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Social Contribution and Next Giant Leap of Semiconductors

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1. Introduction

Today, many semiconductors are widely used in the human society, and, in the future, will deeply penetrate into it, which will result in semiconductor dependent society, i.e., "symbiotic society". However, ordinary people have not paid so much attention to the contribution of the semiconductor industry. For example, it is difficult for them to understand that the recent high fuel efficiency in the automotive is achieved due to semiconductors.

This paper clarifies the social influence and contribution of semiconductors, and discusses the future opportunity of the semiconductor industry.

2. Social Contribution of Semiconductors

2-1. Technology Spreading-out and Economical Effects

Many advanced technologies have been developed for semiconductors. These technologies can be applied to non-semiconductor products and create new markets. For example, thin film deposition technology developed for the semiconductor manufacturing is used for sunshine reflection glasses, artificial tooth, etc.

This technology spreading-out effect is evaluated by the market size including the direct and the indirect effects. The direct effect is defined by the market size of the products using semiconductor technology considering attributable fraction of each technology. The indirect effects are derived from the direct one, using the inter-industry relations table in Japan. The total value (direct and indirect effects) is 21 trillion yen in 2007 and 399 trillion yen in 1970-2007.

In Fig.1, the technology spreading-out effects as well as the product outputs in three major industries are compared. Semiconductor industry shows larger effect than the aviation and automotive industries.

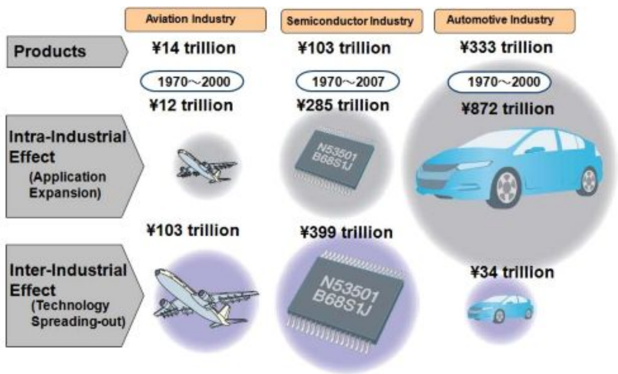

Fig.1 Technology Spreading-out Effects

On the other hand, direct economic effects are also evaluated based on the total product output of semiconductors (= 103 trillion yen during 1970-2007). The calculated economic ripple effect, i.e., induced demand by the demand to semiconductors, is 450 trillion yen. And the effect to the downstream supply chain, i.e., the size of the application market using semiconductors, is 730 trillion yen in Japan, and, if the same calculation applies, 1540 trillion yen outside of Japan by its export.

2-2. Total Factor Productivity (TFP)

TFP accounts for changes in economic output that are not caused by changes in the amount of labor and capital as shown in Fig 2. TFP explains the changes by innovative factors such as technology advances, business model improvements, etc, adding to labor and capital productivity.

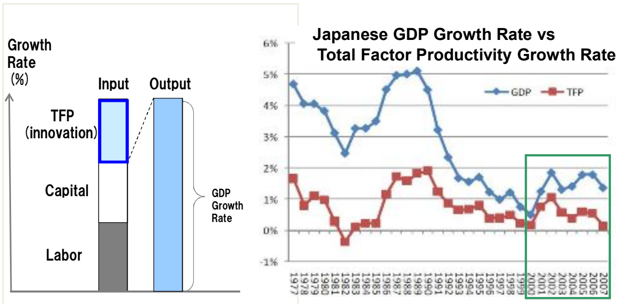

Fig.2 TFP definition and GDP/TFP growth rate trend in Japan

This figure also shows GDP/TFP growth rate trend. From 2000 to 2007, the average GDP growth rate is 1.45% and TFP growth rate is 0.57%. This means that contribution of the TFP (=innovation) to the GDP is essential in an advanced country.

The TFP growth rate of 0.57% can be divided into IT and non-IT domains and semiconductor contributions in both domains can be calculated as shown in Table 1.

The semiconductor contribution is 0.04% in IT and 0.09% in non-IT, respectively. Therefore, the semiconductor portion in TFP is 23% from 2000 to 2007 in Japan.

This big portion means that the role of semiconductor innovation is an important factor for Japanese GDP growth, although semiconductor industry occupies just 1% of GDP.

			2000-2007	2000-2009
TFP Growth Rate			0.57%	-0.24%
TFP Analysis	IT	Computers	0.14%	0.19%
		Software	0.01%	0.00%
		Communication	0.06%	0.10%
		Semiconductors	0.04%	0.03%
		Sub total	0.25%	0.32%
	Non IT	Semiconductors	0.09%	0.08%
		Others	0.23%	-0.64%
		Sub total	0.32%	-0.56%
		Total	0.57%	-0.24%
Semiconductor Total			0.13%	0.12%

Table 1 Semiconductor contribution to TFP

If including 2008 and 2009, both GDP and TFP growth rates are negative due to the economic crisis in 2008. Negative TFP growth rate of -0.24% (2000-2009) is numerically derived, because it is difficult to take account of lower utilization rate of capitals. Even so, the semiconductor contribution to TFP shows positive figure, i.e. +0.12%.

2-3 Green of/by Semiconductors

It is easy to define the power dissipation reduction of the semiconductor chips, and resultant semiconductor contribution to the power reduction in any sets. On the other hand, it is hard to separately define the semiconductor contribution volume to suppress CO_2 emission or to reduce power dissipation in the sets, i.e., green by semiconductors. Here, the inter-industry relations table can be used to define the semiconductor contribution to the fuel efficiency improvement in modern passenger cars, as an example.

The fuel efficiency improvement is due to many factors as engine control, transmission control, lighter body, etc. However, almost 90% of factors are related to semiconductors. The portion of semiconductors in these 90% factors is estimated to be 24%, amongst those industries having technological contribution, based on the inter-industry relations table. This means the semiconductor contribution to the fuel efficiency is 22% (09*0.24).

		1995	2005	delta
Fuel Efficiency	Km/L	12.3	15.1	2.8
CO2	K-ton	201320	163989	-37331
CO2 Reduction By Semi	K-ton			-8213
Semi Mft CO2 for Auto	K-ton	110	175	65

Table 2 Fuel Efficiency Improvement (in Japan)

As shown in Table 2, the average fuel efficiency is improved by 2.8Km/l from 1995 to 2005, which is corresponding to 37,331K-ton reduction of CO_2 and 8,213K-ton reduction of CO_2 by semiconductors. Since the increased CO_2 for manufacturing semiconductors for cars is 65K-ton, "Green by Semiconductor" is remarkable.

3. New Products and Services

As is mentioned in Section 2, even today, semiconductors' social contribution is so big. In today's ubiquitous society, convenience and efficiency are the main focus. In future smart society, this focus will be expanded to new application markets of semiconductors, such as HEMS, BEMS, CEMS for lowering carbon, environment control, health care, medical, etc. Special characteristics in these markets is the connectivity between the real world and the existing cyber world (computers and networks including mobiles) to constitute "symbiotic society" as shown in Fig.3.

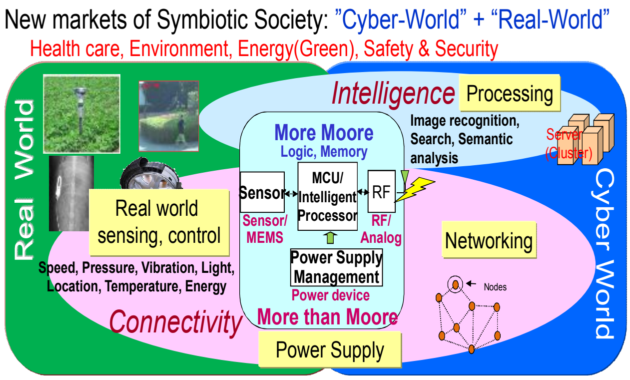

Fig. 3 New Semiconductor Markets

Semiconductor devices for realizing this connectivity are categorized into 1) Functional devices: RF, analog, power, sensor, etc. and 2) Intelligent devices for vision, voice and security. Of course, the essential factor is technology innovation in the devices, i.e., low power, low cost and high dependability. However, government clear policy and cooperation with service business are also important to realize such smart society markets.

4. Conclusion

The social contribution of semiconductors is evaluated with respect to technology spreading-out effects, GDP growth rate and green. Innovation of/by semiconductors is an important factor for the contribution.

Coming symbiotic society is a good chance for the next giant leap of semiconductors.

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