

# **Testing the general validity of the Heckscher-Ohlin theorem: the natural experiment of Japan<sup>1</sup>**

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## **Abstract**

We exploit Japan's 19<sup>th</sup> century move from autarky to free trade to test the general validity of the Heckscher-Ohlin theorem. The formulation used in this test employs Ohlin's measure of factor scarcity, where autarky factor prices impose a single refutable prediction on the economy's factor content of trade. Our test combines factor price data from Japan's late autarky period with commodity trade data and the economy's technology matrix from the early free trade period. The technology matrix is constructed from input requirements at the task level for Japan's tradable and key intermediate goods. It draws from a range of historical sources, including a major Japanese survey of agricultural techniques, accounts by European visitors and numerous studies by Japanese and western scholars that draw on village records and business accounts. For the early period of open trade, we evaluate Japan's factor content of trade at the corresponding autarky factor prices. We fail to reject the Heckscher-Ohlin hypothesis in each sample year.

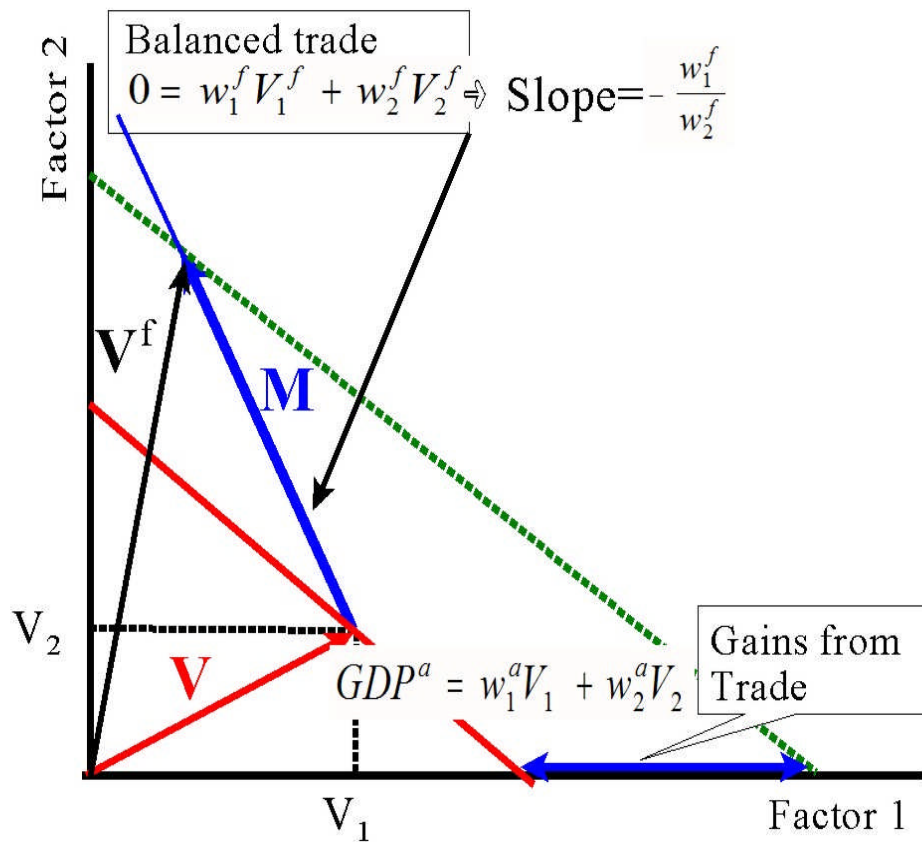
JEL classifications: F11, F14, N10, N75.

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**Figure 1 Heckscher-Ohlin Prediction in a Two-factor Case**



Notes:

1. a=autarky f=free trade
2.  $w_1^a/w_2^a < w_1^f/w_2^f$      $w_1^f/w_2^f \leq w_1^{\text{ROW}}/w_2^{\text{ROW}}$
3.  $M$ =net factor imports
4.  $V^f = V + M$

**Table 1a: The A matrix for Japan during the early trade period (1868-1875) (per metric ton) [Exports]**

<b>Export</b>	<b>Share</b>	<b>Male skilled labor (days)</b>	<b>Male unskilled labor (days)</b>	<b>Female labor (days)</b>	<b>Capital (ryō)</b>	<b>Land (tan)</b>
Silkworm eggs and pierced cocoons	16.72	66.9	997.9	500.6	151.9	22.7
Silk	33.77	676.6	12,777.2	16,564.0	2,813.5	390.7
Silk waste	1.50	135.3	25,55.4	3,312.8	562.7	78.1
Tea	27.49	452.7	584.7	208.4	151.0	22.9
Bancha tea	0.57	0.0	183.0	107.4	8.8	0.0
Wheat	0.11	16.7	181.3	28.0	12.0	8.1
Tobacco	0.84	38.4	474.9	27.4	17.7	10.3
Camphor	0.70	0.0	397.0	261.4	18.4	33.0
Vegetable wax	1.16	0.0	375.2	0.0	30.1	0.0
Mushrooms	1.11	0.0	967.7	0.0	0.0	24.8
Seaweed	1.99	8.8	17.6	26.5	3.4	0.1
Cut Seaweed	0.51	19.4	24.8	58.5	3.8	0.1
Kanten (Seaweed gelatin)	0.62	29.7	1,465.5	89.2	11.5	0.4
Copper	2.94	546.0	537.7	58.4	299.4	0.3
Charcoal	0.01	73.2	132.3	0.0	0.8	0.1
Coal	1.62	4.0	1.7	0.0	0.0	0.2
Sulphur	0.09	21.5	0.0	0.0	8.8	0.3
Cuttlefish	1.37	24.8	33.1	0.0	0.6	0.0
Iriko (sea cucumber)	0.77	10.9	231.6	0.0	0.1	0.1
Awabi (abalone)	0.73	615.6	0.0	0.0	2.4	0.0
Share of total exports	94.6					

*Notes:* All resource requirements are per metric ton unless otherwise specified. The ryō was the gold-based currency of Japan through 1871. One tan is about one-tenth of a hectare.

*Sources:* For a detailed discussion of the sources, please see the Bernhofen, Brown and Tanimoto (2009).

**Table 1b: The A matrix for Japan during the early trade period (1868-1875) (per metric ton) [Imports]**

<b>Import</b>	<b>Share</b>	<b>Male skilled labor (days)</b>	<b>Male unskilled labor (days)</b>	<b>Female labor (days)</b>	<b>Capital (ryō)</b>	<b>Land (tan)</b>
	Share of Imports	Skilled	Unskilled	Female	Capital	Land
Rice	9.93	10.0	132.3	14.0	3.1	4.1
Soy	1.32	3.6	106.7	24.7	1.4	8.8
Wheat	0.02	16.7	181.3	28.0	12.0	8.1
Indigo	0.04	139.1	762.6	182.6	43.9	10.5
Kerosene	0.70	51.0	523.6	0.0	27.3	0.3
Lead	0.45	1,200.8	889.6	1,097.3	31.5	0.0
Tin	0.06	4,151.7	414.3	0.0	0.6	0.2
Pig iron	0.11	319.0	160.6	0.0	1.1	0.1
Iron manufactures	2.56	514.0	221.2	0.0	3.4	0.1
Steel	0.07	466.2	228.5	0.0	0.0	0.2
Brown Sugar	6.65	67.7	419.6	44.2	123.4	4.2
White Sugar	2.84	162.1	900.6	88.4	265.1	8.7
Raw Cotton	2.07	64.4	461.8	261.2	35.7	9.6
Cotton Yarn	14.47	297.6	1333.4	6,578.5	104.5	27.7
Unfinished Cotton Cloth (per 1,000 meters)	10.73	11.2	50.1	447.3	4.0	1.0
Finished Cotton Cloth (per 1,000 meters)	8.63	43.3	59.1	449.4	5.6	1.1
Share of Total Imports	60.3					

**Table 2: Input Requirements for Ten Meters of Finished Cotton Cloth**

	Production site	Skilled labor (days)	Unskilled labor (days)	Female labor (days)	Capital (Yen)	Land (Tan)
<b>Cotton yarn</b>						
Fertilizer	Hokkaido: fishing and on shore	0.68	2.79	0.16	0.27	0
Seed Cotton	Farm (Osaka)	0	2.22	2.67	0.12	0.10
Preparation: Ginning and “Bowing”	Farm and Specialized “Bower”	0.46	0	1.89	0.01	0
Spinning	Farm	0	0	20.00	0.09	0.00
<b>Yarn subtotal</b>		1.14	5.01	24.72	0.48	0.10
<b>Dyeing of yarn</b>						
Fertilizer	Hokkaido: fishing and on shore	0.11	0.44	0.03	0.04	0
Indigo Leaves	Farm (Awa or near Osaka)	0.0056	0.41	0.19	0.01	0.01
Indigo Dye making	Farm or specialized firms	0.047	0.05	0	NA	0
Dyeing	Specialized firm	3.02	0	0	NA	0
<b>Dyeing subtotal</b>		3.18	0.90	0.22	0.05	0.01
Preparing and Weaving	Farm	0	0	20.00	0.02	0
<b>Total</b>		4.33	5.91	44.94	0.56	0.11

*Notes:* Columns may not add up because of rounding.

*Source.* For the sources for individual row entries, please see the text.

**Table 3: The Autarky Value of Japan's Factor Trade in the Early Years of Open Trade (in thousands of gold ryō ( $w^aAT$ ))**

	Factor Price ca. 1854- 1857	1868	1869	1870	1871	1872	1873	1874	1875
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Exports									
Labor male skilled	0.051	213	183	256	408	424	328	466	444
Labor male unskilled	0.029	509	374	418	681	598	570	667	642
Labor female	0.019	247	174	178	305	232	238	256	254
Capital	0.240	743	561	667	1190	1129	904	1109	1027
Land	0.720	302	227	282	403	343	337	451	435
Total $w^aA^{1870}X^i$ :		2014	1518	1801	2988	2725	2040	2499	2367
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Imports									
Labor male skilled	0.051	295	446	669	616	502	571	796	993
Labor male unskilled	0.029	495	1025	2240	1923	879	856	1094	1312
Labor female	0.019	823	896	1490	1651	1837	1772	2095	2084
Capital	0.240	675	947	1806	1807	1243	1283	1581	1934
Land	0.720	192	652	1466	1118	339	306	377	446
Total $w^aA^{1870}M^i$		2480	3965	7672	7116	4800	4788	5942	6769
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Imports-Exports									
Labor male skilled	0.051	82	263	414	208	78	244	330	549
Labor male unskilled	0.029	-14	651	1822	1242	281	286	427	670
Labor female	0.019	576	722	1312	1346	1605	1533	1839	1830
Capital	0.240	-68	386	1140	617	115	379	471	907
Land	0.720	-110	425	1184	715	-4	-31	-74	10
Total Net ( $w^aAT^i$ )		466	2447	5871	4128	2075	2748	3443	4402

Notes: The yen superseded the gold ryō at 1:1 in 1871. Factor prices are those prevailing ca. 1854-1857 (prior to the opening up of trade). The test of the Heckscher-Ohlin theorem is the final row of the table.

**Table 4: The Autarky Valuation of Net Factor Imports for Gold, Silver and Woolens**

Panel A: Input Requirements for Woolen Cloths and Precious Metals

<b>Product</b>	Male skilled labor (days)	Male unskilled labor (days)	Female labor (days)	Capital (ryō)	Land (tan)
Woolen cloths (per 1,000 meters)	201.6	107.1	319.2	22.5	2.8
Gold (Traditional technology per 100 ounces)	4266	227	682	0	2
Gold (Western technology per 100 ounces)	474	25	0	0	0
Silver (Traditional technology per 100 ounces)	1880	0	38	610	0
Silver (Western technology per 100 ounces)	204	0	0	66	0

Panel B: Autarky Valuation of Net Factor Imports of Japanese Trade in Precious Metals and Woolens (in thousands of gold ryō)

	1868	1869	1870	1871	1872	1873	1874	1875
Gold and Silver (Traditional Technology)					-151	-390	-1127	-2143
Gold and Silver (Western Technology)					-96	-401	-1367	-2203
Woolen Cloth	353	209	312	352	526	930	647	1156

*Notes:* For a discussion of the calculations, please see the text. The calculations in Panel C assume the use of traditional technologies for mining and refining silver and gold.

*Source:* Bavier(1874, pp. 126-127), Porter and National Association of Manufacturers (U.S.)(1898, p. 76) and Ichikawa(1996, pp. 108-110) for the input requirements for *chirimen*, *habutai* and *obi* silk cloths. Jenkins(1988), Sugiyama (1988), and Tamura(2001 and 2004) provided data on the equivalence between imported woolen cloths and domestically produced silks. Lyman(1879, pp. 43-45 and 160-162) provides the input requirements for gold and silver mining. Ishibashi(1935) provides the data on net exports of gold and silver coin and bullion.

**Table 4: The Autarky Valuation of Net Factor Imports for Gold, Silver and Woolens**

Panel C: The Autarky Value of Factor Trade Including Precious Metals and Woolens (in thousands of gold ryō ( $\mathbf{w^aAT}$ )) for Years with Data on Imports and Exports of Specie

Gold and Silver produced using pre-industrial Japanese technologies

	1872	1873	1874	1875
Labor male skilled	198	233	-456	-991
Labor male unskilled	353	406	487	774
Labor female	1710	1713	1915	1976
Capital	175	568	602	1142
Land	32	32	-35	79
Total Net ( $\mathbf{w^aAT^i}$ )	2449	2952	2513	2980

Gold and Silver produced using western technologies

	1872	1873	1874	1875
Labor male skilled	229	440	39	124
Labor male unskilled	355	417	517	833
Labor female	1713	1725	1972	2068
Capital	175	324	-227	-195
Land	33	35	-29	91
Total Net ( $\mathbf{w^aAT^i}$ )	2505	2940	2272	2921