Gender Divisions of Labor and Structural Transformation: Industrializing Japan

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PRELIMINARY DRAFT DO NOT CITE

Abstract

Gender differences in labor opportunities can accentuate urban-rural wage gaps if laborers are married and must co-move. We study the effects of a silk boom which increased demand for silk cocoons, predominantly produced by women in farms, on migration in Japan, 1910-1920. We use large variation in silk cocoon prices, due to its perishability, and an IV approach to show areas with higher prices experienced lower migration among men and women. Men's wages declined in high price areas but they remained to maximize household incomes. These findings show that gender divisions of labor can slow down industrialization.

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Industrialization occurs within contexts of vast gender differences in economic opportunities (Duflo, 2012; Jayachandran, 2015; Goldin, 2021). Women tend to have less education and are limited from joining some occupations in addition to facing gender pay gaps. Thus, there is a gender aspect to the urban-rural differences in wages and productivity (Gollin et al., 2014; Herrendorf and Schoellman, 2018; Alvarez, 2020; Lagakos et al., 2020; Hamory et al., 2021). Further, each gender's migration problem are not independent problems within many developing societies where most people are tied by marriage from early ages. Thus, one member of the family may decide to not move to a high wage job in order to maximize family incomes, creating a wage gap. Can this partially explain the existence of wage gaps in developing countries?

This paper studies the effects of a silk boom, that primarily benefited women, on urban-rural migration in industrializing Japan. The silk boom, 1916-1919, was an exogenous shock that occurred due to the First World War destroying European silk production. The shock resulted in a 20% increase in silk prices and a 100% increase in the real value of silk cocoon production. It benefited Japanese silk cocoon farmers who were primarily women due to the low needs for physical strength. While silk cocoons could be produced anywhere within Japan, the benefits were spread unevenly due to the segmentation of the silk cocoon market. Silk cocoons were highly perishable so had to be sold to a local silk reeling factory within a couple of weeks (Arimoto et al., 2014). As a consequence, local prices varied by as much as 40% depending on local competition among silk reeling factories. We exploit this geographic variation using data on factories from the silk reeling factory survey to identify the effects of the silk boom on migration.

Using data from the 1920 census, we create a proxy for migration, the share of men/women of age 15-25 per household. This measure uses the fact that the number of rural households were highly stable due to an institution that emphasized the inheritance of households by sons (Hayashi and Prescott, 2008). We regress this on our measure of competition, the Herfindahl-Hirschman Index (HHI) of silk demand within 20km of the centroid of the village. To avoid the endogeneity of silk reeling factory location, we use an instrumental variable approach that measures the viability of using water power in any village. This is correlated with factory location because many used water power at the time. The location of rivers with the correct slopes to generate hydro energy are exogenous features and unlikely to be correlated with the error term.

Our main results show causal evidence that the incomes of women affected male migration. We show significantly more young women remained in rural villages with high levels of competition in the silk cocoon market. This is due to the high marginal value product of their time relative to areas where silk cocoon sold for less. More surprisingly, there were also significantly more young men in these villages despite their low contribution to silk cocoon production. The large magnitude shows this was not simply to substitute for the lost female labor in non-silk farm work. Instead, they seem to have remained for their wives or for better prospects in the marriage market relative to cities which were male biased.

Further, we conduct a falsification test by looking at the effect of silk cocoon market competition on the number of children age 6-14 per household. This population should not be affected because they are too young to be workers who respond to economic incentives. Consistently, we find no significant effect for this age group. This allays concerns that these villages had a fundamentally different population distribution.

Finally, we also examine the effect of the silk boom on wages in the labor market. We find that male wages declined by 36% in areas that benefited from the silk boom. This shows men remained in silk producing regions despite lower wages. They decided to forgo higher individual wages to maximize household incomes. The surprisingly large magnitude can be explained by the high profitability of silk cocoon production. These households typically owned the capital and there were large profits after accounting for the (implicit) wages of female labor. These additional findings show many male laborers remained in rural Japan with relatively low marginal products. Had some of these men moved to factories, factory wages would have declined and industrialization could have accelerated.

Our paper contributes to the literature on the efficiency of labor allocation during early stages of development. While there is some debate on the extent of the urban-rural wage gap due to the difficulties of controlling for selection (Young, 2013; Lagakos and Waugh, 2013), a number of papers show evidence for a real wage gap based on controls for human capital or fixed effects (Beegle et al., 2011; Alvarez, 2020; Lagakos et al., 2020; Hamory et al., 2021). There is also causal experimental evidence showing positive effects at least in the case of seasonal migration (Bryan et al., 2014) although some other evidence points the other way (Nakamura et al., 2022). There is also some evidence from the industrializing Western economies that show urban-rural wage gaps were small but present among these early successes (Williamson, 1987; Hatton and Williamson, 1991, 1992; Lundh and Prado, 2015). We contribute to this literature by adding a gender aspect to the debate on urban-rural wage gaps which has not received focus within the past literature. Our results suggest that larger gender differences tend to create greater inefficiencies.

We also contribute to a literature trying to understand why people are not moving to opportunity. These first relate to the benefits of remaining in farming such as the asset incomes from land (Abramitzky et al., 2013; Fernando, 2022; Boberg-Fazlić et al., 2022), the lack of formal landownership rights which makes abandoning lands costly (Chernina et al., 2014; Valsecchi, 2014; De Janvry et al., 2015), the difficulty to transfer skills (Bazzi et al., 2016), and networks that mitigate risk (Munshi and Rosenzweig, 2016). A second set of explanations focus on the costs of migration including the high costs of failed migration for people in poverty (Bryan et al., 2014), information frictions (Aker et al., 2011; Farré and Fasani, 2013; Baseler, 2023), liquidity constraints (Cai, 2020) and migration costs (Bryan and Morten, 2019). Our paper contributes to this literature via a new mechanism that emphasizes women's contribution to households. This is highly relevant to the context of many developing countries where marriage rates are high, marriage ages are low, and women's opportunities in urban areas are limited to varying degrees. A consequence is a slower industrialization due to lower labor supply in cities.

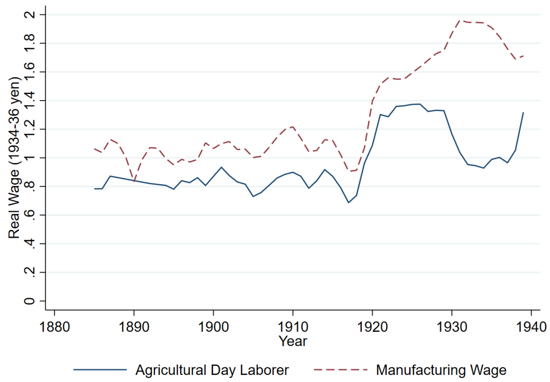
Background

The Urban Rural Wage Gap

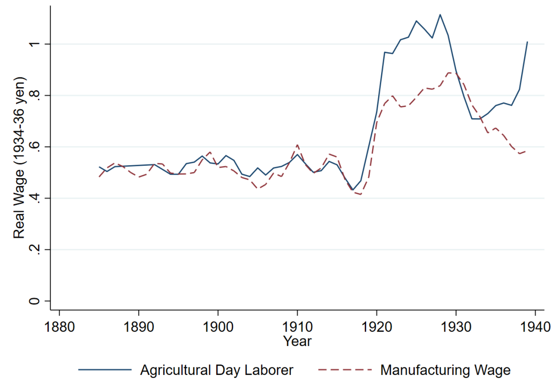
The urban rural wage gap is a measurement of the efficiency of labor allocation. If real wages in both urban and rural areas are equalized, labor is being allocated where it has the highest marginal product. While this cannot be taken at face value due to issues such as human capital or selection, this measure remains an informative indicator of the efficiency of the labor market. How efficient was Japanese labor allocation as it industrialized?

We construct a measure of the urban rural wage gap using data from the long-term economic statistics database.[1] We compare the aggregated manufacturing wage to the agricultural day wage. We turn this into real wages using the GDP deflator. However, we partially account for the lower cost of food in rural Japan by assuming

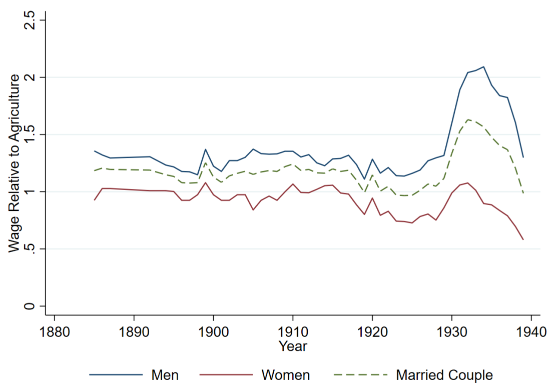
[1] This database is available online at The Research Centre for Information and Statistics of Social Science, Hitotsubashi University



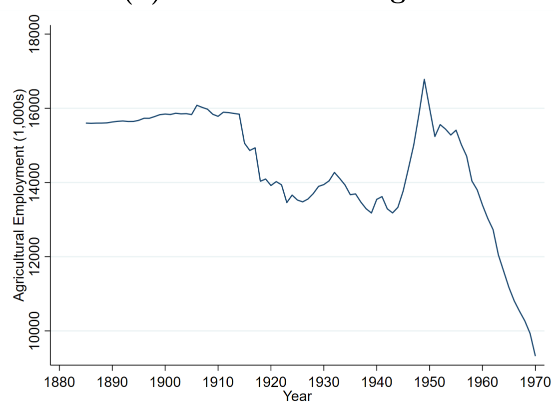
(a) Male Real Wages



(b) Female Real Wages



(c) Urban Wage Premium



(d) Agricultural Employment

Figure 1: Urban rural Wage Gaps and Employment

Source: Long-Term Economic Statistics (LTES) Database made available online by The Research Centre for Information and Statistics of Social Science, Hitotsubashi University

food was 15% cheaper in the countryside and that food was 50% of consumption as stated in the long-term economic statistics.

Despite rapid industrialization, the urban rural wage gap was surprisingly stable up to 1920 (see figure 1a and 1b). Despite the First World War causing a fall in the agricultural labor force (see figure 1d), due to people leaving for factory work, the wage premium was stable at 25%. The wage premium changed little up to 1930 but the wages themselves rose in 1920. The wage premium jumped up in the 1930s but this was due to the great depression that led to high unemployment in cities.

Combined with sticky nominal wages, the wage premium increased, much like in other high income countries at the time (Hatton and Williamson, 1991; Lundh and Prado, 2015).

In comparison, a surprising story emerges for women. Women's wages were similar or higher in rural areas. Considering migration costs, the vast majority of women would have found it more profitable to remain in rural areas. This incentive became even stronger in the 1920s, partially due to the continuing high price and volume of silk production. In a society where almost all men and women married, at the average age of 25 and 21 respectively (Atō, 1991), there was a clear problem due to the need to co-move.

This gender aspect of the wage gap has received little attention in the literature but clearly played a large role in labor distribution. Why did gender matter so much? Part of the wage gap can be explained by differences in physical attributes (Burnette, 1997). However, there was also gender discrimination. This resulted in women's participation in some occupations being limited, a feature common to pre-industrial times (Whittle and Hailwood, 2020). Simultaneously, there was also a large gender wage gap within occupations that suggests discrimination.[2] Although more empirical work needs to be done for Japan, it is clear from other early industrializing countries that wage gaps seem to emerge by the industrialization phase (Goldin, 2014, 2021).

However, there is also some evidence that gender discrimination did not exist or was much weaker in agriculture (Burnette, 1997; Whittle and Hailwood, 2020; Kumon and Sakai, 2022). This gave women greater opportunities and higher wages in this sector. As a consequence, this may be have also led women's agricultural wages to be high relative to manufacturing wages.

[2]See long-term economic statistics for wages.

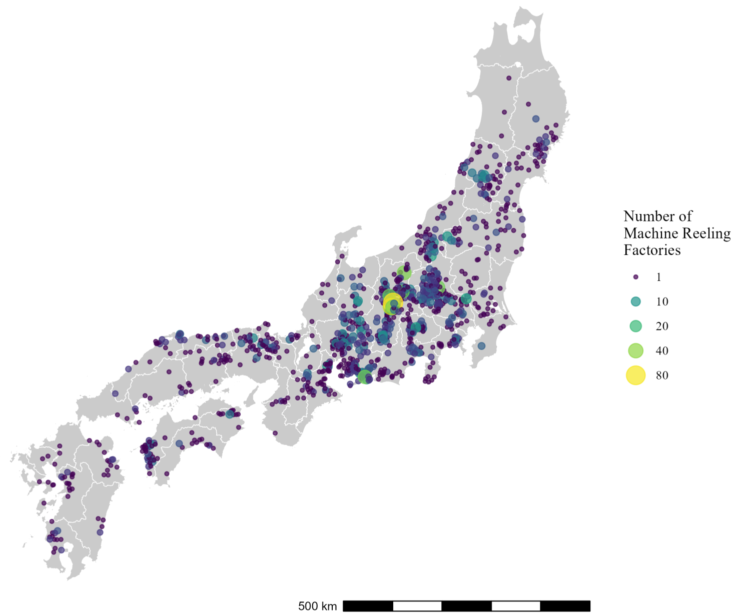
The Market Structure of Silk Cocoons

Women clearly benefited from remaining in agriculture due to the silk boom. The production of silk cocoons was possible throughout the Japanese archipelago. However, the actual production of silk cocoons was highly regionally clustered due to the nature of silk cocoon markets. Therefore, not all women benefited equally.

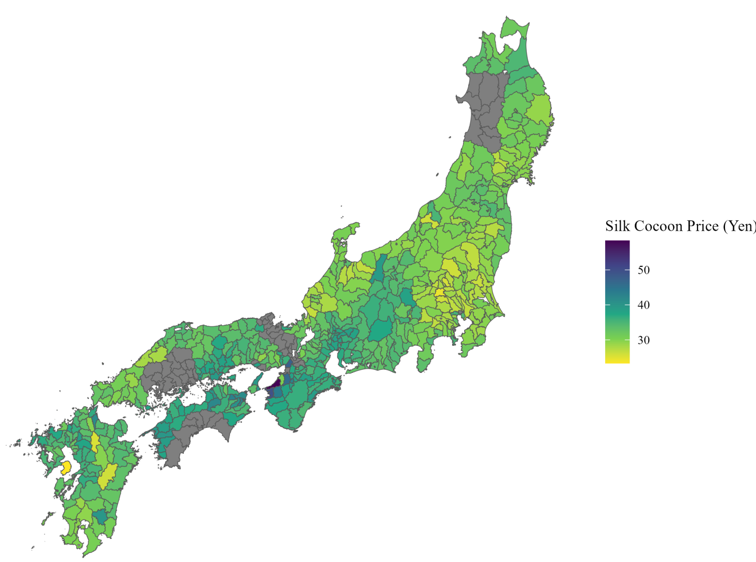
The main constraint among silk cocoons producers was that silk cocoons were perishable. They had to be quickly transported to buyers who could dry and store them appropriately. Otherwise, the quality of silk declined until the partial destruction of silk threads upon metamorphosis which occurs after two weeks.

These conditions resulted in two distinct features of the silk cocoon market relative to standard goods. First, producers had to be able to find a buyer within close proximity to their farms. Silk production therefore closely mirrored the locations of silk-reeling factories. Second, this also meant silk markets were highly localized. Further, the equilibrium price depended upon local competition among silk-reeling factories. Competition could be fierce due to the co-location of multiple factories resulting in high silk cocoon prices that was advantageous for farmers. In other locations there were monopolies resulting in very low prices. This incentivized few farmers to make silk cocoons.

We can verify this by comparing the location of machine reeling factories and silk cocoon prices by counties in 1915. We collected prices from the prefectural statistical yearbooks compute prices by dividing the value of silk cocoons produced by quantities. These are not direct observations of prices so there is some clear measurement error in particular among counties with low silk-cocoon output. We therefore do not use these prices in later analyses although they remain valid if we look at broader regional patterns. We note that some prefectural yearbooks did not collect the same data



(a) Number of Machine-reeling Factories by Municipality



(b) Silk Cocoon Prices

Figure 2: The Silk Market in 1915

Source: Prefectural Statistical Yearbooks, *Zenkoku Seishi Kojo Chosa*

Table 1: Silk Prices and Local Competition

	Dependent Variable: ln(Silk Price)		
	(1)	(2)	(3)
ln(#Factories)	0.016**		
	(0.007)		
ln(#Machine reeling factories)		0.013*	
		(0.007)	
HHI of silk cocoon input			-0.042**
			(0.019)
Observations	364	364	364
R^2	0.022	0.015	0.017

Standard errors are clustered by prefectures and are in parentheses.
$*p < 0.10, **p < 0.05, ***p < 0.01$.

leading to missing observations. We have also collected data on all factory locations and their inputs/outputs from the national survey of silk reeling factories (*Zenkoku Seishi Kojo Chosa*).

The resulting maps in figure 2 shows the silk reeling industry had a number of major clusters with the most notable being in central Japan. The areas without clusters had prices around 28 yen while those with clusters had prices around 37 yen, a very large difference.[3]

We can also verify this using a simple OLS regression of market concentration measures on prices. To do this, we first drop prices from counties within the lowest quartile of production due to the existence of many outliers. This is due to how officials collected the data, most likely be recall. The smaller the sample of farmers, the greater the potential measurement error.

We then regress the price on three measures of competition: the total number of factories, the total number of machine reeling factories, and the Herfindahl-Hirschman

[3]Taking prices from counties that produced non-trivial amounts of silk cocoons (the top three quartiles) and the data is more reliable, the mean price was 32.5 yen with a standard deviation of 3.5 yen. The 1st decile was 28 yen while the 9th decile was 37 yen.

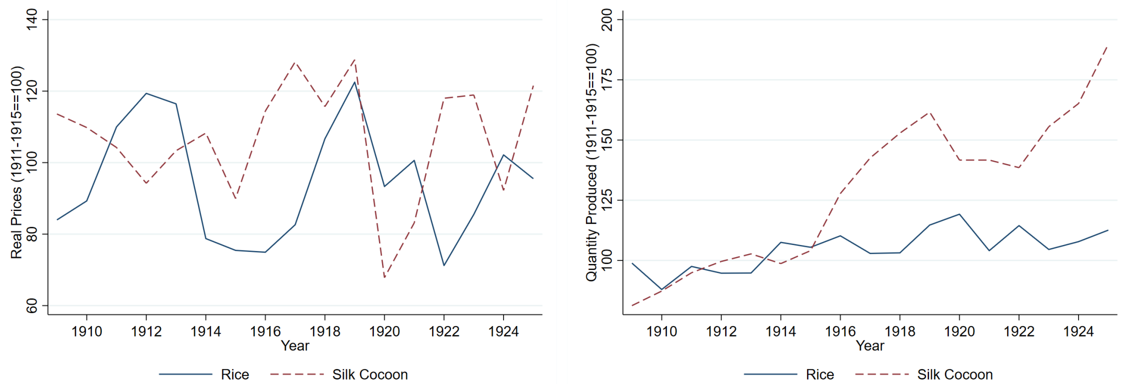
index (HHI) of the silk cocoon input used in each county. The total number of machine reeling factories is relevant because these were the most advanced factories that consumed the largest amount of silk cocoons.

The resulting table 1 shows the predicted relationship. More factories raised competition and raised local prices. With regards to the HHI, it ranges from zero to one where a zero indicates perfect competition and one indicates monopsony. Therefore a negative relationship is consistent with our hypothesis. Competition affected prices at the local level. It was in the areas with clusters that silk prices were highest.

These silk prices translated into higher marginal value products of women's labor. This was because silk farming was primarily conducted by women due to the minimal amounts of strength required. The main task was to feed mulberry leaves every few hours to silkworms throughout the day and night. This can be confirmed from time use reports in the agricultural household surveys (*nouka keizai chōsa*) that show women did around 59% of the hours in silk cocoon production whereas they only did 37% of the hours in other farm work. Overall, if there was a shock that increased silk prices, it affected women's (implicit) wages in regions that had high compeitition in the silk cocoon market.

Empirical Strategy

We study the effect of the silk boom of 1916-1919. The price shock was caused by the First World War, an unpredictable event, that greatly reduced silk cocoon production, an input in silk, within Europe. Therefore, despite decreased silk demand from Europe, prices still rose due to demand from other regions of the world. Importantly, silk was largely exported so the increased silk cocoon price was not due to endogenous changes in the local economy.



(a) Real Silk Cocoon Price **(b) Silk Quantity Produced**

Figure 3: The Silk Boom of 1916-1919

Source: The long term economic statistics database

Figure 3a shows that *average* prices increased by around 20% relative to the levels in 1911-15. As noted earlier, local prices differed widely such that the shock may have been amplified further in regions with high competition in silk-reeling. Prices increased despite a very large increase in silk cocoon supply which was 61% higher by 1919 relative to the pre-shock average. In contrast, rice, which was the most important agricultural good, showed fluctuating prices as was common in grain markets. There was no clear contemporaneous shock for rice and limited changes in quantity produced due to lack of excess lands. Thus, the main shock faced by rural Japan at this time was the silk cocoon shock.

We exploit the local variation in the strength of this shock to study its causal effect on migration patterns. As stated earlier, the silk cocoon market was highly fragmented due to its perishibility. Prices depended on local competition among buyers. We measure local competition using data on factories from the national silk reeling factory survey (*Zenkoku Seishi Kojo Chosa*). This source includes the exact location of factories in addition to data on inputs that allow us to construct various measures of competition. We focus on our preferred measure, the HHI of silk cocoon inputs by factory. The values range from zero to one with zero implying perfect competition and one implying monopsony. We also show results are similar when using other measures in appendix A.

Our specification of interest is below.

$$Y_{m,p} = \alpha_p + \beta Market\,power_m + \gamma X_m + \epsilon_{m,p} \tag{1}$$

Our dependent variable are various measures of migration. The market power measure takes the HHI of silk cocoon inputs among factories that are within a 20km radius of the municipality centroid. As this is straight line distance, the actual walking distance is likely closer to 30km which is one day's walking distance. Due to the arbitrary number, we experimented with 10km and 30km radius and found similar results (see appendix A). As controls, we have the share of workers in agriculture in the 1920 census to account for differences in functionality of these villages. We also absorb prefecture fixed effects to account for regional differences in migration patterns. To avoid the obvious issue that men/women may have remained in municipalities that had silk reeling factories, we drop all municipalities which had such factories. We also drop all towns and cities (*chō* and *shi*) to limit our analysis to rural villages.

We use data from the Japanese census (*kokusei chōsa*) of 1920 to construct our proxy for migration. We use the number of people per household, by gender, who are between age 15-24. This age group includes the youngest workers who were most likely to migrate. One immediate concern is that the number of households is endogenous to migration. However, the number of household in prewar Japan was highly stable due to an institution that emphasized the inheritance of households by sons (Hayashi and Prescott, 2008). We can also confirm that household numbers were stable using data from Ohkawa et al. (1983). The number of agricultural households by prefecture changed from 1915-1920 by an average of 0% with a standard deviation of 2.7% despite a 12% decline in the agricultural labor force (Umemura, 1979).

Another concern is that factory location is not exogenous. Factories may have located in areas with greater supply of young female laborers who typically worked the lines. Therefore, we use an instrument variable identification strategy. Our instrument is the geographic availability of water power, one of the main sources of power within factories at the time. Thus, our identification relies on plausibly exogenous geographic features that determined the location of factories.

Specifically, we map all municipalities in 1920 using shapefiles from the *kokudo sūchi jyōhō* website operated by the Ministry of Land, Infrastructure, Transport and Tourism. We interact this with river data from the HydroRIVERS database and elevation raster data from the ASTER Global Digital Elevation Model that has rasters of approximately 30 m^2.[4] We focus on the length of river with a flow of more than 1 m^3/s and a gradient of more than 4 degrees (Duflo and Pande, 2007; Borge et al., 2015; Karadakic, 2022). These attributes are amenable for generating water power. We also account for differences in water flow class with greater water flow increasing water potential. Our instrument is constructed as follows.

$$hydro\,potential_m = \sum_i river\ length_{i,m} \times water\ flow_i \tag{2}$$

Where m denotes municipality and i denotes each individual river. The river length is the length of river with water flow class i that is greater than 4 degrees. The water flow variable is grouped in the dataset as logarithmic size classes.[5] We use the logs of (1 + hydro potential) as we do not believe in a linear effect among municipalities

[4]The ASTER global digital elevation model is available online at https://science.nasa.gov/. The HydroRIVERS database is available online at https://www.hydrosheds.org/.

[5]Within Japan there are rivers of 1-10 m^3, 10-100 m^3, and 100-1000 m^3. The water flow varible takes values 1, 10, and 100 respectively for each of these classes.

Table 2: IV First Stage

			Within 20km of Municipality	
	(1)	(2)	(3)	(4)
	ln(#Plants)	HHI	ln(#Plants)	HHI
ln(hydro potential)	0.006***	-0.002***		
	(0.002)	(0.001)		
ln(hydro. potential within 20km)			0.051**	-0.054***
			(0.021)	(0.011)
Prefecture FE	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes
Other Controls	No	No	Yes	Yes
Clusters (Prefectures)	45	45	45	45
Observations	7642	7642	8870	8870
R^2	0.099	0.072	0.398	0.466
F-statistic	6.8	5.4	2.7	8.9

Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality. Urban municipalities and those with silk reeling factories have been dropped.

with very high hydro potential.

Results

We begin by showing the validity of our instrument in table 2. We first show a simple OLS of the log number of plants in a municipality with the constructed measure of hydro potential and a prefecture fixed effect. We find a very strong positive correlation between factory location and hydro potential within each municipality. When we aggregate the hydro potential in a 20km radius around each municipalities, we find the expected correlations. As the water potential around a municipality increases, the HHI decreases (or competition increases). Therefore the geographic features surrounding each municipality partially determined local market competition in the silk cocoon market, and therefore the price of silk cocoons.

We next estimate the effect of local market competition in the silk cocoon market

Table 3: Census HHI: distance 20km

	Pop. Age 15-24/Total Households			
	(1)	(2)	(3)	(4)
	Male OLS	Male IV	Female OLS	Female IV
HHI of Silk Cocoon Demand	-0.010	-0.184***	-0.011	-0.155***
	(0.011)	(0.057)	(0.008)	(0.051)
Controls?	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Clusters (Prefectures)	45	45	45	45
Observations	8073	8073	8075	8075
Mean Dep. Var.	0.393	0.393	0.408	0.408
Kleibergen-Paap F		22.17		22.17

$*p < 0.10, **p < 0.05, ***p < 0.01$. Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality.

on our proxy for migration by gender, the number of people aged 15-24 per household (see table 3). Our OLS specification find a negative effect among both men and women but there is a very weak statistical significance. However, this may be due to endogeneity in the areas in which silk reeling plants located. When we use our IV specification, the effect becomes larger and significant. Importantly, the prefectural fixed effect should be absorbing differences in family types across broad geographic region within Japan.

As hypothesized, the co-location problem seems to have incentivized young men to remain in rural areas that benefited from silk production. This may have not been limited to already married couples but also those who are searching for or were promised brides. This led to a wage gap because men had higher earning potential in cities. GDP would have grown faster had these men moved to regions where their marginal product of labor was maximized. However, it was rational to remain in rural villages when they maximized family income.

The magnitudes can be interpreted by comparing it to the mean of the dependent variable which is around 0.4 for both men and women. If competition went from monopsony to perfect competition, these regions had about 56% more young men and 41% more young women per household. While we only have a snapshot here, many of these laborers would have lost their opportunity to migrate to the cities since the benefits of migration declined with age.

We also conduct a falsification test to see whether people of an age group preceding migration age, at age 6-14, responded to the silk boom. We test this in specification (1) and (2) in table 4 and find insignificant coefficients that are close to zero. While the standard errors are not as tight as one would like, the coefficients themselves are tiny compared to the mean of the dependent variable. These results show that municipalities close to multiple silk-reeling factories were similar to their peers until cohorts reached working age.

We further estimate the same regression for the most disaggregated age groups of interest. Interestingly, the magnitude of effect among men is larger among those aged 20-24. This may be because these men are more likely to be married or in active search of partners. We also find that people of age 25+ also had less tendency to migrate in areas with high silk cocoon demand. This is not surprising because people at higher ages also migrated. However, the magnitude relative to the mean of the dependent variable is much lower showing the lower tendency to migrate relative to the young.[6]

Robustness

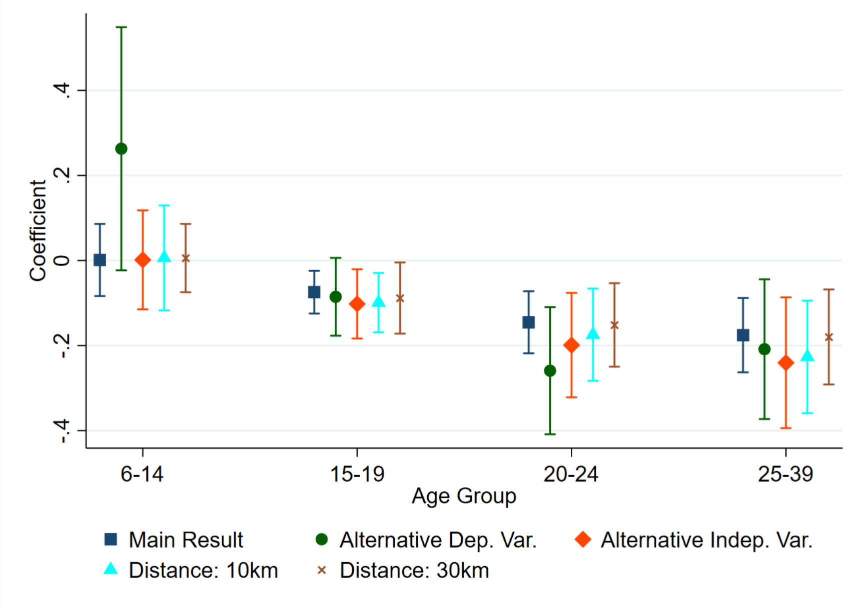
There are a number of concerns with our specification that we address. For ease of comparision, we graphically show the results in figure 4. While the coefficients look much larger for age 25+, we remind the reader that the coefficients are much smaller

[6] The age groups are not identical among men and women because they were tabulated differently.

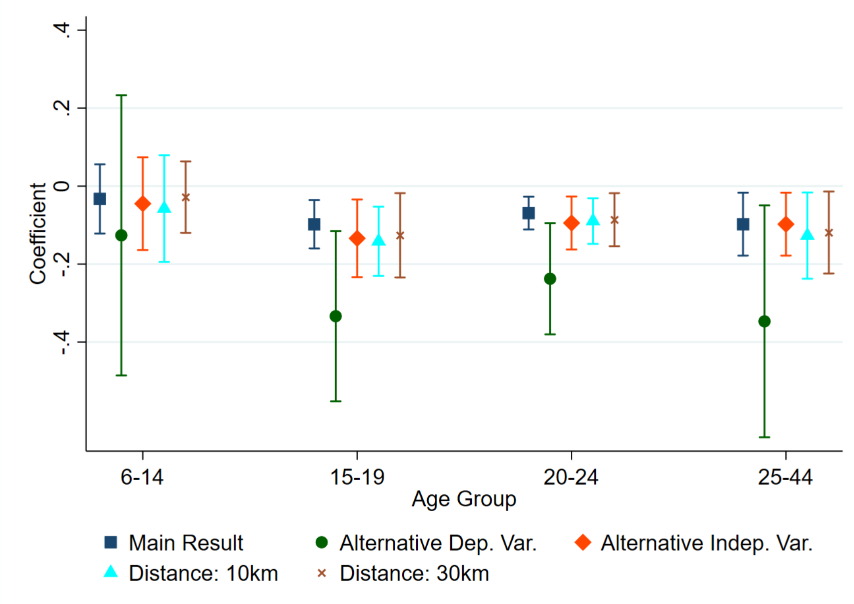
Table 4: Census HHI Other Ages

	Age 6-14		Age 15-19		Age 20-24		Age 25-39	Age 25-44
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Male IV	Female IV	Male IV	Female IV	Male IV	Female IV	Male IV	Female IV
HHI	0.018	-0.017	-0.055**	-0.089***	-0.129***	-0.066***	-0.165***	-0.095**
	(0.038)	(0.039)	(0.025)	(0.031)	(0.039)	(0.022)	(0.050)	(0.040)
Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clusters (Prefectures)	45	45	45	45	45	45	45	45
Observations	8073	8073	8075	8075	8073	8075	8075	8075
Mean Dep. Var.	0.560	0.541	0.222	0.220	0.172	0.188	0.460	0.624
Kleibergen-Paap F	22.17	22.18	22.17	22.17	22.17	22.17	22.17	22.17

$*p < 0.10, **p < 0.05, ***p < 0.01$. The dependent variable is the number of people at various age groups (listed at the top of the column) by gender per household. Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality. Urban municipalities and those with silk reeling factories have been dropped.



(a) Men



(b) Women

Figure 4: Coefficients for Alternative Specifications

relative to the average of the dependent variable as seen in table 4. We address three major concerns.

First, the dependent variable includes the number of households. While the evidence suggests household numbers changed little due to institutions (Hayashi and Prescott, 2008), there can be some concern of the endogeneity in what little variation remained. We therefore tested out an alternative dependent variable that takes the population aged 25-59 of each gender as the denominator. We find similar results for women and men. The exception is the coefficient for men in the age group 6-14. However, the coefficient is higher which makes it more surprising that other age groups have lower numbers of people relative to age 25-59. Therefore, this does not undermine our results.

Second, we take an alternative independent variable as the HHI of the capital of machine-reeling factories as the measure of competition. Specifically, this is the number of pots used to process silk cocoon. This can be considered as a measure of capacity of factories. This is arguably a better measure of competition than silk cocoon inputs that are a result of bargaining and competition. We find no large change in results relative to our preferred specification.

Third, there is a concern that the distance parameter in which we measure local silk cocoon demand is arbitrary. We therefore tested whether the coefficients are significantly different if we change the distance parameter to either 10km or 30km. Both cases yield very similar results to that using a distance parameter of 20km.

The Silk Boom and Rural Wages

While our analysis of rural migration patterns are consistent with our hypothesis, one can raise alternative stories that explain these patterns. For example, men may have remained in rural areas to substitute for female labor that was lost to sericulture. We therefore examine a second prediction that men's wages declined in areas that were affected by the silk boom due to an oversupply of male labor. If true, this will show men remained in rural areas despite having greater opportunities elsewhere.

We collect data on day wages of agricultural laborers from prefectural statistical yearbooks in the years 1910-1920. The quantity of data that was collected varied by prefecture but was usually composed of wages by gender from a few locations within a prefecture. We use all observations from rural counties which is our area of concern (*gun*).[7] One issue with the data is that most prefectural yearbooks do not specify whether laborers received in-kind payments. In-kind payments were generally very common and an important component of the wage. Thus, many of the reported wages are lower than the true value were we to account for in-kind payments. We can control for this using fixed effects for each county. However, this affects the interpretation of magnitudes of the effect which we discuss below.

Our specification is a two way fixed effect regression with a pre and post period as follows.

$$ln(Wage_{c,t}) = \alpha_c + \gamma_t + \beta HHI_c \times post\ 1916_t + \delta_p post\ 1916_t + epsilon_{c,t} \qquad (3)$$

Our main coefficient of interest is β which captures how prefectures with differing levels of HHI experienced differential changes in wages as a result of the silk boom. Much like our previous regression, our HHI measure will include factories just beyond the border of the county. This accounts for how silk cocoons were often sold to factories outside the counties since these borders were purely administrative. To do this, we take a 10km buffer beyond each county's border. This is close in spirit to

[7]For the very few counties with multiple observations, we take the average day wage of agricultural laborers.

Table 5: The Effect of the Silk Boom on Wages

	ln(Agricultural Day Wage)			
	(1)	(2)	(3)	(4)
	Male OLS	Male IV	Female OLS	Female IV
Post 1916 × HHI	0.054	0.432**	0.072	0.216
	(0.072)	(0.217)	(0.056)	(0.224)
Controls?	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes
County FE?	Yes	Yes	Yes	Yes
Clusters (Counties)	158	148	158	148
Observations	1132	1122	1132	1122
F-statistic		13.344		13.823

$*p < 0.10, **p < 0.05, ***p < 0.01$. The dependent variable is the natural log of the agricultural day wage. Standard errors are clustered at the county level.

the 20km radius of municipality centroids that we used earlier because counties had median radius of 10.8km. The results are not sensitive to using a slightly higher buffer.

We control for county and year fixed effects as is standard in the literature. We additionally include prefectural fixed effect in the post period. This will address the major concern that the First World War had a large contemporaneous effect that may have differed by region. As previously, we use an IV specification to account for the non-random placement of factories.

For our preferred IV specification, we find male agricultural day wages increased in areas that did not benefit from the silk boom (high HHI) relative to the areas that did benefit. In contrast, we find a positive but insignificant effect among women. This suggests an oversupply of male labor in areas where women benefited from the silk-boom. This is consistent with our earlier finding of fewer out-migration among men in areas benefiting from the silk boom. It shows that men in these regions did not benefit from the silk boom but remained regardless.

The magnitude is large suggesting a 54% increase in male wages in areas that benefited little from the silk boom. However, this figure cannot be taken at face value because most of these laborers would have also received in-kind payments of food while working. Fortunately, some prefectural statistics report the monetary value of in-kind payments in addition to the monetary wage. They show the in-kind payment was worth around 50% of the monetary wage.[8] Assuming most of the agricultural laborers received in-kind payments, as seems likely, the magnitude would be closer to a 36% increase in wages inclusive of in-kind payments. This shows men were willing to earn substantially lower wages in exchange for higher household incomes due to the silk boom.

This seems puzzling at first because women's wages do not seem to have increase in counties with the silk boom. However, a substantial proportion of the income would have been in the form of profits rather wages. These silk cocoon farmers mostly owned their own capital and produced silk cocoons within the household. Therefore, household incomes increased despite a decrease in men's wages and stable women's wage. This is akin to the finding that other asset incomes such as landownership also reduced out-migration (Abramitzky et al., 2013; Fernando, 2022; Boberg-Fazlić et al., 2022). Overall, these lower male wages in silk producing regions signal the inefficiency of the allocation of male labor. This also rationalizes part of why the urban-rural wage gap never fully closed in Japan despite the rapid onset of industrialization.

Conclusion

This paper showed that a silk price shock in prewar Japan increased female incomes in rural Japan but this reduced migration out of the countryside. The surpris-

[8] We use the average from the 1917 Miyagi Prefectural Statistics.

ing finding is that not only women remained in agriculture but men also remained within these villages. This does not seem to be because men also had greater opportunities. It was men who reached typical marriage ages, between age 20-24 who were more likely to remain in these villages. Further, evidence from male farm wages indicate men in these regions experienced a decrease in wages relative to other regions as a result of the shock. Therefore, the evidence points towards two body problems whereby couples had to co-move based on the income of households.

These findings have implications for labor allocation during structural transformations. Countries with higher marriage rates and earlier ages at marriage will have more couples with co-movement problems. This problem may have been less severe in Western Europe during its industrialization which had low marriage rates and late ages at marriage. Second, countries with greater gender discrimination or gender divisions of labor will face greater co-movement problems. Third, price shocks in commodities such as the silk boom in Japan are not purely beneficial for economies as has been portrayed in the historical literature. One of the costs was greater difficulty in hiring low wage workers in factories and slower industrialization.

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Appendices

A Additional Estimates

A.1 Alternative Distances

Table A1: Census HHI: distance 10km

	Pop. Age 15-24/Total Households			
	(1)	(2)	(3)	(4)
	Male OLS	Male IV	Female OLS	Female IV
HHI of Silk Cocoon Demand	-0.007	-0.214***	-0.010	-0.206***
	(0.011)	(0.070)	(0.010)	(0.063)
Controls?	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Clusters (Prefectures)	45	45	45	45
Observations	8073	8073	8075	8075
Mean Dep. Var.	0.393	0.393	0.408	0.408
Kleibergen-Paap F		26.78		26.78

$*p < 0.10, **p < 0.05, ***p < 0.01$. Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality.

Table A2: Census HHI: distance 30km

	Pop. Age 15-24/Total Households			
	(1)	(2)	(3)	(4)
	Male OLS	Male IV	Female OLS	Female IV
HHI of Silk Cocoon Demand	-0.020	-0.205**	-0.007	-0.203**
	(0.012)	(0.079)	(0.011)	(0.087)
Controls?	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Clusters (Prefectures)	45	45	45	45
Observations	8073	8073	8075	8075
Mean Dep. Var.	0.393	0.393	0.408	0.408
Kleibergen-Paap F		17.68		17.68

$*p < 0.10, **p < 0.05, ***p < 0.01$. Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality.

A.2 Alternative Dependent Variable

Table A3: Census HHI: distance 20km

	Pop. Age 15-24/Pop. Age 25-59			
	(1)	(2)	(3)	(4)
	Male OLS	Male IV	Female OLS	Female IV
HHI of Silk Cocoon Demand	-0.017	-0.293***	0.012	-0.560***
	(0.022)	(0.103)	(0.025)	(0.181)
Controls?	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Clusters (Prefectures)	45	45	45	45
Observations	8073	8073	8075	8075
Mean Dep. Var.	0.393	0.393	0.408	0.408
Kleibergen-Paap F		22.17		22.17

$*p < 0.10, **p < 0.05, ***p < 0.01$. Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality.

A.3 Alternative Independent Variable

Table A4: Census HHI: distance 20km

	Pop. Age 15-24/Total Households			
	(1)	(2)	(3)	(4)
	Male OLS	Male IV	Female OLS	Female IV
HHI of Capital	-0.006	-0.246**	-0.005	-0.207**
	(0.011)	(0.095)	(0.009)	(0.084)
Controls?	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Clusters (Prefectures)	45	45	45	45
Observations	8073	8073	8075	8075
Mean Dep. Var.	0.393	0.393	0.408	0.408
Kleibergen-Paap F		11.38		11.38

$*p < 0.10, **p < 0.05, ***p < 0.01$. Standard errors are clustered at the prefectural level. Observations are weighted using the population of the municipality.