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Import and export of high-tech products in Russian manufacturing companies

Anna Fedyunina[a,*], Yuliya Averyanova[b]

[a] *HSE University, Moscow, Russian Federation*
[b] *HSE University, St. Petersburg, Russian Federation*

Abstract

The paper explores the relationship between the import of semi-finished products and means of production and the export of high-tech products in Russian manufacturing companies. The key question of the research is whether the export of high-tech products is connected with the import of complex components and semi-finished products. The study confirms that the export of high-tech products is determined by the import of high-tech semi-finished products for the export-intensive Russian manufacturing companies. The research does not find any relationship between the import of equipment and means of production and the export of high-tech products. This has important implications for Russia's structural policy aimed at expanding exports of high-tech products. First, introducing protectionist measures in relation to the import of foreign components should take place gradually to allow companies to adapt to the new conditions. Secondly, they should proceed selectively in order to allow access of Russian exporters to critical components and means of production that have no Russian counterparts.

Keywords: export of high-tech products, import of semi-finished products, Russian economy.
JEL classification: D22, F14, O30.

1. Introduction

Entering export markets allows a firm to earn additional income, leverage economies of scale, and decrease volatility of demand in its markets. At the same time, few firms are engaged in export activities, which is characteristic of economies at any level of development and income, including those of the United States (Bernard et al., 2003; Bernard et al., 2007), France (Eaton et al., 2004), Chile (Alvarez and Lopez, 2005), and South Africa (Matthee et al., 2018). It was shown

* Corresponding author, E-mail address: afedyunina@hse.ru

based on Russian data that the number of export-oriented firms is relatively low even among fast-growing technological companies (Simachev et al., 2019).

Companies from developing countries, wishing to enter foreign markets, usually need to improve the quality of their products to meet consumer demand in developed countries (Verhoogen, 2008). This could be achieved, among other things, by improving the quality and diversity of semi-finished products used in production and by raising the technological level of the means of production.

A number of empirical studies show that imported components are a vital factor in determining a firm's export activities (Aristei et. al, 2013). The correlation between imports and exports is due to the fact that imports provide firms with access to a greater number of intermediate resources, enabling them to increase efficiency, modernize technology, implement product innovations (Goldberg, 2010) and, ultimately, enter export markets (Bustos, 2011).

This study explores how the import and export of high-tech products are related to each other in the Russian manufacturing sector. A key feature of this study is that its authors distinguish between the effects of imports of low-, medium-, and high-tech components on exports in Russian companies, enabling a more accurate estimate of the effects of import activities on export activities.

This study explores whether the imports of semi-finished goods and means of production determines the export activities of Russian manufacturing firms.

By using the two-stage method of econometric analysis, we discovered that high-tech component imports have a positive impact on high-tech product exports. At the same time, export intensity itself is determined by basic variables, such as the age, size, and foreign interest within a company.

The rest of the paper is organized as follows. The second section deals with the key factors that determine a firm's competitive advantage in export markets. The third section describes the study's database, contains the econometric model, formulates hypotheses, and provides descriptive statistics for the variables. Section four of the study contains the modeling results and findings. The paper's conclusion puts forth industrial policy proposals aimed at improving the competitive advantage of Russian exporters.

2. Relationship between import and export activities at the firm level

M. Melitz's trade theory (Melitz, 2003) shows that exporting firms demonstrate higher productivity than those that do not export products. In particular, it was discovered that the most productive firms engage in exports and foreign direct investments, firms with average productivity enter foreign markets only through exports, while the least productive firms only operate in domestic markets (Kiyota and Kimura, 2006; Wagner, 2007). A number of empirical studies have obtained evidence that productivity could be increased through *learning by doing*. What causes the effects of learning by doing?

Empirical studies show that the mere fact a company has entered global markets is an incentive to introduce new technologies and new products and thereby brings about the effects of learning by doing and productivity improvements. Kuznetsov et al. (2011) demonstrate significant positive learning effects from exports, especially noticeable in changes in a firm's organization and management, as well as in its willingness to undertake its own R&D.

The study by Gorodnichenko et al. (2009), based on data from 27 rapidly-growing economies, also shows that export and import activities have a positive impact on the growth of innovative activity, thereby resulting in productivity increases for firms.

While the positive effects of export activities on productivity growth have been extensively researched in literature based on data from both developed and developing countries (Kónya, 2006; Awokuse and Christopoulos, 2009; Lim and Ho, 2013), the related effect on the functioning and productivity of firms involved in import activities has not been studied as thoroughly.

It was shown based on data from Hungarian firms that the import of components can increase a firm's income by 22% (Halpern et al., 2015). The conclusion regarding the significance of import for a firm's export activity was arrived at with respect to countries such as Belgium (Mirabelle and Mauro, 2009), Germany (Vogel and Wagner, 2010), and Spain (Fariñas et al., 2010). Castellani et al. (2017), using used data for 11000 Swedish firms in 2000–2012 and demonstrates that the import of innovative components determines the export of new-to-the-market products and, thus, higher productivity at the firm level.

In this study, we elaborate on previous empirical results regarding the impact of import activities on export activities, and make existing estimates more accurate in two respects. First, this paper distinguishes between the effects from imports of the means of production (machinery and equipment) and semi-finished products. We believe that the effects from imports of the means of production on a firm's productivity and competitiveness should surpass the effects from semi-finished imported products. The reason for this is that purchasing foreign equipment not only leads to higher quality products but also reduces the costs of other resources, including labor. Second, we distinguish between the effects of raw material imports and semi-finished products, depending on the level of their added value. We separately estimated the effect of raw material imports, low-tech components, and high-tech components. The distinction between types of raw materials also allows us to improve the accuracy of existing estimates, as the higher value added by semi-finished products may lead to higher competitiveness of the finished product, thereby expanding a firm's export activities.

3. Data

The paper uses the database created as part of the RUFIGE project, "Russian companies in the global economy,"[1] carried out by the Higher School of Economics Institute for Industrial and Market Studies in 2014. The database contains the results of a survey conducted among 2,092 Russian manufacturing companies numbering ten or more employees. The random stratified sample of firms is representative in terms of the company sectors and size groupings. Over 60% of questions in the RUFIGE survey are identical or comparable to a similar EFIGE project. The breakdown of the sample by type of business is shown in Fig. 1.

The final sample was constructed based on the following criteria.

First, we sampled firms for which at least 5% of their gross income (revenues) comes from exports. Undoubtedly, defining the threshold value at which exports

[1] Project website https://iims.hse.ru/rusfirms (in Russian).

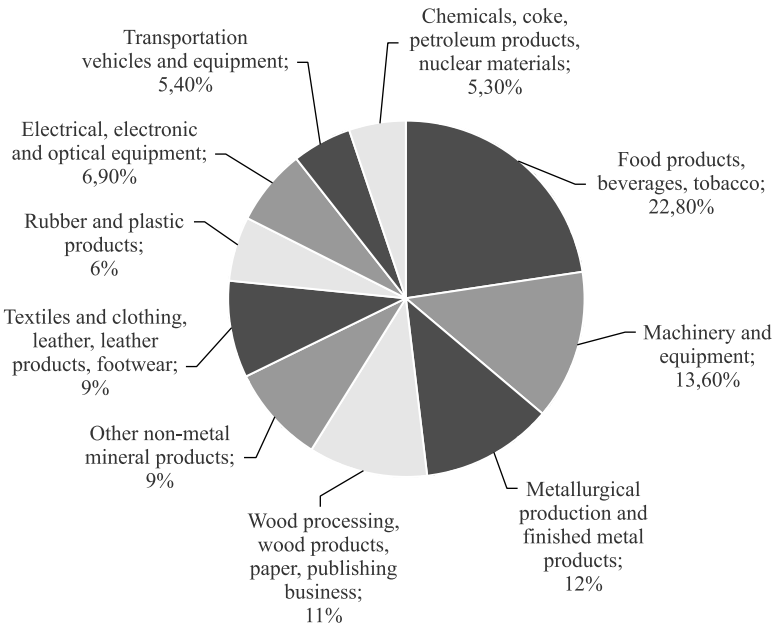

Fig. 1. Breakdown of companies in the sample by business type (%, sample size is 1,950 companies).

Source: RUFIGE project, "Russian companies in the global economy," carried out by the Higher School of Economics Institute for Industrial and Market Studies in 2014.

Table 1
Breakdown of company sample by business type.

Sector	Number of companies	Share of companies, %
Food products	119	21
Textiles, clothing, leather, and footwear	18	3
Wood processing, wood products, pulp and paper	45	8
Chemicals, coke and petroleum products, rubber and plastic products	60	11
Other non-metal products	43	8
Metallurgical production and metal products	69	12
Machinery and equipment	102	18
Electrical, electronic, and optical equipment	67	12
Transportation vehicles and equipment	35	6
Total	558	

Source: Authors' calculations.

become a significant part of a firm's business is a serious research task in and of itself. However, for the purposes of this study, and based on the empirical literature, we decided to set this threshold value at 5%.

The final sample contained 558 companies. A breakdown of the final sample is given in Table 1. Descriptive statistics for the variables used are given in Table 2.

4. Evaluation methodology

The analysis of previous empirical studies identified the factors which affect a firm's export activities. They include basic variables (number of employees, year established, labor productivity within the company measured as revenue

Table 2
Descriptive statistics for variables (number of observations = 558).

Variable	Average value	Standard deviation	Min. value	Max. value
Exports of high-tech products	0.28	0.45	0	1
Raw material imports	0.16	0.36	0	1
Imports of low-tech components	0.13	0.33	0	1
Imports of high-tech components	0.10	0.30	0	1
Number of export markets	2.11	5.52	0	56
Proportion of costs from imported machinery and equipment	27.52	36.56	0	100
International quality certificates	0.41	0.49	0	1
ERP, SAP, etc.	0.37	0.48	0	1
Website in Russian	0.92	0.28	0	1
Website in English	0.22	0.41	0	1
E-commerce system	0.39	0.49	0	1
CRM system	0.33	0.47	0	1
Number of employees:				
20 to 49	0.12	0.32	0	1
50 to 100	0.06	0.22	0	1
101 to 249	0.07	0.26	0	1
250 to 499	0.19	0.40	0	1
500 and above	0.46	0.50	0	1
Established between 1992 and 1998	0.24	0.43	0	1
Established after 1998	0.30	0.46	0	1

Source: Authors' calculations.

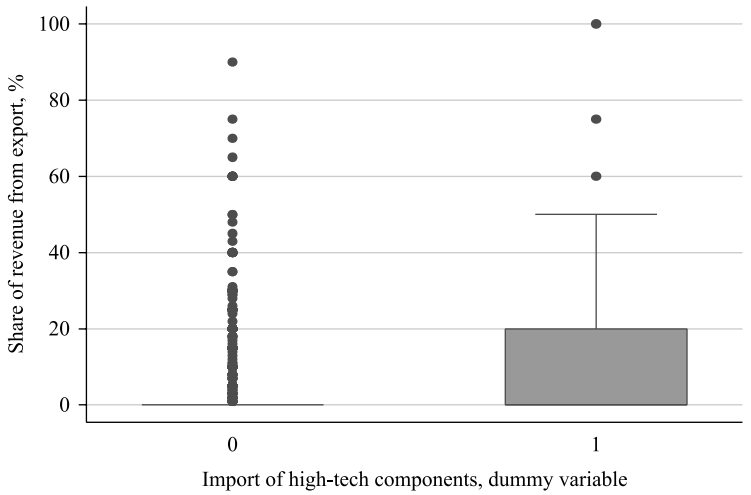

Fig. 2. Cost of high-tech component imports and proportion of gross revenues from exports for Russian companies in the manufacturing sector, 2014.

Note: Here we present boxplots. The upper limit of the "box" is the first quartile, the lower limit of the box is the third quartile, the line in the middle of the box is the median.
Source: Authors' calculations.

per employee), variables characterizing export and import activities (share of export revenues, imports of raw materials and low-tech components, exports of high-tech products, imports of high-tech components, proportion of costs from imported machinery and equipment), and variables reflecting activity related to managerial innovations (website in foreign languages, ERP systems, e-commerce platforms, foreign quality certificates).

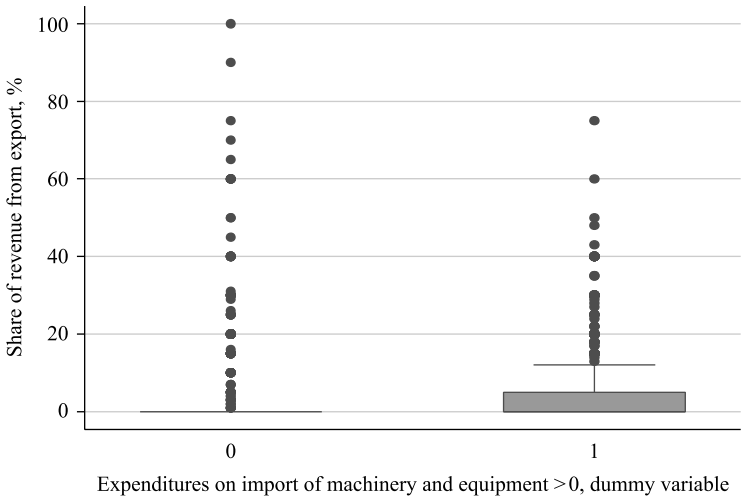

Fig. 3. Costs of machinery and equipment imports and proportion of gross revenues from exports for Russian companies in the manufacturing sector, 2014.

Note: Here we present boxplots. The upper limit of the "box" is the first quartile, the lower limit of the box is the third quartile, the line in the middle of the box is the median.
Source: Authors' calculations.

There is a higher share of export revenues in gross revenues for firms that export high-tech components (Fig. 2). This is also true, on average, for firms importing equipment and various means of production (Fig. 3).

In order to empirically test the effects of semi-finished product and means-of-production imports on high-tech product exports, we used a two-stage model. For the first stage, we empirically sampled firms with high export intensity. Estimating the impact of imports on export activities appears to be appropriate only for firms where exports are a significant proportion of gross revenues. However, sampling on the basis of only the quantitative criterion may result in leaving out a number of firms that are highly export-intensive but, due to a number of reasons, exports make up a somewhat lower proportion of their total gross revenues. The coefficients estimated in the first stage are used afterwards to predict the export intensity of the entire sample. For the second stage, using the sample of firms from the first stage, we estimated the effect of the components, semi-finished product and means of production imports, on high-tech component exports.

At the first stage, we used the variable *share of export revenue exceeding 5%,* taking discrete values between 0 and 1, as the dependent variable. Using a binary variable allows to use probit-evaluation for statistical analysis. The model for the first stage is as follows:

$$share_{exp} = \alpha + \beta_1 prod + \beta_2 age_{dummy} + \beta_3 size_{dummy} + \\ + \beta_4 foreign_{dummy} + \beta_5 fstocks_{dummy} + \\ + \beta_6 \sum industry_{dummy} + \beta_7 \sum region_{dummy} + \varepsilon \quad (1)$$

where *prod* is revenue per employee, *age* is the time in operation, *size* is the company's size, *foreign* means that over 51% of the shares belong to private foreign

owners, *fstocks* means that between 10% and 50% of the shares belong to private foreign owners, *industry* is the fixed effects by industry, *region* is the fixed effects by region.

At the second stage, for the firms with predicted high export intensity, we estimated the effect of imports on high-tech product exports. The model is described in the following equation:

$$\begin{aligned} exp = {} & \beta_1 + \beta_2\, raw.imp_{dummy} + \beta_3\, lowquality.imp_{dummy} + \\ & + \beta_4\, highquality.imp_{dummy} + \beta_5\, perc.machinery_{dummy} + \\ & + \beta_6\, certificate_{dummy} + \beta_7\, size_{dummy} + \beta_8\, age_{dummy} + \\ & + \beta_9\, website_{dummy} + \beta_{10}\, eng.website_{dummy} + \beta_{11}\, CRM_{dummy} + \\ & + \beta_{12}\, trade.platform_{dummy} + \beta_5\, markets_{dummy} + \\ & + \beta_{14} \sum_i industry_{dummy} + \beta_{15} \sum_i region_{dummy} + \varepsilon \end{aligned} \quad (2)$$

where various dummy variables reflect the presence of various elements for a given firm: *exp* stands for high-tech product imports; *raw.imp* — for raw material imports; *lowquality.imp* — for low-tech component imports; *highquality.imp* — for high-tech component imports; *perc.machinery* is a variable reflecting the proportion of costs from imported machinery and equipment out of total capital asset investments; *certificate* captures the presence of international quality certificates; *size* accounts for the number of company employees (2 — 10 to 19, 3 — 20 to 49, 4 — 50 to 100, 5 — 101 to 249, 6 — 250 to 499, 7 — 500 and above); *age* describes the time period in which a firm was established (1 — before 1992, 2 — between 1992 and 1998, 3 — after 1998); *website* indicates the use of a website, while *eng.website* reflects the use of a website in foreign languages; *CRM* indicates the use of an enterprise resource planning system; *trade.platform* is a variable reflecting the use of an e-commerce platform; *markets* shows the number of a company's export markets. A probit regression was used to estimate the coefficients in the model. As a dependent variable, we used the variable taking discrete values between 0 and 1: the presence of high-tech product exports.

We used several specifications of the model to test its robustness. The first specification uses all of the basic explicative variables: the variable describing the proportion of costs from imported machinery and equipment and the dummy variables reflecting the presence of raw material imports, low-tech component imports, and high-tech component imports. The second specification uses only the independent variable accounting for the proportion of costs from imported machinery and equipment. The third specification employs dummy variables reflecting raw material imports, low-tech component imports, and high-tech component imports.

5. Results

The estimates of the first-step model are provided in Table 3. On the whole, the results obtained provide quite a satisfactory illustration of the existing empiri-

cal findings regarding the factors of export intensity for a company. According to the results, firms with direct foreign investments are more export-intensive, keeping other factors equal. As a firm grows in size, the probability of the firm having a greater proportion of exports in its gross revenues rises. It was found that firms established after 1998, other conditions being equal, are less export-intensive than those established during the period up to 1992. This is probably related to the fact that the sample contains a certain proportion of large companies established during the Soviet era, which are large exporters in basic sectors with relatively low value added. The model, taking into account industry and regional effects, correctly predicts 87.1% of the values of the dependent variable, which is used to identify highly export-intensive firms for evaluation in the second stage of the regression. Based on the estimates, there are 558 such firms.

The estimates from the second-step model are provided in Table 4. For companies exporting high-tech products, high-tech component exports are statistically significant. In all specifications in Table 4 (columns 1, 3), the respective coefficient is statistically significant. Raw material and low-tech component imports have no effect on high-tech exports; the coefficients were found to be insignificant for the respective variables.

The proportion of machinery and equipment imports out of total capital asset investment was found to be insignificant. This may be particularly attributable to

Table 3
Empirical estimates of export intensity factors (number of observations = 1,628).

Model specification	(1)	(2)	(3)
Revenue per employee	0.00001 (0.0003)	0.00002 (0.0004)	0.00001 (0.0005)
Established between 1992 and 1998	0.00171 (0.0204)	0.00250 (0.0202)	0.0103 (0.0211)
Established after 1998	–0.0703*** (0.0182)	–0.0689*** (0.0180)	–0.0523*** (0.0194)
20 to 49 employees	0.0574* (0.0332)	0.0603* (0.0325)	0.0554* (0.0325)
50 to 100 employees	0.0416 (0.0366)	0.0531 (0.0364)	0.0484 (0.0358)
101 to 249 employees	0.136*** (0.0335)	0.138*** (0.0333)	0.136*** (0.0334)
250 to 499 employees	0.139*** (0.0371)	0.148*** (0.0368)	0.140*** (0.0372)
500 employees and above	0.239*** (0.0317)	0.241*** (0.0315)	0.244*** (0.0314)
Over 51% of shares belongs to private foreign owners	–0.0182 (0.0467)	–0.0123 (0.0460)	–0.0307 (0.0492)
Between 10% and 50% of shares belongs to private foreign owners	0.0947** (0.0396)	0.0717* (0.0391)	0.105** (0.0415)
Fixed effects by industry	–	+	+
Fixed effects by region	–	–	+
Constant	–1.64*** (0.17)	–1.77*** (0.25)	–1.63*** (0.28)

Note: Marginal effects are reported. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

Table 4
Empirical estimates of high-tech product export factors (number of observations = 558).

Model specification	(1)	(2)	(3)
Proportion of costs from imported machinery and equipment	0.000711 (0.000571)	0.000744 (0.000561)	
Raw material imports	0.00933 (0.0549)		0.0118 (0.0550)
Imports of low-tech components	–0.0790 (0.0574)		–0.0729 (0.0571)
Imports of high-tech components	0.121** (0.0597)		0.126** (0.0600)
Number of export markets	0.0235** (0.0108)	0.0245** (0.0109)	0.0238** (0.0111)
International quality certificates	0.119** (0.0469)	0.124*** (0.0472)	0.128*** (0.0482)
ERP, SAP, etc.	0.0112 (0.0424)	0.0147 (0.0429)	0.0115 (0.0428)
Website in Russian	0.134 (0.0962)	0.147 (0.0964)	0.142 (0.0965)
Website in English	0.164*** (0.0462)	0.166*** (0.0464)	0.164*** (0.0462)
E-commerce	0.106** (0.0444)	0.0955** (0.0445)	0.108** (0.0448)
CRM	0.0773* (0.0431)	0.0850** (0.0428)	0.0726* (0.0431)
20 to 49 employees	1.149*** (0.199)	1.237*** (0.192)	1.132*** (0.193)
50 to 100 employees	1.210*** (0.215)	1.270*** (0.212)	1.180*** (0.211)
101 to 249 employees	1.347*** (0.200)	1.407*** (0.193)	1.319*** (0.194)
250 to 499 employees	1.432*** (0.200)	1.495*** (0.196)	1.404*** (0.195)
500 employees and above	1.336*** (0.196)	1.401*** (0.190)	1.314*** (0.192)
Established between 1992 and 1998	0.0427 (0.0496)	0.0408 (0.0488)	0.0433 (0.0499)
Established after 1998	0.0230 (0.0464)	0.0188 (0.0465)	0.0205 (0.0466)
Fixed effects by region	+	+	+
Fixed effects by foreign economic activity sector	+	+	+
Constant	–1.175*** (0.446)	–1.299*** (0.438)	–1.170*** (0.446)
Percent of correctly-predicted firms exporting high-tech products	58.71	60.65	58.71
Percent of correctly-predicted firms not exporting high-tech products	89.08	87.71	89.42
Total percent of correctly-predicted firms (exporting and not exporting high-tech products)	78.57	78.35	78.79

Note: Marginal effects are reported. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

the fact that manufacturers of products at different processing stages depend on machinery and equipment imports, as well as high-tech product exporters.

Other significant variables include: company size (larger companies are more likely to export high-tech products) and the presence of international quality certificates, CRM systems, e-commerce systems, and a website in English.

The model, using fixed industry and regional effects, correctly predicts 86.5% of observations, including the corrected predictions for 48.4% of firms exporting high-tech products and 96.0% of firms not exporting high-tech products.

6. Conclusion

This article studies the impact of raw material, semi-finished product, and means-of-production imports on high-tech product exports for Russian companies in the manufacturing sector. This study particularly stands out for distinguishing between the effects of imported components (raw materials and half-finished products) and means-of-production imports (machinery and equipment), while low-tech and high-tech imports are isolated within resource imports. All this enabled us to estimate the effects of import activities on high-tech product exports more accurately.

In the first stage of the study, we used econometric modeling to sample firms with a predicted high proportion of exports in gross revenues. At the second stage, we estimated the factors determining the likelihood that a firm exports high-tech products. We found that high-tech half-finished product imports increased the likelihood that a firm exports high-tech products. At the same time, raw material and low-tech component imports have no significant effect on increasing the proportion of export revenues. The authors did not find any statistically significant effects from machinery and equipment imports on high-tech product exports. In our opinion, this is due to the fact that equipment and means-of-production imports are significant for all firms in the economy, and not just for exporters of high-tech products.

On the whole, the most significant result from this study is that firms having significant presence in foreign markets (with relatively high proportions of export revenues) and exporting high-tech products are more dependent on imported half-finished products and machinery and equipment than firms exporting less technology-intensive products, half-finished products, and raw materials. Consequently, import substitution measures in medium- and high-tech sectors, and measures incentivizing companies to purchase Russian-made components may have a strong adverse impact on Russian companies. Protectionist measures should be gradual, providing Russian companies the opportunity to adapt to new conditions. Adaptation here means not only a company's need to refocus on substitute products but, more importantly, the need to find products and substitute components that conform to technological requirements and standards.

The dependence of export-oriented companies on import activities (especially in hard-to-regulate high-tech sectors) suggests yet another conclusion. The task of expanding export activities (primarily non-commodity and non-energy exports) should be accompanied in trade and economic policy by lowering barriers for companies around import activities. Import liberalization in import-sensitive sectors may turn out to be a vital incentive for expanding high-tech product exports.

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