifts in terms of the differences in log wages.

Appendix 2

Comparing Results for 1939 and 1949 Using Data from the Population Census and the Pennsylvania Industry Reports

In the text we focused on the data from the Pennsylvania Department of Internal Affairs for several reasons. First, we had annual data that allowed us to show the changes before, during, and after the War. Second, we wanted to use the year 1941 because that was the pre-War year between 1929 and 1942 that was the closest to the long run trend situation. Third, we could use the Internal Affairs data to develop a counterfactual based on business cycle peaks in the 1920s. Fourth, we could also develop the residual demand estimates by estimating regressions with several types of controls.

To check the robustness of the findings for Pennsylvania, we have also made the same calculations for Pennsylvania using data from the IPUMS one-percent samples from the 1940 and 1950 population censuses. To check comparability, we aggregated the Census data in a way that would match up with how the Pennsylvania Internal Affairs data were structured. The Census information covers two time periods. The wage and salary income and the number of weeks worked during the year refer to the years 1939 and 1949. The person's employment status, industry, and occupation and the number of hours worked the previous week refer to March 1940 and 1950. Thus, any variable that uses measures from both time frames will be somewhat mismatched with information for Pennsylvania. Since the March information was within 2 or 3 months of the end of 1939 and 1949 and the weeks worked and income data are for those years, the IPUMS data most closely measures the situation in 1939 and 1949.

The IPUMS used the reports of industry and occupations reported in each year to put people into broader industry and occupation classifications based on the 1950 structure. The industry listings matched well with our industry listings and thus we feel confident that both sources are reporting on the same group of workers in manufacturing. In the occupation listings we classified people listing occupations as clerks, managers, and professionals and technicians as salaried workers, while operatives, craft workers, and laborers were categorized as wage workers.

To obtain an average employment concept similar to what the Pennsylvania state department reported, we used the information on weeks worked per year. Essentially, average employment reported by Pennsylvania was based on the average number of workers on the payroll over the course of the year. Since people in the Census worked varying amounts of weeks during the year, we sought to take into account the probability that they would appear on the payroll in any month. Assuming that employment spells were continuous, we assumed that people who worked less than 4.333 weeks (52 weeks divided by 12 months) would have appeared on one payroll, those working between 4.333 and 8.667 weeks would have appeared on 2 payrolls, and those working more than 47.667 weeks appeared on all 12 monthly payrolls. We then aggregated the number based on the number of months each worked and divided by 12 to get the average number working on the payrolls.[18]

To calculate average annual earnings to match the way they were calculated in the Pennsylvania data we then used the census reports on wage and salary income to sum up the total earnings in each category of workers and then divided by the average employment. To be

[18] This became more complicated for 1949 because a large number of individuals did not report their weeks worked for the year. Using the sample of people who did report, we developed an estimate of what share of the workers would have been on 1 payroll, 2 payrolls, and up to 12 payrolls, and then scaled the total reported to reflect these differences.

included in the total and the average employment for this calculation people had to have reported positive earnings and hours for the year. In the wage worker male and female categories we calculated average hourly earnings for people who reported working positive hours and received positive incomes by dividing wage and salary income in 1939 by a measure of total hours worked that was calculated as weeks worked in 1939 times the number of hours worked in the previous week in March 1940. The same process was followed for 1949 using incomes and weeks worked from 1949 and the number of hours from March 1950.

The comparisons between the census and the state report information focus on the years 1939 to 1949. The year 1939 is quite different from 1941 and the post-war years. In 1939 real GDP per capita had just barely reached its 1929 level and was therefore well below trend predictions. The unemployment rate was 11.3 percent or 17.2 percent if people on emergency work relief are counted as unemployed. These compare with a real GDP per capita in 1941 that was on a long run growth trajectory from 1929 of over 2 percent per year and unemployment rates of 5.9 and 9.9. Thus the comparisons using 1939 and 1949 are comparing a still heavily damaged economy to the post-war setting. We prefer the comparison from 1941 just before mobilization and the post-war setting.

Appendix Table 2-1 shows the changes between 1939 and 1949 for salaried workers using data from the Population Census and the Pennsylvania state. For the wage workers the comparisons are made for 1939 to 1949 from the Census and for 1939 to 1948 for the Pennsylvania state data because data on hourly earnings are not available after 1948 from the NICB source. There were some large differences in the log point changes over the decade. The Census reports a much larger increase in average salaries for female salaried workers and virtually no changed in total hours worked for female production workers. Frankly, for

employment counts, we trust the Pennsylvania state reports more because there was no question about whether the firms were manufacturing firms or not, whereas the reporting of industry by individuals in the census allowed for much more error in assigning people to industries.

Despite the differences in reported ln(earnings) and ln(employment), both the Census and the Pennsylvania state data imply very large increases in the demand for manufacturing workers of all classifications between 1939 and 1949. These changes are substantially larger than for the periods starting in 1941 in the text because 1939 was still a Depression year and manufacturing demand for workers was still well below the 1929 level and even further below any long-term trend level.

Appendix Table 2-1

Comparisons of Changes in Demand and Supply using IPUMS Data and Pennsylvania Internal Affairs Data

	Changes In							
			Demand When Elasticity is			Supply When Elasticity is		
	ln(salary)	**ln(employ)**	**-0.3**	**-0.8**	**-1.5**	**1**	**3**	**5**
Female Salaried Workers								
Census Change from 1939 to 1949	0.717	0.840	0.72	**0.84**	1.01	0.40	**-0.09**	-0.70
PA State Change from 1939 to 1949	0.177	0.646	0.70	**0.79**	0.91	0.47	**0.11**	-0.33
Male Salaried Workers								
Census Change from 1939 to 1949	0.160	0.881	0.93	**1.01**	1.12	0.72	**0.40**	0.00
PA State Change from 1939 to 1949	0.177	0.430	0.48	**0.57**	0.70	0.25	**-0.10**	-0.55
Female Production Workers	ln(earnings)	ln(hours)						
Census Change from 1939 to 1949	0.319	-0.004	0.09	**0.25**	0.47	-0.32	**-0.96**	-1.76
PA State Change from 1939 to 1948	0.255	0.457	0.53	**0.66**	0.84	0.20	**-0.31**	-0.95
Male Production Workers								
Census Change from 1939 to 1949	0.269	0.336	0.42	**0.55**	0.74	0.07	**-0.47**	-1.14
PA State Change from 1939 to 1948	0.137	0.394	0.44	**0.50**	0.60	0.26	**-0.02**	-0.36

Notes. Census information refers to data from the Integrated Public Use Microdata One-Percent Samples from the U.S. Population Censuses of 1940 and 1950 (King, et. al., 2004). PA State data refers to data from the Pennsylvania Department of Internal Affairs (various years).

Additional information that we might or might not use.

The key finding is that the labor demand for female salaried workers and production workers rose substantially more than the counterfactual trend between 1941 and the late 1940s. Demand rose sharply during the War and fell back afterward, but the demand in the late 1940s was substantially above where it had been just before the war. Had the demand been perfectly inelastic, demand rose at least 0.149 log points for both types of workers. With more elastic assumptions, the demands for both types of workers rose at least 0.19 log points more than the counterfactual rise.

There were a number of potential causes of the change. We can rule out the possibility that it was more costly to hire male workers in each category. Between 1941 and 1950 Table 3 shows that real salaries for male workers rose by only 3 percent and real hourly earnings for male production workers did not rise at all between 1941 and 1950. Relative to the counterfactual the male earnings fell by more than 9 percent. Another possibility was the change in labor productivity as measured by the value of product per worker. Between 1941 and 1950 it rose 1.5 percent per year compared to declines of -0.5 percent per year between 1923 and 1929. It could be that the rise in productivity was tilted more toward women.

Another possibility is that the skill levels of the women were higher after their experience during the War. Even though many left the workforce, Goldin (1991) shows that about 20 percent of the women working in 1950 had entered the workforce during the war. But the demand side estimates Comparisons of the 1950 to the 1940 Census workers in manufacturing in production occupations show that female production workers in 1950 were on average 3.5 years older than they had been in 1950, and had an average of 0.6 years more of completed schooling. They were 28.1 percent less likely to be married and thus not to have obligations

to a spouse. The differences for female salaried workers were much smaller, however, at 0.35 more years of schooling, 0.1 years older, and they were 13.7 percent more likely to be married.

The estimates of labor supply seem consistent with Claudia Goldin's findings of relative small shifts in labor supply. that labor supply expanded for female salaried workers by 0.12 relative to the counterfactual. The estimates for female production workers relative to the counterfactual are less certain but relative small, which is consistent with the analyses of Goldin (1996).