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Knocked-down exports of automobiles

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1. Introduction

The export of automobiles can be done in a variety of ways. Newly produced, finished cars can be shipped abroad. Used cars can also be exported. Alternatively, sets of car components to be assembled at the destination country can be shipped. Items exported in this latter mode are commonly called knocked-down (KD) exports. In this research note, the issue of why Japanese automobile manufacturers sometimes choose to export unfinished cars to certain destinations is examined using trade statistics from the Japanese Ministry of Finance. The general phenomenon of knocked-down exports from an economic theory perspective is also addressed.

The contents of this note are as follows: Trends in knocked-down car exports from Japan are shown in the next section; a theoretical analysis of knocked-down exports is presented in Section 3; and an agenda for further research is outlined in Section 4.

2. Trade statistics on knocked-down car exports from Japan

2.1 Trends

Units

Figure 1a shows the number of Japanese knocked-down (KD) car exports from 1988 to 2015, as well as total car exports (including KD exports) over the same period. During this 28-year span, Japan's annual car export total ranged from roughly three million units to seven million units. Until

the early 1990s, these totals included approximately 200 thousand KD units each year. In the late 1990s, however, the number of KD units fell below 100 thousand units. Today that number stands at fewer than 25 thousand units. These declining numbers are reflected in the percentage share of KD units shown in Figure 1b. As indicated, the KD share of total auto exports exceeded 5% in the mid-1990s; however, following a sharp decline in the late 1990s, that share, with few exceptions, has decreased steadily. Today, the share of KD units is less than 1% of total car exports. Clearly, KD exports have decreased both in absolute and relative terms.

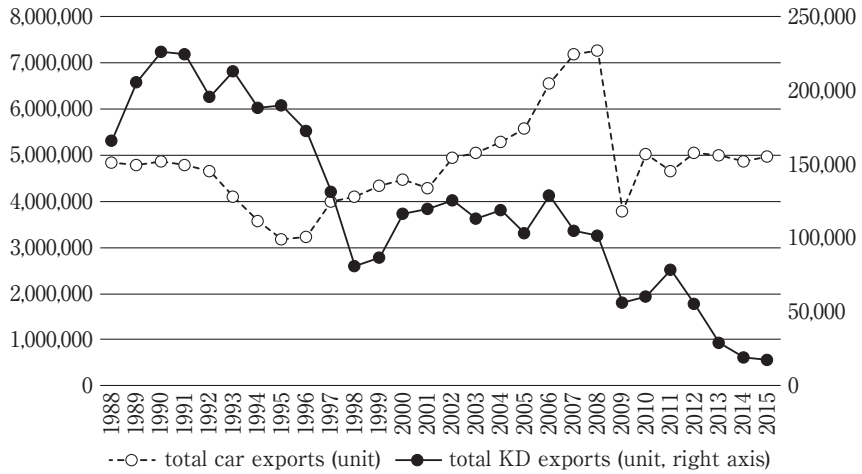
Value totals and unit values

Figure 2a shows the value of total Japanese car exports (including KD units) and the value of KD car exports from 1988 to 2015. The value of total car exports during this period ranged from approximately four trillion to 12 trillion yen. As can be seen in the figure, the value of KD car exports follows a pattern similar to the units pattern in Figure 1a. KD car export values were as high as 120 billion yen in the early 1990s but decreased to around 60 billion yen later in the decade. After recovering briefly to exceed 80 billion yen in 2011, the value figure dropped to less than 20 billion yen in the most recent two years and is now one tenth of what it was in the early 1990s.

The annual KD share of total car export value is shown in Figure 2b. The pattern here appears similar to that in Figure 1b. After exceeding 3% in the mid- 1990 s, the KD share dropped sharply in the late 1990s and today is less than 1% of the total value of Japan's car exports.

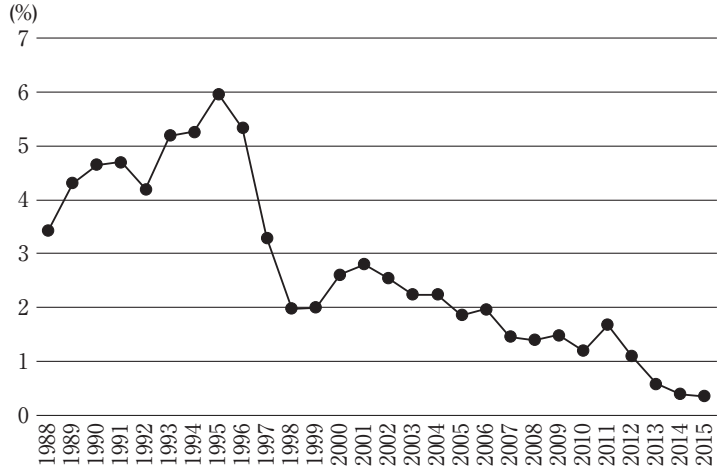
Figure 3 gives the average unit price of KD car exports from 1988 to 2015. As shown, these unit prices are in the range of approximately 500 thousand yen to 1 million yen. This is understandably lower than the price of a typical new car, as the KD sets are basically sets of unassembled car

Figure 1a: Knocked-down car exports in units, 1988-2015



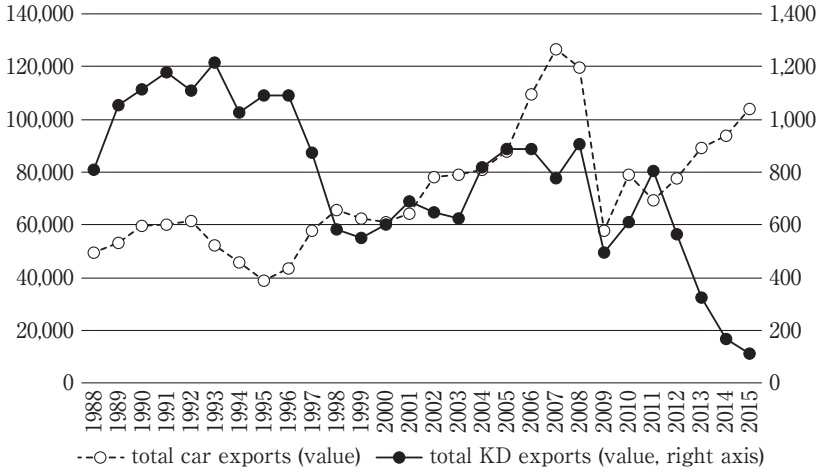
Source: Graph created by author using data from MOF trade statistics.

Figure 1b: Unit share of knocked-down car exports, 1988-2015



Source: Graph created by author using data from MOF trade statistics.

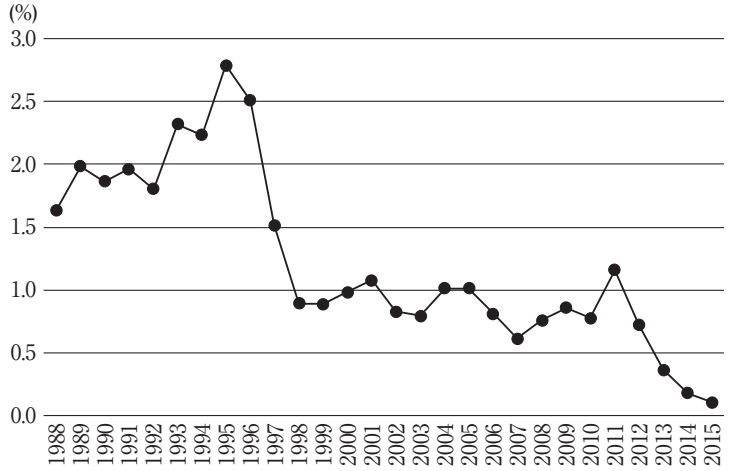
Figure 2a: Value of knocked-down car exports, 1988-2015 (unit: 100 million yen)



Source: Graph created by author using data from MOF trade statistics.

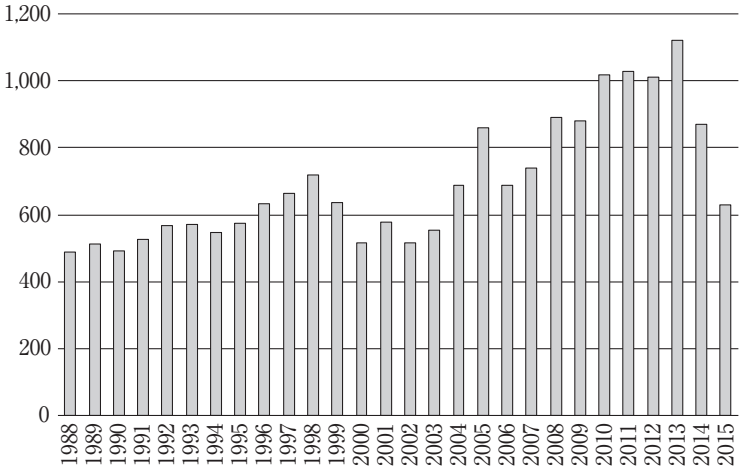
components. The data show some increase in average unit value since 2000, although the average has been decreasing over the past few years.

Figure 2b: Value share of knocked-down car exports, 1988-2015



Source: Graph created by author using data from MOF trade statistics.

Figure 3: Average unit value of knocked-down car exports, 1988-2015 (unit: thousand yen)



Source: Graph created by author using data from MOF trade statistics.

2.2 Destination of Japanese knocked-down car exports

Just where have the knocked-down cars been going? According to MOF trade data for 1990, the destinations were mostly developing countries. Table 1 shows the 1990 exports of KD cars (HS code 8703.22-100, indicating compact cars with 1.0 liter to 1.5 liter engines) by destination country. (For the years studied, KD exports in this car category were greatest in 1990, both in terms of units and value.) In total, 139,119 KD units, with a value of 70,417,407 thousand yen, were exported in 1990. The top four destinations for these exports were developing countries in South-East Asia—Malaysia, the Philippines, Thailand and Indonesia. In 2015 , only two destinations in this developing country

Table 1: Destinations of knocked-down cars in 1990 (compact cars: HS code 8703.22-100)

	Unit	Value (thousand yen)
Malaysia	41,900	20,459,929
The Philippines	18,459	11,083,418
Thailand	15,600	6,662,552
Indonesia	13,651	6,152,051
Colombia	11,936	5,853,199
New Zealand	11,610	6,793,141
Taiwan	10,200	3,963,551
Greece	9,480	5,366,340
Zimbabwe	2,320	1,341,994
Kenya	2,102	1,650,555
Trinidad and Tobago	700	530,107
Mexico	620	228,107
Uruguay	288	145,734
Ecuador	160	108,248
Venezuela	50	40,631
Zambia	40	36,205
United Arab Emirates	2	750
South Africa	1	895
Total	139,119	70,417,407

Source: Table created by author using data from MOF trade statistics.

market—Indonesia and Pakistan—received KD exports, amounting to only 3,624 units worth 2,101,468 thousand yen.

3. A theoretical analysis of knocked-down exports

3.1 Assumptions

Automobiles are not the only knocked-down export; furniture and machinery of various types are also exported in knocked-down form. In this section, a preliminary theoretical analysis of knocked-down exports is presented. The focus is on an automobile manufacturer's choice of a foreign sales mode—either finished new car export (hereafter referred to as EX) or knocked-down export (KD).

The model used is a general equilibrium model with two-sectors—manufacturing and agriculture—and two countries, identified as North and South. North is a high-wage, developed country in which all manufacturing firms are located. South is a low-wage, developing country that does not

produce any manufactured goods. Agriculture exists in both countries. South exports agricultural goods and imports manufactured goods from North.

The population of North and South are L and L^*, respectively. (Hereafter, South variables are given asterisks.) Each member of the two populations supplies a unit of labor inelastically, earning wages w in North and w^* in South. It is assumed that North workers earn higher wages; that is, $w > w^*$. The workers, who are also consumers, have preferences described by the following quasi-linear utility function,

$$U = \mu lnM + A, \tag{1}$$

where M is the composite of differentiated manufactured goods,

$$M \equiv \left[\int_0^n m(i)^\rho \right]^{\frac{1}{\rho}}, \tag{2}$$

A is the amount of agricultural goods, and $\mu > 0$. In (2), n is the mass of varieties of the M-good equal to the mass of M-firms, and $\rho > 0$. The consumers' budget constraint is

$$\int_0^n p(i)m(i)di + p^A = w, \tag{3}$$

where p(i) is the price of variety i of the manufactured good and p^A is the price of the agricultural good.

On the supply side, the manufacturing sector (hereafter referred to as the M-sector) is composed of monopolistically competitive firms, each of which produces a differentiated or similar but original variety of manufactured good. The cost function of a typical M-firm producing output q is $Fw + (c + z)qw$, meaning that setting up a manufacturing firm requires F units of labor and $c + z$ units of labor per unit output; c and z are the unit input requirements of the component production and assembly processes, respectively.

There are two regimes regarding the type of business that North does in South: exporting finished goods (regime EX) and exporting knocked-down components to South (regime KD). The variables for the former are given subscript EX; those for the latter are given subscript KD. In addition, for the KD regime, two different cases of cost structure are considered.

South policy affects the M-firms' decisions. South is a developing country seeking industrial development. To promote local production of M-goods, South imposes tariffs on imports of finished M-goods, but imports of their component parts are tariff-free. Specifically, an ad-valorem tariff rate of $t > 0$ is imposed on finished M-goods imported into South. (For example, Thailand and Malaysia had up to 300% import tariffs on finished cars in the 1980s.)

Firms in the agricultural sector competitively produce homogeneous goods under constant returns to scale technology. Specifically, the unit input requirement for agricultural goods production in North and South is $1/w$ and $1/w^*$, respectively.

3.2 Consumer behavior

The consumers' maximization of utility in (1) and (2) subject to (3) leads to

$$m(i) = \left[\frac{p(i)}{G}\right]^{-\sigma} M, \tag{4}$$

where σ is the elasticity of substitution between any two varieties of M-good, $\sigma \equiv 1/(1-\rho)$ and G is the price index defined as

$$G \equiv \left[\int_0^n p(i)^{\frac{\rho}{\rho-1}} di\right]^{\frac{\rho-1}{\rho}} = n^{\frac{1}{1-\sigma}} p, \tag{5}$$

and income allocated for M and A are

$$M = \frac{\mu p^A}{G} \text{ and } A = \frac{w}{p^A} - \mu. \tag{6}$$

Hence, expenditure on M-goods is independent of income. Further, by setting $w=1$, we have $p^A=1$. Then demand for a variety of an M-good per consumer, hereafter omitting i, becomes

$$m = \frac{\mu}{np}. \tag{7}$$

3.3 Firm behavior and stability analyses of equilibria

Suppose the M-firms are exporting finished M-goods to the South market according to the EX regime. Profit of a representative M-firm is thus its revenue from the North and South markets minus fixed and variable costs, which, in symbols, is

$$\pi_{EX} = p_{EX} q_{EX} + p_{EX} q_{EX}^* - [F + (c+z)(q_{EX} + q_{EX}^*)]. \tag{8}$$

To maximize profits, the price set by each M-firm is

$$p_{EX} = \frac{\sigma}{\sigma-1}(c+z). \tag{9}$$

In equilibrium, however, free entry leads to zero profits ($\pi_{EX}=0$); therefore, total per firm output becomes

$$q_{EX} + q_{EX}^* = \frac{F(\sigma-1)}{c+z}. \tag{10}$$

From (7), market equilibrium of M-goods implies

$$q_{EX} = \frac{\mu L}{np_{EX}} \text{ and } q_{EX}^* = \frac{\mu L^*}{np_{EX}^*(1+t)}. \tag{11}$$

Using (10) and (11), the equilibrium mass of M-firms is found to be

$$n_{EX} = \frac{\mu L(1+t) + \mu L^*}{F\sigma(1+t)}. \tag{12}$$

Case 1: assembly abroad is less efficient ($z < z^*$)

We can now consider the situation in which the M-firms have the KD option. That is, instead of shipping finished goods to South, North firms can ship components free of tariffs and assemble them in South using South labor. It is assumed that assembly in South is inefficient compared to North so that South assembly requires larger labor inputs. Specifically, $z < z^*$. This could mean increased (marginal) production costs for KD operation even with the lower wages in South; that is, it may be true that $zw < z^*w^*$, despite $w > w^*$.

Profits under the KD regime will be

$$\pi_{KD} = p_{KD}q_{KD} + p^*_{KD}q^*_{KD} - [Fw + (c + z)q_{KD} + cq^*_{KD} + z^*w^*q^*_{KD}], \tag{13}$$

and the profit-maximizing prices set by the M-firms will be

$$p_{KD} = \frac{\sigma}{\sigma-1}(c+z) \text{ and } p^*_{KD} = \frac{\sigma}{\sigma-1}(c+z^*w^*). \tag{14}$$

The hypothetical profit that an M-firm can expect by switching to KD is then

$$\tilde{\pi}_{KD} = \frac{\mu}{\sigma n}\left[L + \left(\frac{c+z^*w^*}{c+z}\right)^{1-\sigma}(1+t)^{\sigma-1}L^*\right] - F. \tag{15}$$

Substituting for n in (15) using (12) from the EX equilibrium,

$$\tilde{\pi}_{KD} = \frac{F(1+t)}{L(1+t)+L^*}\left[L + \left(\frac{c+z^*w^*}{c+z}\right)^{1-\sigma}(1+t)^{\sigma-1}L^*\right] - F. \tag{16}$$

The M-firms switch to KD if $\tilde{\pi}_{KD} > 0$. That is, transition from regime EX to KD occurs when

$$\left(\frac{c+z^*w^*}{c+z}\right)^{\sigma-1} < (1+t)^{\sigma}. \tag{17}$$

What about transitioning from KD to EX? Suppose that the M-firms are initially engaged in KD. The profit maximizing prices set by the M-firms are the same as in (14) and, as free entry leads to zero profits, using (13), the mass of M-firms in KD equilibrium is found to be

$$n_{KD} = \frac{\mu(L+L^*)}{F\sigma}. \tag{18}$$

If firms were to switch to EX, their hypothetical profits would be calculated as

$$\tilde{\pi}_{EX} = \frac{FL}{(L+L^*)} + \left(\frac{c+z^*w^*}{c+z}\right)^{\sigma-1}(1+t)^{-\sigma}\frac{FL^*}{(L+L^*)(1+t)} - F. \tag{19}$$

The M-firms will switch to EX if $\tilde{\pi}_{EX} > 0$. That is, when $\left(\frac{c+z^*w^*}{c+z}\right)^{\sigma-1} > (1+t)^{\sigma}$.

Result 1. Under case 1, transition from EX to KD (KD to EX) occurs when the South's relative marginal cost of production is sufficiently low (high) compared to the tariff.

Case 2: assembly abroad requires additional fixed costs, F^*w^*

Assume that the M-firms are initially exporting as in case 1. If assembly abroad requires additional fixed costs, F^*w^*, then

$$\tilde{\pi}_{KD} = \frac{F(1+t)}{L(1+t)+L^*}\left[L+(1+t)^{\sigma-1}L^*\right]-(F+F^*w^*). \tag{20}$$

Transition from EX to KD occurs if $\tilde{\pi}_{KD} > 0$. That is, the transition occurs when

$$F^*w^* < \frac{FL^*[(1+t)^{\sigma}-1]}{L(1+t)+L^*}. \tag{21}$$

Thus, a larger relative population size in South and a higher South import tariff on finished goods are likely to promote the switch from EX to KD by raising Ω, even though KD requires additional fixed costs in South.

The transition condition from KD to EX under case 2 is

$$F^*w^* > \frac{FL^*[(1+t)^{\sigma}-1]}{L(1+t)^{\sigma}+L^*}. \tag{22}$$

Result 2. In case 2, transition from EX to KD occurs when the additional fixed costs needed in South is less than the threshold given by (21). An increase in the relative market size of South and/or an increase in the tariff support the transition by raising this threshold. Transition from KD to EX occurs when the additional fixed costs needed in South exceeds the threshold given by (22). A decrease in the relative market size of South and/or a decrease in the tariff support the transition by lowering this threshold.

Applying these findings to Japanese car exports, it would appear that at least some of the factors explaining the initial popularity of Japanese KD car exports are 1) low foreign wages, 2) a relatively large foreign population size (or market size), 3) low fixed costs of KD assembly in the destination countries, and 4) high import tariffs on finished cars. Conversely, factors that may have contributed to the decline in Japan's KD car exports include 1) an increase in foreign wages, 2) a relative decrease in foreign population (or market size), 3) an increase in the fixed costs of KD assembly in the destination countries, and 4) lower import tariffs on finished cars. In actuality, given the recent rise of Asian industrializing countries and the impact of global trade liberalization, factors 1) and 4) appear to be especially strong contributing factors to the steady decline in Japanese KD car exports evident in Japanese auto export data.

4. Agenda for further research

This note is based on Japanese export data from 1988 to 2015, with a focus on the knocked-

down (KD) export of automobiles. A stark decline in KD car exports was observed, both in absolute and relative terms. A theoretical analysis was presented in an attempt to explain the behavior of firms choosing between finished goods export (EX) and KD export.

Further research is needed along the following lines: 1) trade data prior to 1988 should be studied, since Japanese automotive KD exports began well before 1988; 2) a formal empirical investigation to clarify the factors affecting the modes of export should be pursued; and 3) theory addressing a wider set of export alternatives should be developed, as the export choices of global firms today extend beyond simply choosing between KD and EX. Although automobile factories in developing Asian countries started out as screwdriver factories assembling imported KD cars, many of them are now full-scale factories due to intensive foreign investment and local industrialization.

Acknowledgement

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